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This document is in response to all questions under category #6: "Build computational literacy."

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Training the Future Generation of Computational Researchers

Motivation: *The current disparity in computational knowledge and access across the nation is a critical hindrance to the diversity and therefore the success of the fields of Astronomy and Physics.* Thus, training the next generation of computational researchers is crucial. Preparing all students for careers in Astronomy, Physics, and industry will require universal computational and data science literacy, innovative education models, and equitable access to high performance computing (HPC) as well as elastic, specialized and other emerging computing facilities. The following recommendations are critical to the growth and retention of a new generation of computational researchers that reflect the demographics of the undergraduate population in Astronomy and Physics.

Recommendation 1: All institutions granting Astronomy, Astrophysics and Physics undergraduate and graduate degrees are strongly urged to require computational and data science classes at both introductory and advanced/applied levels

Undergraduate programs are growing and the relevant job markets require coding skills. Over 2006-2017, the AIP reports that the number of institutions offering Astronomy degrees has increased by a factor of 2. Correspondingly, the total number of conferred Astronomy degrees has increased by a factor of 1.6 (Nicholson & Mulvey 2017). Upon graduation, Physics or Astronomy majors who manage to enter the private sector typically find employment in data science, computer systems, and engineering-based companies.[1] These professions require a range of computational skills including software development, data visualization, statistics, machine learning and working with large computational infrastructures. Astronomy and Physics undergraduate programs must prepare students for this reality and provide them with the appropriate practical and computational skill sets to be marketable in the private sector (Heron & McNeil 2016).

Currently, the fields of Astronomy and Physics are driven by big questions that require computational solutions and massive data sets, making computational training imperative for careers in academia. The "grand challenges" facing the field of Astronomy and Physics over the next 10 years will require innovative and advanced methodological and computational methods to solve. In particular, the fields of Astronomy and Physics are generating massive and complex data sets from large observational surveys (e.g., the Legacy Survey of Space and Time, *LSST,* will produce 15 terabytes a night, Juric+2017), large-scale experiments (e.g., the Event Horizon Telescope produced 5 petabytes in the 2017 observation campaign, EHTC+2019; the LHC experiments produce over 50 petabytes of data per year;[2] LIGO generates terabytes a day[3]), and simulations (e.g., IllustrisTNG, 1.6 petabytes in total, Nelson+2019). The resulting petabyte-scale data sets require advanced computational methods and facilities to analyze (Zhang & Zhao 2015).

Given these realities, it is imperative that the current generation of young astronomers and physicists are trained in computational methods. With coding skills in their toolkit early in their academic path, students can join and have greater impact in research groups earlier, solve meaningful problems in upper division courses and obtain higher-paying technical internships.

Dedicated introductory computational courses are not standard requirements within Physics and Astronomy core curricula, creating inequitable access to computational training pathways. It is increasingly clear that computational literacy is as essential as mathematics in modern Astronomy and Physics. However, few degrees have early computational requirements. Only 4 of the Pac-12 universities have mandatory computational course requirements within freshman or sophomore years of Astronomy or Physics degrees. Furthermore, a recent national survey of 357 unique Physics departments find that "only 55% have a simple majority of their faculty reporting that they have some experience teaching computation to undergraduate physics students" (Caballero & Merner 2019). Inequity in early computational training can delay student entry into research and limits early exposure to computationally intensive research areas, such as theoretical research. As a result, students graduating from a subset of institutions have a significant advantage in admission to and performance both during graduate school in Astronomy and Physics, and on the job market. *The current inequity in access to computational education is a major challenge to the diversity, and thereby scientific excellence, of the field.*

We recommend the endorsement of the following statement: ***The realities of modern Astronomy and Physics demand the institutionalization of computational literacy as a core competency, parallel in priority to math.*** All institutions conferring degrees in Astronomy, Astrophysics and Physics implement the following computational requirements, in a relevant computer language:

A. At least one required introductory course (3 credit hours) in programming in the freshman year of undergraduate programs in order to institutionalize programming as a core competency**.** Students enter Astronomy and Physics majors with a wide range of computational expertise, necessitating early access to training to level the playing field. An interdisciplinary approach, partnering with Computer Science/Engineering departments, can help meet a range of student needs and increase instructional capacity.

B. At least one upper-division class in computational methods, optimization, data science and statistics, with a focus on applications to Physics and Astronomy research. With the advent of large surveys, computational datasets, and data intensive experiments, the methods of the modern astronomer and physicist have adapted. These relatively new skills must be taught alongside traditional methods such as astronomical observation and pen and paper calculations.

C. Incorporation of programming into core undergraduate and graduate Physics and Astronomy courses (e.g. quantum mechanics, classical mechanics, thermodynamics, dynamics, cosmology, etc.). With (A) in place, all upper division classes can assume students have a core competency in programming, enabling practical project-type exercises with a significant programming and data analysis component. As such, computing would not necessarily be the focus in these classes, but rather an inextricable component akin to mathematics. The American Association of Physics Teachers (AAPT) have made similar recommendations in 2011: "*The AAPT urges that every physics and astronomy department provide its majors and potential majors with appropriate instruction in computational physics*"[4], and have outlined specific learning outcomes and strategies for incorporating computation within core curricula[5]. We emphasize working with the AAPT to normalize computing in Astronomy/Physics degrees.

Recommendation 2: The Development and Maintenance of a Platform for Open-Source Computational Curricula and Programs for Instructor Training

Open-source curricula have been extremely successful through the development of the *Software Carpentry* and *Data Carpentry* organizations. These programs, recently combined under "*The Carpentries,*"[6] train volunteer scientists to teach programming and data analysis methods in multi-day workshops around the world, and more crucially provide a global community working together at all levels of teaching including curriculum development, lesson infrastructure and maintenance, development of assessment, and instructor training. We recommend extending instructor training programs and curricula that exist as part of, e.g. *The Carpentries,* in order to build such a community at a smaller scale for computational astrophysics**.**

A per-instructor academic teaching model impedes the creation of computational training pathways. Traditional academic teaching is often based on a per-instructor model, where the faculty member responsible for teaching the class is also solely responsible for the development and improvement of that class. The lack of instructor knowledge is found to be one of the major difficulties associated with integrating computation into undergraduate physics (Leary+2018). Well-designed curricula on an open platform will lower the barrier to entry for instructors without a strong background in computational methods to teach needed classes (Rec. 1). However, barriers will likely remain for upper division/graduate classes, necessitating dedicated instructor training pathways, such as the *Software Carpentry Instructor Training Program.*[7]

An open-source platform will increase efficiency. In a per-instructor academic teaching model, every lecturer reinvents the wheel by designing their own curriculum from scratch, leading to duplication of effort. Computational and data science courses are more hands-on than traditional courses and typically require more development time for modules by comparison. With an open-source platform, initial curricula can be improved upon by the community.

Keeping up with the pace of platform development/code changes. Computational methods and technologies change at a much more rapid pace than changes in our knowledge of fundamental physics. Best practices for software development published two years ago may already be outdated today. It is therefore critical that curricula in Computational Astrophysics, where results often depend crucially on programming languages, platforms and software packages, keep pace with these changes. For example, while Python is currently a favored language, there is no guarantee that this will be the case in ten years. Even Python has experienced rapidly evolving features and libraries that require frequent updates of software. While this constant change may be daunting, it is indicative of the broader utility of a computational education and the vast industry accessible with such education. With an open-source platform, multiple instructors can provide incremental updates, allowing adaptations to developments in computation on shorter timescales.

Maximizing the impact of state-of-the-art theoretical simulations, astrophysical data sets and codes. A number of astronomical data sets are publicly available to researchers for a broad range of science cases, including *Gaia, Kepler, TESS* and *LSST*. However, the average graduate student does not have the training to properly analyze and interpret these data sets. The impact of these releases to the broader community would be significantly augmented if training sets, curricula, and individual lessons were released using the simulations or data. Without the development of such educational tools, the analysis and impact of new data will stay within the existing user base or scientific community (see Rec. 3). This is similarly true for the usage of standard codes[8].

We recommend:

A. A community effort, building on the experiences and materials available through *The Carpentries* organizations as a foundation to create an open-source platform for curriculum development and instructor training. This will allow for curricula to be continuously updated to keep lecture material and the tools and methods being taught relevant to students' future careers, both within academia and industry. Some examples of open-source platforms for curricula/training are already available[9]. Maintaining semester-long courses, however, will require institutional support.

B. Explicit language in DOE/NASA/NSF data management plans and new dedicated grant programs to incentivize programs that fulfill the above recommendations. Specifically, large science collaborations that receive operations funding from DOE/NSF/NASA should be required to publish research and educational tutorials based on their main analysis software and provide avenues for instructor training.

Recommendation 3: Development of computational training pathways for students through increased access to national HPC facilities and increased funding for alternative education models beyond standard classrooms.

Formalized, universal training pathways for the usage of state-of-the-art HPC facilities and modern data analysis infrastructures do not currently exist. Training pathways for undergraduates and graduate students that commonly exist in observational Astronomy and experimental Physics ultimately equip students to use state-of-the-art observational/experimental facilities. The absence of comparable HPC and methodological training pathways reflects outdated perceptions of the basic research skills needed to succeed in these fields, formalized in an era prior to the current reality of massive data sets. Instead, students are forced to "pick up" advanced computational skills informally, largely through research experiences, often resulting in only a cursory knowledge of HPC, cloud computing, statistics and machine learning, and a limited eligible user pool for national HPC.

PhD. theses in Computational Astrophysics increasingly rely on HPC and advanced computational methods, both for generating and analyzing massive simulations and observational data sets. Most areas of Astronomy research critically require advanced computational methods (such as modern statistics and Machine Learning) and the usage of HPC facilities. Indeed, the usage of HPC facilities and advanced computing techniques are common among the list of research conducted by awardees of NASA Postdoctoral Fellows over the past 10 years[10]. The lack of training and equitable access to HPC facilities and advanced computational and statistical methods are currently significant barriers to pursuing computational research at the graduate level. The resulting disparity in computational knowledge across the nation is a critical hindrance to the diversity of the field.

Informal learning is a pathway to universal computational literacy. There are models of education beyond the traditional classroom format. *Summer/Winter schools* have long been known as an effective format to disseminate recent results through the community and train students in advanced methods. In recent years, new formats have emerged, including *Massively Open Online Classes* (MOOCs) that allow dissemination of information to a wide audience; *hack weeks,* which combine theoretical learning more akin to traditional classes, and summer schools with practical project work (Huppenkothen+2018), and student competitions that engage undergraduates from academic institutions with less access to computational resources, such as the *Student Cluster*

Competition[1]. The latter serves as a microcosm of the real-world HPC Community and has been shown to both engage and educate students who have not had HPC exposure.

Existing computational summer schools are not meeting student or instructor needs. Computational summer schools generally have a high impact on students, providing them with essential computational skills for their careers (e.g. IHPCSS[11]).[12]. However, existing programs teaching data-intensive skills are massively oversubscribed. In addition, there is typically a high bar of computational knowledge required for acceptance into existing HPC summer schools (e.g. ATPESC, LANL), which explicitly require significant prior experience with HPC techniques (e.g. MPI). There is no formal process or pipeline for reaching students with less preparation or less previous access to resources. Furthermore, many existing programs are not well funded, as evidenced by the recent cancellation of NSF funding for the *Blue Water's Student Internship*[13] and discontinuation of funding for *UC-HiPACC*.[14]

We recommend *the following informal training paths, best practices and funding structures to level the playing field for all students pursuing careers in computational research:*

A) The expansion of student training opportunities in data science and on national HPC facilities, including introductory versions of existing HPC summer/winter schools with a more flexible bar for entry, increased funding and expansion of existing student training programs in data-intensive research, student competitions/programs that engage students at institutions without local HPC resources, new NSF REU programs at HPC facilities and data centers, and reinstatement of programs like the Blue Waters Summer Internship. We further recommend that NSF/NASA/DOE increase funding opportunities for programs specifically aimed at increasing computational access/training for women and underrepresented minorities, such as the *Advancing Theoretical Astrophysics*[15] summer school. Offered trainings should serve as certification for student access to specific facilities.

B) That national HPC facilities reserve a dedicated amount of time on these facilities for startup allocations available for graduate student PIs, particularly from underserved institutions. Graduate students are routinely PIs on proposals for state-of-the-art observational facilities. However, only NSF graduate student fellows can apply to XSEDE startup allocations, and even they must have a faculty PI if they request larger allocations. With the establishment of HPC training pathways (A), and the existence of support staff for national HPC facilities, there is no clear reason why graduate students should not be PIs of their own allocations. We stress the need for the strong growth of open HPC infrastructure to support a growing user base.[16]

C) That funding agencies open up a wider range of flexible funding streams aimed at graduate students for computationally intensive research. While HPC resources are finite, new cloud-based architectures allow computation at scale. At the same time, new hardware dedicated to certain applications (e.g. Google's Tensor Processing Units) undergoes rapid cycles of development, and university computing architectures may not be able to respond to hardware, software and infrastructure needs on timescales required by modern research. While some viable routes exist for university/industry partnerships for graduate students (e.g. AWS Cloud Credits for Research[17] and NVidia's GPU Grants for Researchers[18]), public funding streams should enable early-career researchers to work with state-of-the-art computational methods, irrespective of their home institution. Potential models for such an infrastructure include the Open Science Data Cloud[19] and SciServer.[20]

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[1] http://studentclustercompetition.us/Education/index html

Final Remarks

The 2018 report from the Committee on STEM Education of the National Science & Technology Council explicitly states that in order to build a strong foundation for STEM Literacy we must ensure that "every American has the opportunity to master basic STEM concepts, including computational thinking," meaning "the ability to solve complex problems with data and computational methods"[21].

Over the next ten years, computation will play an increasing role in all fields of Theoretical Physics and Astrophysics, Experimental Physics and Survey Science. In order to harness the data revolution and address the biggest problems in the sciences, all elements of the scientific method must become scalable: hypotheses must be formulated into computation codes; experiments must involve automation; refinement must be assisted by artificial intelligence. "Computational thinking" is thus arguably *the* critical skill for student success in Astronomy and Physics. The recommendations in this document are designed to build computational training pathways for students that are both equitable and in keeping with the state-of-the-art. Furthermore, the recommendations made in this document are central to the realization of five of NSF's 10 Big Ideas in the fields of Astronomy and Physics:

1) *Harnessing the Data Revolution*[22], which has the stated goal of developing "a cohesive, federated, national-scale approach to research data infrastructure, and the development of a 21st-century data-capable workforce."

2) *NSF INCLUDES*[23], which seeks to "transform education and career pathways to help broaden participation in science and engineering."

3) *Growing Convergence Research*[24], which acknowledges that the grand challenges of today, such as exploring the universe at all scales, will not be solved by one discipline alone. For example: capturing the first image of black hole from the *EHT* requires astronomical data processing and computational image reconstruction; and developing the transient classification and prediction algorithms for the *LSST* requires astrophysical models of different transient events and knowledge in machine learning algorithms. Such interdisciplinary research can only be done efficiently if both software and training materials are open source.

4) *Windows to the Universe*, which seeks to combine knowledge through "diverse windows - electromagnetic waves, high-energy particles and gravitational waves" in order to probe and understand the universe. Executing this vision will require a computationally literate workforce that can develop and utilize new analysis capabilities (neural networks, machine learning, etc.) to correlate the massive amounts of data being generated in each of these windows. Of particular relevance to Astronomy and Physics is the amount of data expected to be generated in the era of LISA and the daunting computational task of relating these signals to EM sources.

5) *Quantum Leap*, which aims to exploit quantum mechanics to develop "next-generation technologies for sensing, computing, modeling, and communicating." It is imperative to build a computationally literate population in Physics and Astronomy to realize this goal.

Ultimately the recommendations laid out in this paper will promote the growth and development of a user base for large astronomical data sets and national HPC facilities, creating a new generation of computational researchers that reflect the demographics of the undergraduate population in Astronomy and Physics in the U.S.

Endorsements from individuals:

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Many of the views expressed in this ASTRO2020 white paper are also echoed in that of:

> Norman+2019 "*The Growing importance of a Tech Savvy Astronomy and Astrophysics Workforce*"
>
> Desai+2019 *"A Science Platform Network to Facilitate Astrophysics in the 2020s"*
>
> and past white papers, such as Zingale+2016, *"The Importance of Computation in Astronomy Education*".

The views expressed in this white paper are not necessarily the views of the AAS, its Board, or its membership.

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[8] *Athena, Cloudy, Einstein, Enzo, HARM,Gadget, Pencil, Toolkit,* etc., and newer codes like *Cholla, GAMER2, Trident*, etc.
[9] AAPT: Partnership for Integration of Computation into Undergraduate Physics (*PICUP*). https://www.compadre.org/PICUP/ ; GitHub *Open Astro Bookshelf* https://github.com/Open-Astrophysics-Bookshelf; HPC Carpentry hosts advanced computing curricula https://hpc-carpentry.github.io/
[10] http://www.stsci.edu/stsci-research/fellowships/nasa-hubble-fellowship-program/meet-the-fellows
[11] http://www.ihpcss.org/
[12] At Los Alamos National Laboratory (LANL), for example, the retention rate of students attending HPC summer schools (i.e. students who return to work at LANL in fields involving HPC) is ~50%, compared to ~20% with other summer programs H. Nam, private communication 2019
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[redacted]

[redacted]: STEM RFI Response

Organizational Information

[redacted]
Form Completed On: September 11, 2020
Form Completed By: (b) (6) [redacted]
Education System: Informal STEM Education
Audience: Students, Teachers, Schools, Community (PreK-12)

Category: Future Opportunities in STEM Education

1. When COVID hit, our greatest challenge was finding a way to make hands-on STEM still accessible to students using a virtual platform. We took a month or two to strategize, and by May, we were engaging students in virtual camps and hands-on webinars every single week. This summer, we engaged thousands of students across the globe, and we're looking forward to engaging even more students moving forward.

2. We have a live weekly webinar, virtual class sessions, virtual STEM events, and virtual summer camps, all of which have been working well this summer. We're also looking into creating more virtual programming, including virtual PD for teachers and a fellowship for high school students. At this point, most of the programming that we do is synchronous, though the webinar is recorded and posted to Youtube and can be used asynchronously.

3. Shifting to virtual programming has allowed us to expand our reach to students across the country. While we miss the in-person interactions we loved so much, we're working to build community with every child that crosses our path. Providing additional funding to nonprofits, such as ourselves, would allow us to expand that reach further and provide even more high-quality, meaningful hands-on experiences for students in our country.

4. Some of the greatest challenges facing equity are funding and imaging. Students need to see themselves in the profession in order to consider that profession as something they might like to do. At [redacted], we employ local college interns to interact with students, often from similar backgrounds and cultures as the participating students. This allows students to feel seen and valued, and it increases the effectiveness and impact of our

[redacted]

programming. Having more funding would allow us to create even more programming and reach even more schools and students.

5. Teachers would benefit primarily from learning (a) best practices in STEM and (b) how to employ those in a remote or blended classroom.

6. We're looking to gather data regarding impact on families, primarily focusing on the socio-emotional effects of our programs. We see learning happening in real-time, and we want to know: Do students see this as a sustainable interest?

Category: Increase Diversity, Equity, and Inclusion in STEM

12. Our founder and president, [redacted], studied organizing after his tenure as an engineering professor, and he has found that community-building is the single most important aspect of creating impactful programming. Our mission is to serve underserved students, and in order to do so, we create partnerships with schools and organizations locally, nationally, and globally, we create programs tailored to the needs of the individual school/community, and we treat each and every person we interact with with respect such that they feel seen and valued. In addition, we create a community registration process that allows for students on free/reduced lunch to participate cost-free, while students who can afford it pay. We're also working with organizations to adapt our programming to meet the needs of students with disabilities and students who speak other languages.

Category: Build Computational Literacy

20. Computational Literacy is essential to STEM literacy. While our organization focuses primarily on hands-on learning, we also have technology camps and programs meant to expand student computational literacy. Now, in our virtual programming, even hands-on learning requires some level of proficiency with computers.

21. All areas of computational literacy should be included: coding, cybersecurity, robotics, etc.

23. We use UBTech, Google Suite, Zoom, Youtube, our own website, and shared resources. We would like to look into a more seamless version of Google Classroom, if possible, that would be more intuitive for younger students and/or could be used to create self-paced learning modules.

“Future Opportunities in STEM Education, questions 1-3, 5”

Shared by (b) (6) [redacted]

1. There are numerous software related problems in the COVID era as it relates to K-12 education, most notably in the local district I affiliate with, the problem is Learning Management Systems (LMS). The majority of districts in my area utilize Google Classroom, which technically may not be a LMS due to its lack of its features, albeit close to being one. However, it is not a full LMS and therefore creates issues. Other issues are lack of clear online resources for distance learning. Due to thinning school budgets, schools are forced to turn to private education companies which safeguard their learning content for customers only. The solution is a clear technology training department as well as public LMS and training content that can be deployed nationally to train districts. Current professional development makes no sense in the disjointed manner because of the patchwork of many different private educational companies as well as consultants various K-12 schools utilize.

2. To create robust online learning schools must turn their eyes towards the professional STEM industry. In the K-12 school system a robust public LMS is the first start. From there engaging students with a “badging” system is something that motivates students, many educational startups have various success with badging. K-12 students are increasingly impatient, they require instant gratification. Therefore, developing STEM resources that are gamified are a must, a diverse set of activities is a must. Proper video conferencing is crucial now, combine all the above and you have an appropriate LMS.

3. Cloud based resources such as www.repl.it, www.TinkerCAD.com, www.Onshape.com, Google Classroom (which is the best we have at a K-12 institution). All schools should be running STEM resources through a professional industry connection. The fact that many educational companies dumb down STEM content for children is doing them a disservice. Speaking from a professional standpoint as a Tech / Engineering Teacher, Engineering Designer as well as President of a makerspace company, we are teaching STEM increasingly wrong. The federal government must give greater flexibility to schools in its ability to work and purchase with private companies. The soft STEM companies that put their own spin on STEM topics soften the point of hard STEM skills for children, the subjects are being warped farther from necessary skills and being molded so that any untrained teacher could teach these skills, you would not have an ELA teacher teach math for instance.

5. Teachers do not need another course on assessment, differentiation and things of this nature, in fact this is seen as a waste of time for the faculty of my K-12 institution. Educational preparation programs teach the theory and pedagogical methods, teachers are in desperate need of hard technological skills. I am surrounded by educators with Master’s Degrees that cannot formulate enough technological critical thinking to fix minor computer or technology problems. This is a common issue in many industries but is clearly disproportionately impacting the K-12 educational sector. K-12 educational institutions are in desperate need of in-depth hard technology training. Critical thinking and creativity solutions, as you might see in business professional development. With the knowledge further training should be facilitated to think of

innovative online learning initiatives, blending in person and distancing learning, using flipped classroom models as the standard for K-12 models. While the numbers dwindle the teachers of this subject area have so much to offer, we are underutilized.

"Develop STEM Education Digital Resources, questions 9-10"
Shared by (b) (6) [redacted]

9. A STEM education website needs to be a functional website, we are subjects of practice and we should not be bogged down by the clutter of other educational websites, UX on most educational organizations / standards websites is subpar at best. I propose a functional website that has the following:

A dedicated STEM search engine, that links to resources that one might find in a STEM curriculum, which then links to a simple tutorial for children and adults. Please find an example below: https://www.hastingstech.com/help/How-to-adjust-%2F-turn-off-the-snap-grid-in-TinkerCAD%3F

A dedicated national STEM networking group that unifies each letter of STEM. Science and Mathematics are the most widely known. T and E needs more focus, those subjects are lost, and need to be incorporated in the robust national spotlight.

National Standards like Common Core but specifically in applied STEM subjects.

10. I work at a K-12 institution as a Technology Engineering Teacher. I am the department head and personally work with 5th-8th graders in the classroom and facilitate learning for 9th-12th grade in various projects utilizing a wide array of high-end engineering processes, tools, and technology

"Engage Students Where Disciplines Converge questions 13-15"
Shared by (b) (6) [redacted]

13. As a teacher in the K-12 school system I am lucky enough to teach a 5th-8th grade curriculum. Formerly in the tech industry and someone who founded a Makerspace (technology workshop with co-working, adult and children's classes) I utilize engineering design, integrated STEM every single day. In the K-12 classroom I am pulling knowledge from the engineering industry through my advisory group I formed for my classroom curriculum and utilizing personal knowledge. My students all use the engineering design process for each project. A ball maze project for instance, with my 6th graders we learn how to brainstorm and be creative. We create original 3-D models utilizing rapid prototyping via 3-D printers to produce the physical good. The students utilize a lasercutter to create the top and learn about "engineering fits", which allows students to learn important engineering concepts while still completing age appropriate work. The opportunities in this single project are endless, advanced geometry, estimation and measuring while creating 3-D models. We use Algebra and basic operations while calculating fits. Materials science is utilized when thinking about polymers and how they deform and flex to one another. The technology program at my school is completely transdisciplinary.

14. The same concepts are still successful. As a flexible critical thinking technology program, we shift to meet demands, much like industry. 3-D printers can be removed remotely, files can be sent online, instruction can be pre-recorded, streamed and created in the flipped classroom model. I use a combination of Google Meet, Zoom, Nearpod to utilize concepts. It is not good enough; I reiterate my plea for a proper LMS.

15. As stated above the Technology and Engineering Education teachers need greater say in STEM. My personal college course work in an engineering major and then my Technology Education degree have given me incredible depth and breadth of knowledge. We are taught to teach all STEM concepts through project-based learning. Engineering itself can facilitate the rest of STEM, I believe pushing STEM through Science was a noble goal, however you do not have the expertise nor the manpower to facilitate the T and E of STEM without Technology / Engineering Teachers. We are experts and because of the confusion and ever-changing name of Manual Arts, Industrial Arts, Technology Education we are being lost, this can change with proper vision. In addition, outside of the K-12 system my technology industry colleagues are of great help and knowledge.

"Develop and Enrich Strategic Partnerships, question 19"

Shared by (b) (6) [redacted]

19. My makerspace company partnered with a large boys and girls club to explore a "community school" model that was based around STEM / Technology. We relied on our company's wide diverse skill set in the private industry for skill sets and to attract industry professionals to the site. We utilize the nonprofit entity for fundraising and utilized them as fiscal sponsors / partners. The ecosystem works top to bottom, we attract skilled adults in NYC to events and open workshop nights inside the boys and girls club. We concentrate people in media, finance, engineering, technology, IT and more. The paying members are involved in being in an adult learning community, which excites them. Then through word of mouth, opportunities and interest we employed some adults to teach after school programs in robotics, 3-D modeling, CNC milling and other subjects to the clubs population of afterschool students, which was proportionally made up of underserved students who would never otherwise have the chance to have such programs. We were able to be partially funded by grants, private funding as well as revenue. In addition, we created a satellite campus in upstate NY that served unemployed adults. Partnering with a chamber of commerce, workforce development we were able to certify adults in Microsoft applications. This was funded by grant money. The model has incredible potential if the right agencies could grasp the concept.

"Build Computational Literacy, question 21"

Shared by (b) (6) [redacted]

21. The youngest learners in K-5 need to be heavily skill building in typing, proper computer usage. That is the sole skill that I need them to come in with as a middle school teacher, they do not, however. In middle school we should cover cyberbullying, best practices in online safety,

combating cyber bullies etc. The biggest problems are going to be parents worrying about screen time.

"Community Use and Implementation of the Federal STEM Education Strategic Plan, question 24"

Shared by (b) (6) [redacted].

24. I am following this plan closely, in the makerspace industry by developing strong partnerships with schools, nonprofits and industry connections to give children the most robust program possible. In the K-12 sector I try this, and it is extremely hard being a public school because of archaic rules and regulations, but I do have an advisory board of coworkers / industry connections. I regularly engage children using the T and E in STEM which covers the M and S as well as ELA and science, the implementation should be flipped in this direction. And we always are looking to create 21st century learners in both industry and the K-12 classroom.

I am responding, as an individual, to the Request for Information published in the September 4, 2020 notices of the Federal Register.

My Name is [redacted] and I was a recipient of a [redacted]. Currently, [redacted] I was a member of the Chemical Engineering faculty for 46 years while my academic degrees are in Chemistry. In addition, I and a colleague established a Center for Pre-College Programs in 1979 for which I had serviced as [redacted] for 33 years. . As a retiree, I am therefore responding as an individual, based upon my experiences and expertise, which spans both the K-12 sector as well as higher education. During my tenure I was co-author of over 100 peer-reviewed papers on STEM related education areas. Two of the papers are directly related to STEM Education and are attached. I also authored a book entitled, "[redacted]", copies of which were left with staff at the October 2019 recognition event for [redacted]. This publication is attached.

My comments will focus on three of the categories, as follows:

1. Future Opportunities in STEM Education
2. Engage Students Where Disciplines Converge
3. Community use and implementation of the Federal STEM Education Strategic Plan

Future Opportunities in STEM Education

Recently, 3 colleagues and I submitted a paper for publication which deals with this category, "[redacted]". It has been accepted for publication as a chapter in a book, with the following citation:
[redacted]
The document is attached to these comments.

Technology and Internet access became major issues when education was forced to go from face-to-face classes to remote learning because of the coronavirus. And as we enter the 2020-2021 school, these remain as issues in education. Studies have found there is no one "right" way to perform distance teaching, but the remote instructional methodologies should be similar to in-class instruction, although the details of the processes may vary. But I believe that the most important challenge is one that appears to be minimized in the report as well as the category and questions within the category. That is the issue of student learning and the learning loss that has occurred and will probably continue to be lost as we go into the 2020-2021 school year. Substantial learning gaps that occurred in the Spring 2020 may grow much wider in the 2020-2021 school year as many schools are continuing with remote learning or going to some form of hybrid learning. This can lead to making the instructional tasks much harder because of a range of learning differences of the students. This is especially true of hybrid learning where the instructor is in a face-to-face class while providing instruction synchronously to remote students, also creating additional problems with assessment of student learning. In addition, it has been reported that despite the "lost learning", many schools have gone from an A to F grading type system to a pass/fail system and promoted their students to the next grade level because "they did not want to punish them for circumstances beyond their control". This issue needs to be given more serious consideration than exists in the request for comments.

It should be recognized that effective instructional practices in a face-to-face classroom is required for effective remote instruction, with some necessary adjustments due to the mode of instruction. Poor instructional practices will be poor in any delivery mode. Let us acknowledge that learning is complex, and requires both assessment and feedback practices to be effective. References to such matters in the questions and the report are barely touched upon and vague at best. Effective instructional practices require instructors to decide:

- What knowledge and skills will students be learning (criteria)?
- What experiences will be used to ensure that students learn (instruction)?
- What evidence will be gathered and used to ensure that students learn (assessment)?

Providing this teaching-learning-assessment cycle to students becomes even more critical in a virtual classroom. Successful implementation provides the pathway for the establishment of a quality remote learning experience for the students, and practical methods to approach assessment for the online learners. Adequate and effective assessments of student learning can be challenging in the face-to-face classroom, and poses additional challenges in the remote classroom, or in any hybrid version of the two modes of instruction. And the design of assessments which also provide feedback to both students and instructor are not considered in any category of the request, and vaguely considered in the Report.

Engage Students Where Disciplines Converge

Please note that my comments for this category appear also to apply to other categories. The use of the term “transdisciplinary learning” to STEM is misleading at best, and really is an incorrect application to STEM. The request for comments may include an occasional use of the term “integrate STEM”. But that gets lost in the continued use of “transdisciplinary learning” throughout the request for comments. STEM is defined as the “integration” of the four subjects. It is an interdisciplinary approach that integrates knowledge and methods from the different disciplines using a real synthesis of approaches. For example, classes in engineering would include concepts from other areas, such as science and mathematics. “Transdisciplinary” does not have that connotation. A transdisciplinary approach is meant to create a unity of intellectual frameworks beyond the disciplinary perspectives. In my many years of experience it is misused by many instructors in higher education as well as the K-12 sector.

Community use and implementation of the Federal STEM Education Strategic Plan

Based upon my years of experience in higher education as well as the K-12 sector, I found that the report was very limited in specific actions and superficial; so much so, that I believe it would be of little value to educators at all levels. The report also lacks a survey of the literature, a critical omission to establishing credibility for the report and providing important background in its preparation. The report does have a vision and goals, which was a significant. Start. But it lacks the specificity required to move forward. And for the most part, the categories and questions in the request for comments have the same weaknesses. For example, the table on page vii lists the goals for the pathways, and then provides the pathways with what are termed “objectives”. These “objectives” are in reality what might be called “sub-goals”. But they should not be considered objectives. Objectives must contain “action verbs”, which are measurable and therefore potential “outcomes” can be assessed to determine success. And the section in the report, “Use Common Metrics to Measure Progress’ (page 31) is of little use to measure progress. The report needs real objectives that can be assessed so that progress and success can be measured.

[redacted]

September 25, 2020

To whom it may concern;

I would like to comment on 12. **Increase Diversity, Equity, and Inclusion in STEM.**

I have been a STEM educator for almost a decade but before that, I was an engineer. I studied [redacted], becoming the first Black person to ever receive a Ph.D. from that department. However, I had no idea how racism played out in education until I started working with children of color in inner city schools. The middle school students that I work with in [redacted] do not have science teachers. How can that be acceptable in the 21st century? Some schools have no science classes at all and some science classes in middle and high schools are staffed by substitute teachers with no science background for the entire school year. Only 8% of Black students in [redacted] are proficient in math.

Oftentimes when I see STEM funding from the department of education, it saddens me that no funds are set aside to address inequity in education. STEM is almost like icing on the cake for students with resources. My students have no cake. What good is the best STEM curriculum when nobody is addressing the fundamental lack of basic science and math education? I would highly recommend additional resources to address the lack of science and math teachers in schools with high levels of poverty. There are is a lack of qualified teachers, but I also believe that we can incentivize investing in these schools and create alternate solutions while the pipeline is being developed to fill these positions. I also believe that part of equity in STEM education is having teachers that look like you. In fact research already supports the validity of self-efficacy in education (https://hechingerreport.org/the-educational-value-of-a-black-teacher/?). Funds need to be provided to help people of color be included in the next generation of science and math teachers.

Our organization has achieved student success on standardized tests in math along with increased interest in advanced math & science courses and increased intention to go to college with middle school students that are 97% Black and Latinx. The reason our program is successful is that our staff mirrors the student population we work with racially and we have a high level of dosage, approximately 60 hours of after school STEM programming in a typical school year. We also teach science and remedial math. This isn't a typical STEM program. We are supplementing the science and math education opportunities for the most vulnerable children in our community. The work we do is making a difference and I would like to see funding for the type of work that is being done by the STEM Greenhouse.

Sincerely,

(b) (6) [redacted]

Future Opportunities in STEM Education

Question #8

What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

At first, when schools closed for COVID-19, the STEM team worked with teachers virtually to create lessons which incorporated STEM practices. Two major barriers hampered our actions: Not all families had access to reliable internet, and we were not able to safely distribute any hands-on materials to students. With the start of this school-year, in a hybrid mode, we are able to give students hands-on materials (individually packaged since they cannot share materials at this point), create digital media which can be accessed when doing home learning, and work more with teachers in person. Reliable internet access remains an issue, but, at this time, we are able to give students hard copy materials.

Develop STEM Education Digital Resources

Question #9

What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

Vetted video clips on topics in our standards would be helpful, especially at various age-appropriate levels. Additionally, hands-on activities which do not require very specialized materials would be most helpful, with both digital resources, as well as PDFs which could be made available to students without reliable internet. Mysteryscience.com is a very useful site for elementary students. A wonderful resource for all levels is https://www.stem.org.uk/elibrary/.

Question #10

Please describe your primary audience (*e.g.*, I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.

I am an elementary STEM Coach for K-5. Stem.org.uk provides a wide range of useful materials, including video clips, digital resources for teacher background knowledge, and for using directly with students. There are whole units of lessons, as well as individual lessons, and problem-based learning lessons on a wide range of topics. Both sites noted have real-world applications which make the learning more meaningful for our students.

Build Computational Literacy

Question #23

What technologies and resources do you currently use (*e.g.*, apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

We utilize Schoology for our LMS. At the elementary level, teachers also use Seesaw and Google Classroom. We utilize a wide range of websites for resources, including Mysteryscience.com. We also use WeVideo and Screencast-o-matic to create digital media for student use. When we are in-person, and able to share materials, we use LEGo WeDo 2.0, Spheros and Mini Spheros, green screen technology, Ozobots and Finch robots. We also use the Stop-Motion app with students to show their learning.

[redacted]

Manuscript Number:	[redacted]
Full Title:	[redacted]
Abstract:	It is widely accepted that ingroup role models can inoculate students from stereotyped backgrounds (e.g. women, racial groups) against stereotype-related anxieties - helping to boost their achievement in Science, Technology, Engineering and Mathematics (STEM). Here we test two competing propositions to this effect. The stereotype inoculation model (SIM) assumes that this identity-based vaccine is mostly beneficial to anxious students prone to doubting their capacity to succeed in STEM. We compared this proposition to a newer spotlighting thesis, assuming that this type of vaccine could harm STEM-related outcomes of anxious students from stereotyped communities. Using a novel acoustic approach to measure anxiety in three field experiments, we extracted the jitter in students' vocal responses in class upon exposure to their professor during a lecture and again prior to sitting a STEM quiz. Consistent with SIM, exposure to ingroup professors calmed students' anxiety (via decreased vocal jitter) when negative ingroup stereotypes were salient, and this effect occurred only at the outset of (but not after) the class. Although ingroup professors exerted a largely positive effect on students' performance (consistent with SIM), we also found, consistent with the spotlighting thesis, that this benefit did not extend to highly-anxious women with low self-efficacy. Discussions focus on the theoretical and policy implications of these findings.
Article Type:	Article
Keywords:	Stereotype inoculation model, spotlighting thesis, stereotype threat, vocal jitter and anxiety.
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Corresponding Author's Secondary Institution:	
First Author:	(b) (6) [redacted]
Order of Authors Secondary Information:	
Manuscript Region of Origin:	[redacted]
Suggested Reviewers:	(b) (6) [redacted] (b) (6) [redacted] Prof (b) [redacted] is a renowned expert and advocate of the stereotype threat perspective. We will value his opinion greatly. Note too that our novel spotlighting thesis contrasts somewhat from his position on the efficacy of ingroup role models.

	[redacted] Professor [redacted] is a renowned social psychologist interested in identity-based social cures (e.g. of anxiety). Some of the patterns we report somewhat contrasts with his, and we expect to benefit from his insight.
	[redacted] Prof [redacted] is a student of Prof. [redacted] (the proponent of stereotype threat [ST]) and currently active in research on the topic of ST. We would appreciate his views.
	[redacted] Prof [redacted] is the key proponent of the stereotype threat perspective. His opinions/comments will be extremely useful for our paper.
Opposed Reviewers:	[redacted] Our spotlighting thesis is a competition for Prof. [redacted] stereotype inoculation model that we find some partial evidence against. We believe that the potential conflict of interest here rules her out as an impartial evaluator.
Order of Authors:	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
Manuscript Classifications:	Anxiety; Attitudes; Other (Please notify [redacted] of these); Self-Efficacy

(b) (6) [redacted]

[redacted] | (b) (6) [redacted]

23rd September 2020

Professor (b) (6) [redacted]

[redacted]

Professor (b) (6) [redacted]

[redacted]

Dear Editor:

We would be delighted if you could consider our manuscript titled [redacted] for publication in [redacted]

Briefly, our paper documents a previously unknown side-effect of using ingroup role models to enhance the classroom outcomes of students from stigmatized communities, which we term the *spotlighting effect*. We show that ingroup roles models can undermine the academic outcomes of students from stigmatized backgrounds, especially when they lack confidence in a relevant STEM subject. Our evidence also provided some support the classic finding that roles may alleviate anxiety, but under specific conditions that we outline in the paper. In particular, we show these effects using a novel acoustic approach to measure classroom anxiety, and also demonstrated the replicability of our findings. We discuss the policy implications of our findings, with a notable one being that interventions that stress the use of role models may not *always* benefit the very stigmatized individuals that such policies target. Our work is the first of its kind and situated in the context of ongoing debates around the stereotype threat phenomenon. Some potential reviewers are:

1. Prof. (b) (6) [redacted]
2. Prof. (b) (6) [redacted]
3. Prof. (b) (6) [redacted]
4. Prof. (b) (6) [redacted]

We would be delighted to share our data with reviewers should the need arise, and to deposit this also to OSF if accepted for publication.

Sincerely,

(b) (6) [redacted] (corresponding author).

Title page with All Author Information

[redacted]

[redacted]

and [redacted]

[redacted]

11,670 words

Author Note

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Correspondence concerning this article should be addressed to [redacted]

[redacted], [redacted]

[redacted]

Acknowledgments

We are grateful to [redacted] for help with proofreading an early draft of this paper. We are also grateful to the [redacted] for a grant that enabled the collection of collection in [redacted] and the [redacted].

[redacted]

[redacted]

23-09-2020

11,619 words

Abstract

It is widely accepted that ingroup role models can inoculate students from stereotyped backgrounds (e.g. women, racial groups) against stereotype-related anxieties - helping to boost their achievement in Science, Technology, Engineering and Mathematics (STEM). Here we test two competing propositions to this effect. The stereotype inoculation model (SIM) assumes that this identity-based vaccine is mostly beneficial to anxious students prone to doubting their capacity to succeed in STEM. We compared this proposition to a newer spotlighting thesis, assuming that this type of vaccine could *harm* STEM-related outcomes of anxious students from stereotyped communities. Using a novel acoustic approach to measure anxiety in three field experiments, we extracted the jitter in students' vocal responses in class upon exposure to their professor during a lecture and again prior to sitting a STEM quiz. Consistent with SIM, exposure to ingroup professors calmed students' anxiety (via decreased vocal jitter) when negative ingroup stereotypes were salient, and this effect occurred only at the outset of (but not after) the class. Although ingroup professors exerted a largely positive effect on students' performance (consistent with SIM), we also found, consistent with the spotlighting thesis, that this benefit did not extend to highly-anxious women with low self-efficacy. Discussions focus on the theoretical and policy implications of these findings.

Keywords: Stereotype inoculation model, spotlighting thesis, stereotype threat, vocal jitter and anxiety.

Educational Impact and Implications Statement

Innovation and creativity are potential benefits of (demographic) diversity, yet, as the world grapples with global challenges requiring innovative solutions, there continues to be an underrepresentation of women and minority groups in the frontline fields of science, technology, engineering and mathematics, in part due to academic under-achievement. Intervention like Athena Swan and affirmative-action policies in educational settings try to address this underachievement problem by boosting the numbers of role models with whom students from underrepresented groups share a social identity. The idea (also supported in this research) is that exposure to such role models helps to reduce stereotype-related anxieties and consequent underperformance; however, there may be an unknown side-effect of this identity-based “vaccination,” showing that ingroup role models might not always benefit the academic outcomes of those who are most vulnerable to anxiety.

[redacted]

As the world becomes more automated and connected, and healthcare demands skyrocket with aging populations, jobs in science, technology and healthcare are growing at a rapid rate all over the world. For example, the top 20 fastest growing occupations in the U.S. require training in science, technology, engineering and mathematics (STEM) (Bureau of Labor Statistics, 2019). Despite the rapid growth in these fields, not everyone will have access to these opportunities. Women and racial/ethnic minorities, while representing a sizeable portion of the population, are underrepresented in STEM fields (National Science Board, 2015). The need to understand this persistent gender and racial gap is urgent. The present paper investigates one important factor that could impact achievement in STEM for underrepresented groups: the identity match between teacher and student (e.g., being the same gender or ethnic background).

Explaining the Achievement Gap in STEM

The underrepresentation of women and other stereotyped groups within STEM fields was originally attributed to natural differences (e.g., that men's brains are better adapted for science and math relative to women's; see Stewart-Williams and Halsey, 2018, for a review). This nativist explanation has persisted across time and multiple cultures (Lippa, 2010). However, this explanation has serious flaws. First, girls in grade school excel in math and science, and often outperform boys (Halpern et al., 2007; Stoet & Geary, 2015). However, around puberty—a time of identity development—the advantage for girls begins to shrink and reverse (Hyde et al., 1990). Second, girls are not rewarded or encouraged by teachers, parents, or peers to succeed in STEM classes the same way that boys are (e.g., Lavy & Sand, 2015). Finally, cross-cultural research (Berry, 1966; Halpern, 2012; Reynolds et al., 2015) suggests that an achievement gap may result from lack of experience due to less exposure of women to tasks requiring STEM-related skills. In other words, women might underperform in STEM fields relative to men due to *social forces* that (a) discourage them from pursuing or persisting in STEM, and (b) enable fewer opportunities for them to develop the needed competencies. It is precisely for these reasons that advocacy groups are calling for conditions that empower students from stereotyped backgrounds to feel more confident about their place in STEM. One such initiative concerns boosting the number of individuals from underrepresented groups who could act as role models to students with similar backgrounds (e.g., more teachers, mentors and supervisors who are women or minorities).

Stereotype Threat and Stereotype Inoculation

The origin of the aforementioned interventions is rooted in research on the impact of stereotype-related anxieties in educational settings, otherwise known as stereotype threat (ST; see e.g., Steele & Aronson, 1995; Spencer et al., 1999). The way we socialize boys and girls can create beliefs about what women (or men) are bad or good at, causing targets of negative expectations to become anxious about confirming them in situations where those expectations are salient/relevant. Hence, students from stigmatized backgrounds might underachieve in STEM fields because stereotype confirmation (or even disconfirmation) anxieties impair their cognitive function (Ajilchi & Nejati, 2017) by diverting attentional resources away from the task at hand (Cheryan & Bodenhausen, 2000). For example, women's performance in mathematics was reliably worse-off in a condition that heightened the salience of negative stereotypes about women in math, especially for anxious participants (Delgado & Prieto, 2008). These ST effects also manifest in the context of stigmatized racial/ethnic groups (see Steele, 2010, for review). Conversely, situations that ease stereotype-related anxieties enable people from stereotyped groups to overcome ST effects, and bring performance up to the level of their counterparts from non-stigmatized groups (Spencer et al., 1999). Hence, the evidence shows that ST can (at least partly) explain the achievement gap in some STEM fields in a diverse range of stigmatized groups (Davies et al., 2002; Johnson et al., 2012; Marchand & Taasoobshirazi, 2013).

But not all the evidence supports ST. In a recent pre-registered large-scale test, for example, Flore, Mulder, and Wicherts (2018) found that Dutch high school girls underperformed in mathematics relative to boys, and an induction of ST could not explain this achievement gap. Also, recent meta-analyses on the subject of stereotype-related achievement gap in STEM suggest that the induction of ST probably only causes a small negative effect (d_{Cohen} = -.22; Flore & Wicherts, 2015; Stoet & Geary, 2012) that is practically wiped-out when testing is conducted in operational real-world scenarios where motivational inducements (such as the need to excel) are more apparent (Shewach et al., 2019; Stafford, 2018; but see Smerdon et al., 2020, for a rebuttal). What might be the cause of this weak and conflicting evidence for ST?

There are two possible explanations: First, the presumed mechanism of anxiety has mostly been measured with self-reports (e.g. in Delgado & Prieto, 2008; Flore et al., 2018). Self-reports do not always accurately assess the intended phenomenon (Davidson et al., 2020), and are sensitive to socially desirable responding. This latter point is important in light of prevailing egalitarian and feminist norms that could pressure women to minimize their negative emotions (e.g., anxiety) that could reflect poorly on their competence and question their equality with men. Thus, the present research will use non-reactive measures of anxiety (see below).

Second, evidence suggests that ST plays less a role in the achievement gap of stigmatized students when experimental tasks were administered by ingroup experimenters who could act as role models for these students (Flore et al., 2018). This is important because over a decade of research on *stereotype inoculation* shows that such "ingroup ambassadors" can act as social "vaccines" that immunize stigmatized students against the experience of anxiety that causes ST effects (Dasgupta, 2011). Thus, the present research will focus on the positive, and potentially negative, effects of an ingroup role model.

Stereotype Inoculation Model (SIM)

The stereotype inoculation model (SIM; Dasgupta, 2011) assumes that the performance of stigmatized students on STEM-related tasks is undermined by them feeling out of place in STEM classes—i.e., as *imposters* (imposter syndrome). This is especially true in situations that align with negative stereotypes about one's group (i.e., ingroup) and associated anxieties. Although the presence of an outgroup (a group that a person does not identify with: e.g., men) can accentuate evaluative anxieties (Vorauer et al., 2000), such concerns are less severe in the presence of fellow ingroup members (e.g., women). Hence, the anxiety over being negatively judged should be weaker when people are with an ingroup rather than with an outgroup audience (Hopkins et al., 2007; Owuamalam & Rubin, 2014). Ingroup role models (e.g., female STEM professors) directly challenge negative stereotypes that underrepresented students do not have what it takes to succeed in the field, which can boost students' subject-specific confidence/efficacy (Stout, Dasgupta, Hunsinger, & McManus, 2011). According to SIM, anxious students from stereotyped backgrounds who feel out of place in STEM are especially likely to benefit from the buffering effect of ingroup role models because the latter can calm anxiety and improve STEM-related outcomes by allowing these students to devote attentional/cognitive resources to the task at hand (Dasgupta et al., 2015) (henceforth the *inoculation thesis*; Dasgupta, 2011).

Numerous studies have confirmed the positive impact of ingroup role models in boosting women's subject-specific efficacy (Stout et al., 2011) and actual performance in mathematics (Marx & Roman, 2002). This could account for inconsistent effects of stereotype induction in ST research. For example, the ST induction in Flore et al.'s investigation of gender and ST (Flore et al., 2018), could have been diluted by the stereotype-disconfirming presence of an expert ingroup member (a female experimenter), which could have eliminated stereotype-related anxiety that is theorized to underlie ST effects.

The Spotlighting Thesis in STEM Contexts

Despite the promising effects of ingroup role models, they could create a different type of stress for some students. Exposing anxious women to ingroup role models could actually *undermine* their performance (Flore et al., 2018) instead of *inoculate* them against anxiety (Dasgupta, 2011). The notion that ingroup role models could *worsen* STEM-related outcomes of anxious women might be rooted in several processes. For example, studies have shown that people are especially mindful of the opinions of those they care about (e.g., ingroup members) and are dismissive of the opinions of those they do not care so much about (e.g. outsiders, Hornsey et al., 2002). Thus, a female teacher's evaluations might be particularly important (and thus anxiety producing too) to girls compared to boys, especially if those girls have a lower sense of self-efficacy to begin with. Furthermore, a female role model also removes the excuse that "STEM isn't for women," which could generate additional demands for girls to excel in the domain. Anxious women may feel especially *spotlighted* in this context.

Spotlighting has been used elsewhere in the literature to refer to behaviors that "single out women by gender in ways that make them feel uncomfortable" (McLaughlin, 2005). This research has focused on behaviors perceived as overtly or tacitly sexist, or those that are presumptive and demeaning (e.g., unsolicited help in STEM based solely on gender), and often emanating from the outgroup. In the present research, we propose a different form of spotlighting originating from within one's own group, which can negatively impact female students' outcomes in STEM: The pressure that exposure to a female role model might put on female students to (likewise) excel in STEM. Without such a role model, there is attributional ambiguity that could shield women's self-esteem from harm in the event of underperformance. That is, when women are exposed to (or are being evaluated by) a male professor, underachievement in STEM could be attributed to structural barriers like sexism, lack of motivation/interest, or lack of aptitude/experience and so on (Stewart-Williams & Halsey, 2018). However, in the presence of a woman who is successful in STEM, attributing the cause of potential failure in STEM to bias and/or sexism may be hard to do because an ingroup role model provides a glaring example that women can overcome these barriers. To the extent that externally directed attributions for potential set-backs in STEM become limited, the search for excuses for potential failure could deplete cognitive resources and increase the burden of having to prove one's self in this type of situation, particularly for those women who are less confident in the subject, and/or are anxious about their place in STEM. In short, according to our *spotlighting thesis*, highly anxious women should achieve *worse* (not better) STEM outcomes, and should be even more motivated to *search for excuses* for this underachievement when exposed to ingroup role models (contrary to SIM's inoculation thesis, Dasgupta, 2011). We are not aware of any study that has investigated this potential side effect of a social identity-based vaccination using ingroup role models.

The Present Research

The present research examines the positive and potentially negative impacts of an ingroup (vs. outgroup) role model on STEM performance in women and racial groups as a function of ST and anxiety. In this research, we use a novel measure of anxiety that has been used in linguistic research—vocal jitters. Humans engage nearly a hundred muscles when speaking, whose movements are often sensitive to the emotions that people are feeling (Planalp, 1996). Emotions may affect short-term fundamental frequency fluctuations of voice (i.e. vocal jitter), caused by poor laryngeal musculature in response to emotional stress (Ozdas et al., 2004; Titze, 1994). Research has shown that elevated levels of jitter in speech denote higher levels of anxiety (Fuller et al., 1992), which is why vocal cues (e.g., jitters) are the most common direct means of determining others' emotional state (Planalp, 1996). Hence, we capitalized on vocal jitter as an involuntary index of anxiety in order to provide a less biased and conclusive test of ST effects on anxiety and performance (unlike self-reported measurements that can be consciously/deliberately distorted).

In this research, we pit the two competing theses against each other: SIM's *inoculation thesis* and our alternative *spotlighting thesis*. Specifically, the inoculation thesis would predict that the jitter in students' voices should be accentuated when negative ingroup stereotypes are salient versus non-salient (stereotype salience hypothesis), especially in classes that are taught by outgroup (but not ingroup) professors (salience x identity interaction). This jitter (anxiety) should predict manifest increases in performance errors (the anxiety-performance hypothesis). We expect that overall, students will perform better on a STEM test with an ingroup teacher compared to an outgroup teacher (inoculation hypothesis for performance). However, for anxious students with low subject efficacy (compared to less anxious or more confident students), those who are exposed to an ingroup but not to an outgroup professor should show increased performance errors (the spotlighting hypothesis) rather than reduced performance errors (as per the inoculation thesis). We conducted three field experiments to examine the inoculation hypothesis and test a new process (spotlighting) that could undermine inoculation processes under certain situations.

This research will also address empirical holes in ST research by specifically manipulating some of the variables that have been previously conflated with ST (professor's group membership) as well as other measures that could introduce stereotype-irrelevant sources of anxiety that should be teased out: formality of the professor; and timing of the measurements (at the start of class vs. before an assessment). Regarding formality, research using the classic Trier Social Stress Test has shown that placing individuals in formal settings where they are likely to be evaluated (such as classrooms) is a robust predictor of stress and anxiety (Kirschbaum et al., 1993). Factors that increase anxiety could combine with stereotype-related anxiety, thus making the unique effects of stereotype-driven anxiety difficult to discern. Thus, the present research will control for professor's formality by manipulating it along with our key ST variables. Regarding timing, we aimed to isolate stereotype-induced anxiety from anxiety caused by academic evaluation expectancy (i.e. 'exam fever'). We expect that only anxieties tied to stereotype induction should undermine women's performance (based on ST/SIM). For this reason, we measured participants' anxiety at the onset of class when impression management concerns should heighten the pressure to disconfirm stereotypes, and after class but prior to taking a STEM test when impression management stress should be low but exam anxiety should be high.

Study 1

Study 1 sought to verify key assumptions of ST via the salience of negative ingroup stereotypes—namely intellectual inferiority and incompetence (see Hauser et al., 2018). We aimed to decouple its effect on anxiety from another potential source of classroom anxiety:

perceived formality of the professor. Also, it has been suggested that the intersection of gender identity with other social identities (e.g. race) may play a role in shaping non-White women's academic outcomes, but this notion has not yet been empirically tested (Jaxon et al., 2019) until now. Specifically, Southeast Asian women were exposed either to a White or to a Southeast Asian male professor to establish whether the salience of "incompetent" stereotypes[1] induces threat/anxiety depending on the ethnic background of the professor (the inoculation hypothesis).

Method

Participants, design and procedure. One hundred and thirty-eight women enrolled in the foundation in science program at a university in [redacted] took part in this field (classroom) experiment (M_{age} = 18.87, SD_{age} = 0.60). They were randomly assigned to different conditions of a stereotype salience manipulation (salient vs. non-salient); professor formality conditioning (formal-acting vs. non-formal-acting) and professor identity treatment (ingroup vs. outgroup).

The primary dependent measure was vocal jitter, which we used as a direct behavioral/physiological index of anxiety. Vocal jitters (in percentage) were extracted with Praat version 6 (Boersma, 2001) from brief recordings of students' response to the question, "How much do you anticipate enjoying this workshop?[2]" They were asked this question at the outset of the class, when the convening professor was about to begin the class. Recordings were made at the recommended optimal distance for speech sound capture of 1ft (Titze, 1994), using an Olympus digital voice recorder (VN-6800PC, set at HQ recording mode with a sampling

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[1] Southeast Asians are often stereotyped negatively in academic domains, and are often associated with poverty and underachievement compared to their East Asian counterparts (Ngo, 2006; Reyes, 2017)

[2] This question was framed to mirror items commonly used to tap subject aspirations in the stereotype inoculation literature (e.g. "How likely are you to pursue a professional job in engineering"; Dasgupta et al., 2015, supplementary information p.1).

frequency of 44.1kHz/32kbps). We took this early recording because it was a period in the session that an impression management concern (i.e., stereotype disconfirmation anxiety) with regards to meeting their new professor would be most apparent.

After a session on chemistry that lasted about 30 minutes, we also extracted the vocal jitter in a subsequent recording of students' response to the question, "How much did you enjoy this workshop?" We did so to test whether our ST induction continued to influence students' anxiety beyond the initial meeting with their new professor when impression-management pressures should have eased somewhat. This was to provide an initial gauge for us to determine whether the distinction that we seek to make with regards to stereotype-relevant anxiety vs. exam fever (following Fuller et al.'s 1992 example), was even possible using this novel approach. That is, stereotype-related impression management concerns should be rife at the onset of the class but should be less influential after such initial encounters.

Professor identity. We manipulated this variable by presenting our female students with two professors of roughly similar years of teaching experience (> 5years). Half the students were exposed to a White male professor (outgroup condition, n = 74), and the other half were exposed to an Asian male professor (ingroup condition, n = 64). Hence, the gender identity of the professor was constant, with racial identity being the distinguishing factor across the two conditions. The key inoculating ingredient in SIM is a "shared social identity" and this was met by exposing Asian women to a male professor who shared a racial identity in common with them (versus a male professor who did not). Hence, in this context, an inoculative benefit should manifest for Asian women in the Asian male professor condition. Importantly, the lecture notes across the two professor identity conditions were the same, so that resulting effects cannot be easily attributed to lecture quality.

Stereotype salience. Prior to the class starting, half the students were either exposed to incompetence-related stereotypes on the computer screen that was mounted on each desk in the lab (i.e. salient stereotype condition, $n = 72$). In a non-salient stereotype condition, another half were exposed to pictures of beautiful scenery ($n = 66$). In the salient stereotype condition, two incompetence stereotypes (“incapable” and “dumb”) were presented on-screen via a desktop assigned to each participant, along with other stereotypes often attributed to women (“shy”; “timid”; and “fearful”). We used this approach rather than the typical ST induction that focuses on fabricated stories of gender difference in test performance (Steele & Aronson, 1995) for three reasons: (a) different operationalizations of a construct should yield the same results, especially in light of (b) skepticisms over the efficacy of the performance-related induction of ST in recent times (Sackett et al., 2004), and (c) to focus on the impact of negative stereotypes on anxiety, the exact mechanism proposed in ST theory. Prior research using information about test performance of women may not be triggering anxiety associated with a stereotype but a different source of anxiety (e.g., test anxiety). Our manipulation avoids this problem.

Afterward, participants were presented with a word-fragment completion task (e.g., t_m_d; d_m_ etc.) designed to check the salience of the intended stereotypes across the two conditions. The five word-fragments could be completed with other words that were unrelated to the stereotypes that participants in the salient stereotype condition were exposed to (e.g., t**i**m**i**d/t**a**m**e**d). Hence, a stereotype was salient if the word-fragment completions corresponded to the stereotypes that participants in the salient condition viewed.

Classroom formality and other controls. We had reasoned that the professors’ *formality* could contribute to feelings of anxiety in a classroom (Kirschbaum et al., 1993). To control for this possibility, we manipulated the perceived formality of the professor’s behavior in the classroom, using an adaptation of a procedure developed by Chesebro (2002). Specifically, half our participating students were exposed to a professor that acted formal: he wore a formal-looking buttoned-up shirt with a tie and properly rolled down sleeves. He started the class with a set of rules and instructions that must be adhered to (*n* = 78). The other half (*n* = 60) were exposed to a professor who was non-formal-acting: he wore a casual shirt with rolled up sleeves, and started the class with some humor. We reasoned that a formal-acting professor should elicit more teacher-related anxiety amongst students relative to a less formal-acting one. We assessed the validity of this assumption using an 8-item ad-hoc measure of professor-related class anxiety: "we are afraid of this lecturer"; "this lecturer's standards are very high"; "this lecturer can take a joke" (reverse scored); "this lecturer is strict"; "this lecturer has a sense of humor" (reverse scored); "this lecturer's class is pleasant" (reverse scored): "this lecturer is friendly" (reverse scored); "we have to be silent in this lecturer's class" (1 = *strongly disagree*, 7 = *strongly agree*; Cronbach's α = .73).

Second, social interactions tend to be rife with interpersonal/group anxieties (Shelton et al., 2006; Stephan, 2014). One argument against the use of vocal jitter as an index of anxiety, therefore, might be that participants' vocal fluctuations could actually result from mimicking the vocal modulations of the teaching assistant (TA) posing the question that students responded to. This is especially true given past evidence of emotional contagion (Hatfield et al., 1993) and mimicry of vocal properties (Eriksson & Wretling, 1997; Rueff-Lopes et al., 2015). To counter this argument, we extracted the vocal jitter from the TA and factored it into our models as a covariate, so that its effects are statistically held constant across participants/conditions.

Results and Discussion

Manipulation checks. Concerning *stereotype salience*, results from an independent *t*-test confirmed that stereotype-relevant word-fragment completions were significantly higher in the salient than in the non-salient condition (see Table 1). In relation to *professor-related anxiety*, results from an independent *t*-test revealed that self-reported teacher-related anxiety was significantly greater for those students exposed to a formal-acting than a non-formal-acting professor (see Table 1). Lastly, onset vocal jitter was positively correlated with after class vocal jitter (r = .33, p < .001), suggesting that both measurements tap a similar underlying process.

Testing SIM's version of ST. *Students' vocal jitter at the beginning of class***.** Full ANOVA model results are presented in Table 2 and show a main effect of stereotype salience on anxiety (% vocal jitter). Consistent with the ST perspective, vocal jitter was significantly higher when negative stereotypes were salient ($M \pm SE$: 5.50 ± .19) compared to when they were non-salient (4.47 ± .18). Consistent with the salience x identity interaction prediction, salience was qualified by professor identity (see Table 2). Stereotype-induced accentuation of vocal jitter was apparent only when female students were exposed to an outgroup White male professor, F(1, 131) = 31.53, p < .001, $\eta_p^2 =$ .16, but not an ingroup Asian male professor, F(1, 131) = 0.02, p = .886, η_p^2 < .001 (see Figure 1a). The main effect of professor formality (4.63 ± .20 vs. 5.53 ± .22, formal vs. non-formal respectively, p < .001) was also contingent upon the professor's social identity (see Table 2). Interestingly we found, against expectation, that this interaction occurred because students' vocal jitter was reliably more elevated when the professor was less rather than more formal acting, but this occurred only when the professor was an outgroup member, F(1, 131) = 20.16, p < .001, η_p^2 = .133. This effect was absent when the professor was an ingroup member, F(1, 131) = 0.01, p = .909, η_p^2 < .001. Although this is contrary to our formality prediction, it is consistent with the inoculation hypothesis that ingroup role models reduce anxiety.

None of these results changed meaningfully: (a) in a subsequent bootstrap simulation with 20,000 resamples of the raw data that somewhat helps to address the issue of sample adequacy and statistical power (Table 2, Model 2; Preacher & Hayes, 2004); (b) when we controlled for the potential effect of emotional contagion from the TA's vocal modulations (Table 2, Model 3); or (c) when we accounted for students' self-reported experience of teacher-related anxiety (Table 2, Model 4).

Students' vocal jitter at the end of class. Results revealed neither a main nor an interactive effect of stereotype salience, perceived professor's formality, or professor identity on vocal jitter after class (ps > .100). Hence, our treatments did not exert an influence on students' anxiety beyond the onset of class.

Summary of key findings. Study 1 revealed four things: (a) stereotype salience does increase anxiety amongst female students (stereotype salience hypothesis), but only (b) when they were exposed to an outgroup (not an ingroup) professor (salience x identity interaction). (c) This effect on anxiety appears to be momentary and did not extend beyond the immediate encounter between the students and their new professor. Finally, (d) we showed that although a professor's formality could also be a source of anxiety in the classroom (formality hypothesis), that a stereotype-related anxiety was still visible even after decoupling other relevant sources of anxiety within the classroom. Thus, we established in this initial study that stereotypes produce unique effects on a novel measure of anxiety (vocal jitter) for women, especially in the context of outgroup but not ingroup professors. This pattern supports the inoculation thesis.

The question that we then tried to address in the subsequent study was whether anxieties that are induced by the current treatments also exert a measurable influence on students' test performance (anxiety-performance hypothesis). Seeing that vocal jitter at onset of (but not after) class captured stereotype-induced anxieties, we reasoned that after class vocal jitter could indicate 'exam fever' if students were told to expect a quiz after the class. In the next study, therefore, students were told that there would be a quiz after the class, and we then took vocal jitter measurements prior to this exercise. Our goal was to compare the link that onset and after-class vocal jitter (anxiety) have with students' actual performance when exposed to either an ingroup vs. an outgroup professor.

Study 2

Method

Participants, materials and procedure. The experimental protocol was identical to the one that we described in Study 1, only this time, participants (N = 163, M_{age} = 18.83, SD_{age} = 0.65) completed a multiple-choice quiz (MCQ) on biology after the class, while being exposed to an ingroup vs. an outgroup professor who delivered a biology lecture. There were two notable adjustments. First, because the current cohort contained only a modest number of women (n = 119), we augmented our sample size with the inclusion of men (n = 44) and focused on race (rather than gender). The stereotype that Southeast Asians are less competent (Ngo, 2006; Reyes, 2017) also applies here due to the colonial history of the Asian nation [redacted], in which Western (British) tertiary education is held in higher esteem than the local alternative (see also Owuamalam & Matos, 2019). Second, we tried to mirror the heterogeneity of outgroup professors in the current institution (and indeed in the real-world), by exposing our Asian students to two British educated professors who were visibly different in terms of race: One was

White and the other was Black[3]. Meanwhile, the Asian professor was educated locally. Based on a careful reading of SIM, we predicted that the specific racial identity of the outgroup professor should be irrelevant to a test of the inoculative benefits of ingroup role models.

What matters, however, is the extent to which students from stereotyped backgrounds are vulnerable to imposter feelings. According to Dasgupta (2011), those who suffer from an imposter syndrome tend to "be *unsure of their ability, be anxious*, and have low expectations of repeated future success compared to others who do not feel like imposters" (p. 232, our emphasis). We therefore relied on this operational definition of the imposter syndrome to obtain participants' self-reported efficacy in biology prior to the class, using a 15-item scale that we adapted from Miller et al. (1996) and Pintrich and De Groot (1990): E.g. "I don't think I will be successful in biology" [reverse scored]; "I am confident I can do well in biology"; 1 = *strongly disagree*, 5 = *strongly agree*, Cronbach's $\alpha = .85$). SIM's inoculation thesis would predict that students with low scores on this scale, and elevated vocal jitter (i.e. highly anxious) would perform better when exposed to an ingroup professor; however, according to the spotlighting thesis, they might perform worse.

We chose 10 multiple choice items from a 30-item list that we piloted in order to gauge their level of difficulty and to ensure as much variation as possible across students (see SI 1 for a list of items on this MCQ, and a description of our standardization protocol). ST is theorized as

[3] In both the White and Black professor conditions, the effect of salient stereotypes was similar in direction for onset vocal jitter (White professor: 3.53 ± .14 vs. 3.21 ± .17; Black professor: 3.88 ± .22 vs. 2.91 ± .26 salient vs. nonsalient conditions respectively) and after class jitter (White professor: 3.44 ± .16 vs. 3.17 ± .20; Black professor: 3.50 ± .20 vs. 3.07 ± .25, salient vs. nonsalient conditions). Meanwhile the effect was in the reverse direction in the ingroup professor condition for both onset (3.07 ± .26 vs. 3.67 ± .19, salient vs. nonsalient) and after class (3.19 ± .26 vs. 3.61 ± .20, salient vs. nonsalient conditions) vocal jitter. In short, students' reactions to both outgroup professors were identical. This informed our decision to collapse the two outgroup conditions.

impairing cognitive function via the experience of anxiety because it diverts cognitive resources away from cognitive tasks. Questions that were not attempted tell little about 'cognitive disruption' in the manner that answered (but incorrect) questions do. Unfinished questions could be due to time constraint imposed on the quiz (of 11 seconds per question) and not a cognitive impairment *per se*. Hence, we focused only on the number of incorrect answers as our index of performance impairment.

Participants completed the same manipulation checks for stereotype salience (i.e., word fragments) as in Study 1. They also completed the same teacher-related anxiety measure in Study 1, to verify the assumptions that we made about the anxiety-eliciting potency of our professor formality manipulation (Cronbach's α = .80). As before, vocal jitter was extracted from participants' voice prior to lecture starting (onset jitter) and again after class (after-class jitter). An equipment failure occurred during the after-class recording of students' vocal responses in the Black professor condition, and although the TA improvised with a different mobile device (a Blackberry Bold 9780), we could not guarantee that the acoustic measurements were the same. Consequently, the after-class recordings in the Black professor condition were discarded. This meant that we could only use, for our analysis, the after-class vocal jitter measurements from the White vs. Asian professor conditions with regards to test performance.

A final consideration with regards to the diverging predictions of SIM's inoculation and spotlighting theses was whether the anticipated effects would extend beyond the immediate classroom situation (i.e. how long the effects would persist). Therefore, we repeated the same MCQ test four weeks later (with no further exposure to the experimental treatments) to unpack these issues on an exploratory (theory-development) basis.

Results and Discussion

Assumption/manipulation checks. With regards to the *stereotype salience* manipulation, results confirmed that stereotype relevant word-fragment completions were significantly higher in the salient than in the non-salient condition (see Table 1). Regarding teacher-related anxiety, results showed that self-reported anxiety was significantly greater for those students exposed to a formal-acting professor compared to a less formal-acting professor (see Table 1). Finally, as in Study 1, onset vocal jitter was also positively correlated with after class vocal jitter (r = .41, p < .001).

Anxiety: Testing SIM's version of ST. We repeated the same ANOVA in Study 1 to address the question of how the experimental treatments affected students' actual experience of anxiety via their vocal modulations. Once again, we examined the impact of the experimental treatments on vocal jitter at the onset of class and then after class (prior to the quiz).

Anxiety at onset of class (stereotype-relevant). Model results are presented in Table 2, showing a non-significant main effect of stereotype salience. However, in line with SIM's salience x identity thesis (Dasgupta, 2011), the null effect of stereotype salience was qualified by professor identity (see Table 2, and Figure 1b). Simple effect analysis revealed that, in the outgroup professor condition (i.e. when exposed to British professors), vocal jitter was significantly higher when stereotypes were salient (3.71 ± .14) compared to when they were non-salient (3.13 ± .16), $F(1, 152) = 7.33$, $p = .008$, $\eta_p^2 = .05$. However, stereotype salience did not have a reliable effect on vocal jitters in the ingroup professor condition, $F(1, 152) = 3.59$, $p = .061$, $\eta_p^2 = .04$ (see Figure 1b). Hence, we replicate the patterns in Study 1, by showing that the presence of ingroup role models can inoculate students from stereotyped backgrounds against the effects of stereotype salience (Flore et al., 2018). The main effect of professor formality was not significant, (3.38 ± .13 vs. 3.40 ± .14, formal vs. non-formal conditions respectively) nor was its interaction with professor identity (see Table 2). Once again, none of these results changed meaningfully: (a) in a subsequent bootstrap simulation with 20,000 resamples of the raw data (see Table 2, Model 2); (b) when we controlled for the potential effect of emotional contagion from the TA's vocal jitter (see Table 2, Model 3); or (c) when we accounted for participants' self-reported experience of teacher-related anxiety (Model 4).

Anxiety after class but prior to quiz (exam fever). Consistent with the inoculation thesis, results revealed a stereotype salience x professor identity interaction, $F(1, 152) = 5.11$, $p = .026$, $\eta_p^2 = .05$, which occurred because exposure to ingroup role models significantly *reduced* anxiety (vocal jitter) when stereotypes were salient (3.05 ± .19) compared to when they were non-salient (3.55 ± .16, $p = .049$). This effect was not statistically reliable in the outgroup professor conditions ($p = .238$). No other effect reached statistical significance (*p*s > .30). Hence, like Study 1, our outgroup condition did not influence students' anxiety beyond the onset of class when impression management concerns should be highest. However, for those exposed to an ingroup professor, students had the lowest anxiety (jitters) in the stereotype salient vs. not salient condition, suggesting some continued immunity that an ingroup professor provided with regards to anxiety going into the exam.

Quiz performance errors: Testing SIM's inoculation thesis vs. the spotlighting thesis. To resolve the theoretical disagreement between SIM's inoculation thesis and the spotlighting thesis, we performed a moderated regression in which either of the two behavioral anxiety measures (mean centered) were specified as focal predictors of test performance, while professor identity (effect coded: with outgroup as reference) and efficacy in biology (mean centered) were moderators. Number of incorrect answers was the outcome. That is, we investigated whether students' high and low subject efficacy impacted their quiz performance as a function of anxiety (vocal jitter) when they were taught by an ingroup vs. outgroup professor, using a moderated regression approach, with 20,000 bootstrap samples of the raw data.

With regards to after-class anxiety, we found, consistent with SIM's inoculation hypothesis, a main effect of professor identity, $b = -1.35$, $se = .40$, $p = .001$: The number of incorrect answers were lower when students were taught by an ingroup (2.25 ± .28) than by an outgroup (3.60 ± .28) professor. Also, consistent with previous findings (Flore et al., 2018), increases in vocal jitter (anxiety) were associated with increases in number of incorrect answers, $b = .54$, $se = .26$, $p = .040$.

Importantly, the vocal jitter x biology efficacy x professor identity interaction approached statistical significance, $b = -1.79$, $se = 1.02$, $p = .083$ (see Figure 2). A breakdown of this interaction showed that a vocal jitter x self-efficacy in biology interaction occurred only when the professor was ingroup, $b = -1.43$, $se = .65$, $p = .031$, but not outgroup, $b = .36$, $se = .79$, $p = .649$. Consistent with the spotlighting thesis, we found that when self-efficacy in biology was low (M-1SD; i.e. high imposter feelings), the number of incorrect answers was higher for those students who were more (M+1SD) rather than less (M-1SD) anxious, $b = .84$, $se = .35$, $p = .019$, while this trend was absent when self-efficacy in biology was high (M+1SD), $b = -.44$, $se = .49$, $p = .896$. There was neither a main effect of onset vocal jitter on test performance nor did professor identity and self-efficacy in biology qualify this null effect (ps > .05).

Longitudinal follow-up. Students' test scores (four weeks after the initial one) were subjected to the same moderated regression as before, with after class vocal jitter, professor identity and self-efficacy in biology (and their interaction terms) as predictors. Result from this analysis revealed only a main effect of professor identity, $b = -.94$, $se = .35$, $p = .009$. Consistent with SIM's inoculation thesis, the number of incorrect answers were significantly lower amongst students who were taught by an ingroup professor (4.66 ± .26) compared to those who were taught by an outgroup professor (5.60 ± .24). All other main and interactive effects did not approach statistical significance (*p*s > .25). Results were the same when ‘after class vocal jitter’ was substituted in the model with ‘onset vocal jitter’ (*p*s > .15), with the exception of professor identity being the only reliable predictor ($p = .031$). Hence, the predicted spotlighting effect seems to be time-sensitive, occurring only following the spotlighting event, while the beneficial effects of ingroup role models endured over a 4-week period irrespective of the students’ initial imposter feelings at Time 1.

Summary of key findings. Study 2 replicated the main findings from Study 1 in that stereotype salience was related to higher levels of anxiety when exposed to outgroup professors compared to ingroup professors. Furthermore, Study 2 revealed: (a) that ingroup role models can cause a reduction in the number of incorrect answers provided by Asian students on a biology quiz and, for the first time, demonstrated the longitudinal potency of this social identity vaccine. That is, retention rate was significantly improved when students were taught by a professor who shared a social identity with them. Results also showed (b) that situations that accentuate the potential for spotlighting can thwart the positive effect of this identity-based vaccine, especially for those vulnerable students likely experiencing an imposter syndrome. This latter finding is remarkable because, until now, such students are the ones theorized to be especially likely to benefit from the inoculative effects of ingroup role models (Dasgupta, 2011). So, although the current evidence is largely consistent with the idea that ingroup role models do provide immunity against stereotype threat, it also corroborates the spotlighting thesis when it comes to stereotyped students likely experiencing an imposter syndrome.

It is important to note, however, that it was not the anxiety at the onset of class (when concerns about ingroup stereotypes were more relevant) that significantly impaired students' test scores, but the corresponding feeling prior to the exam. Hence, like Flore et al. (2018), students' test performance errors here were not easily attributable to the salience of negative ingroup stereotypes (and the anxiety that follow it). However, it may be too early to discard the idea that situational salience of stereotypes undermines students' STEM performance based on the outcome of a single study. Therefore, we conducted a replication in the gender context where STEM stereotypes are more visible, and, for the sake of a closer comparison with Flore et al.'s (2018) data, we decided to collect this evidence in the Netherlands.

The issue of replication is crucial because one of the problems raised in previous discussions of the mixed evidence in ST-related research is that field studies (such as the approach we have adopted) are often poorly powered (Flore et al., 2018). Although the empirical (bootstrap) simulations that we have used in our analysis of the data so far helps to address this problem (Preacher & Hayes, 2004), it is important to bear in mind that researchers often have limited flexibility with regards to the size of the classrooms that they are able to sample, and large *N*'s are difficult (though not impossible) to achieve in field studies (see also Lakens, 2020 feasibility argument). This is why replications are critical in this context, especially when this is spread over different cohorts of students, so that the stability vs. fragility of the relevant effects can be determined as the evidence accumulates.

Study 3

It is entirely possible to argue that Study 2 provided a narrow test of the inoculation thesis given its focus on test performance alone, especially when previous studies have shown that an identity-based vaccine is most potent in its effect on students' subsequent confidence in a relevant STEM subject (see Dasgupta et al., 2015; Stout et al., 2011). Therefore, Study 3 included a measure of post-lecture confidence in mathematics, to examine anxious female students' efficacy in mathematics following exposure to a female (ingroup) vs. male (outgroup) professor.

A second consideration, this time with regards to the spotlighting thesis, is that we have yet to demonstrate that students are, to a greater extent, motivated to search for excuses for (potential) failure when they have been exposed to ingroup role models. Here, we anticipated that students will endorse attributions that preserve self-esteem and control (internal, controllable, unstable attributions) vs. those that imply forces beyond their control (external, uncontrollable, stable attributions) (Reyna, 2008). Based on the spotlighting thesis, we reasoned that self-preserving attributions will increase when anxious students are exposed to an ingroup role model.

Method

Participants, materials and procedure. Again, the experimental protocol here largely mirrored the approach that we described in Study 2 including: the salient stereotype, professor identity, and formality manipulations, as well as the corresponding manipulation checks (for salient stereotypes: "unintelligent"; "illogical"; "bad at math"; "inconsistent"; and for formality induction using the same teacher-related anxiety that we described in Studies 1-2, Cronbach's α = .87). There were a few alterations. This time, participants were all female (N = 113, M_{age} = 19.76, SD_{age} = 2.05) to maintain a more direct focus on the gender gap in STEM. Rather than a live classroom (as in Studies 1 and 2), first-year psychology students at a Dutch university were exposed to a 10-minute pre-recorded lecture on introductory statistics (ANOVA), that was taught by a male versus female Dutch professor with identical lecture notes. Prior to this lecture, participants completed the same 15-item subject-specific efficacy measure described in Study 2, modified to reflect the current focus on mathematics (e.g., “I am confident I can do well in mathematics.”; 1 = *strongly disagree*, 5 = *strongly agree*, Cronbach’s α = .94). After the lecture, we again administered the same 15-item measure of math efficacy, to examine the effect of our identity-based vaccine on students’ post lecture *confidence in math* (α = .94).

Students were tested in groups of 12-17 students. They were welcomed by a TA who seated them in a lecture room so that they could view a projection screen. The TA in each session (one male, one female master’s student) was matched with the gender identity of the professor that students were exposed to, in order to eliminate the potential for cross-contamination of gender effects. TAs also matched the professor with regards to the perceived formality manipulation, so that in the formal-acting professor condition, they dressed formally and conducted themselves with utmost professionalism, while in the non-formal-acting condition, they wore casual attire and were less formal with the students. As before, recordings of students’ voices were collected at the onset of lecture (having exposed them to a short biography and image of the professor displayed on-screen, see Figure 3) and after the class, but prior to the quiz that followed. As in Study 1, vocal jitter from these recordings were extracted as our index of anxiety, and students completed a 10-item MCQ test after class that underwent a similar calibration for test difficulty that we described in Study 2. MCQ performance impairment scoring was identical to the approach described in Study 2, with the focus being on incorrect answers.

Lastly, we measured excuses for potential failure after the quiz using an attribution scale from the classic stereotype threat literature (Steele & Aronson, 1995). One item asked about factors within their control (“how much stress have you been under lately”) and, two items asked about factors beyond their control (e.g., at the test: "how tricky did you find the test"; and "how unfair did you find the test" r = .42, p < .001). Responses were obtained on a 7-point scale (1 = *not at all stressed*/*tricky*/*unfair*, 7 = *very stressed*/*tricky*/*unfair*).

Results and Discussion

Assumption/manipulation checks. We replicated the pattern of results with regards to *stereotype salience*, confirming that stereotype-relevant word-fragment completions were significantly higher in the salient than in the non-salient condition (see Table 1). We also replicated results from Studies 1 and 2 with regards to *teacher-related anxiety*: showing significantly greater anxiety for those students exposed to a formal-acting vs. a non-formal-acting professor (see Table 1). Once again, onset vocal jitter was positively but marginally correlated with after class vocal jitter (r = .17, p = .066).

Anxiety: Testing SIM's version of ST. As in Study 2, our test was conducted in two stages. First, we examined the impact of the experimental treatments on vocal jitter at onset of class and then after class.

Anxiety at onset of class (stereotype-relevant). The results show a nonsignificant main effect of stereotype salience (contra ST). Importantly, and in line with SIM's inoculation hypothesis, an effect of stereotype salience was contingent upon the professor's identity (see Table 2; cf. Flore et al., 2018), so that a stereotype-induced accentuation of vocal jitter was apparent only when our participating female students were exposed to an outgroup (male) professor, $F(1, 107) = 3.94$, $p = .050$, $\eta_p^2 = .04$, but not to an ingroup (female) professor, $F(1, 107) = 1.35$, $p = .248$, $\eta_p^2 = .01$ (see Figure 1c).

The main effect of professor's formality on vocal jitter was consistent with expectation this time (2.59 ± .10 vs. 2.17 ± .10, respectively for formal-acting vs. non-formal-acting professor conditions, see Table 2), but was qualified by professor identity (see Table 3). A breakdown of this interaction revealed that an accentuation of vocal jitter in the formal-acting (relative to the non-formal-acting) professor condition was limited to the outgroup professor condition (3.00 ± .14 vs. 2.27 ± .14, $p < .001$, $\eta_p^2 = .11$), and did not manifest in the ingroup professor condition (2.18 ± .14 vs. 2.07 ± .15, $p = .609$, $\eta_p^2 = .002$). Hence, once again a social identity vaccine (ingroup role model) provides immunity against anxiety even in the context of a professor's formality.

Again, replicating the trends from the previous studies, none of these results changed meaningfully: (a) in a subsequent bootstrap simulation with 20,000 resamples of the raw data (see Table 2, Model 2); (b) when we controlled for the potential effect of emotional contagion from the TAs' vocal jitter (see Table 2, Model 3); or (c) when we accounted for students' self-reported experience of teacher-related anxiety (Table 2, Model 4).

Anxiety after class, but prior to quiz (exam fever). Results revealed neither a main nor interactive effect of stereotype salience, perceived professor formality and professor identity (*p*s > .10). Hence, our treatments did not exert an influence on students' anxiety beyond the onset of class when impression management concerns should be operational.

Quiz performance errors: Testing SIM's inoculation thesis vs. the spotlighting thesis. With regards to *onset anxiety (stereotype-relevant)*: Results from a moderated regression involving vocal jitter, professor identity and self-efficacy in mathematics using 20,000 bootstrap samples revealed no significant main effect of vocal jitter on number of incorrect answers, and professor identity and self-efficacy in math did not qualify this null effect (*p*s > .05).

With regards to *after-class anxiety* (exam fever): The main effects of professor identity and vocal jitter did not emerge (*p*s > .15). These null effects were, however, qualified by a significant professor identity x vocal jitter interaction[4], *b* = -.42, *se* = .20, *p* = .040, showing that highly anxious women (*M*+1*SD*) gave more incorrect answers than their less anxious counterparts (*M*-1*SD*), but only when the professor was ingroup, *b* = 1.06, *se* = .34, *p* = .002, but not outgroup, *b* = -.17, *se* = .18, *p* = .334. Importantly, the expected vocal jitter x math efficacy x professor identity interaction emerged, *b* = -.54, *se* = .19, *p* = .006. A breakdown of this interaction showed that a vocal jitter x math efficacy interaction largely occurred in both the ingroup professor, *b* = -.48, *se* = .24, *p* = .053, and the outgroup professor, *b* = 6.01, *se* = 2.97, *p* = .046, conditions.

Ingroup (female) professor condition. Consistent with the spotlighting thesis, results from a simple slope analysis revealed that highly anxious women (*M*+1*SD*) with low math efficacy (*M*-1*SD*), gave more incorrect answers than their less anxious counterparts (*M*-1*SD*) when they were exposed to an ingroup role model, *b* = 1.20, *se* = .38, *p* = .002 (see Figure 4). Meanwhile, highly anxious women whose efficacy in math was strong (*M*+1*SD*), did not perform any worse than their less anxious counterparts, *b* = .25, *se* = .50, *p* = .611, in terms of the number of incorrect answers (see Figure 4)[i].

Outgroup (male) professor condition. Interestingly, the number of incorrect answers were substantially reduced amongst highly (relative to less) anxious women with low math efficacy when they were exposed to an outgroup (male) professor, *b* = -.72, *se* = .32, *p* = .027, but was absent for their counterparts with high math-efficacy, *b* = .48, *se* = .37, *p* = .191 (see Figure 4).

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[4] SIM enthusiasts might wonder what the simple slope outcome of this interaction was if we investigated professor identity as the contrast variable, under high and low levels of anxiety. Results from this analysis, revealed that an ingroup (vs. an outgroup) professor caused the students to provide fewer incorrect answers only when vocal jitter was low, *b* = -.52, *se* = .24, *p* = .029, while the opposite was the case when vocal jitter was high, *b* = .73, *se* = .27, *p* = .008.

After-class confidence in mathematics: There are two predictions here: An increase in anxiety should cause (a) a *drop* in math-specific confidence amongst anxious students who are exposed to an ingroup relative to an outgroup professor (following the spotlighting thesis), but (b) an *increase* in confidence amongst anxious students who are exposed to an ingroup vs. an outgroup professor (following SIM's inoculation thesis). Our analysis primarily focused on the professor identity x vocal jitter interaction because students with an initially low level of confidence in math should have little room to further downgrade their self-efficacy (i.e. a floor effect).

Onset vocal jitter. Results from a moderated regression involving professor identity and onset vocal jitter using 20,000 bootstrap samples revealed no significant main effect of onset vocal jitter on post-lecture confidence in mathematics and, professor identity did not qualify this null effect (*p*s > .05).

After-class vocal jitter. Results revealed that vocal jitter (anxiety) undermined students' confidence in mathematics, $b = -.19$, $se = .08$, $p = .018$, although this effect was qualified by professor identity in a 2-way interaction[ii], $b = .40$, $se = .16$, $p = .015$. Consistent with the spotlighting thesis, anxiety undermined students' post lecture confidence in mathematics only when they were exposed to an ingroup professor, $b = -.40$, $se = .14$, $p = .006$, but not when they were exposed to an outgroup professor, $b = -.002$, $se = .08$, $p = .979$ (see Figure 5a).

Post-quiz search for excuses. Consistent with the spotlighting thesis, results from a paired *t*-test showed that students were, overall, more likely to endorse self-esteem preserving attributions that implied their outcomes were unstable and under their control (4.89 ± 1.54) than excuses that implied lack of control (3.76 ± 1.32) for potentially poor performance on the quiz, $t(105) = 5.58$, $p < .001$, $d_{Cohen} = .78$. Nonetheless, a convincing evidence of the spotlighting thesis should demonstrate that a motivated endorsement of these excuses was higher when students were exposed to an ingroup vs. an outgroup professor. Hence, we combined the controllable and uncontrollable excuses to generate an index of post-quiz attributions. A moderated regression revealed that professor identity and after-class anxiety (vocal jitter) interacted to predict post-quiz search for excuses, b = -.45, se = .22, p = .046. Consistent with the spotlighting thesis, simple slope results showed that post-quiz attributions were higher in the ingroup than in the outgroup professor condition, when students were highly anxious, b = -.78, se = .33, p = .018, but not when students experienced lower levels of anxiety[iii], b = .17, se = .29, p = .551 (see Figure 5b).

The corresponding moderated regression analysis with onset vocal jitter (as the index of anxiety), revealed neither a main effect of professor identity (p = .591) nor a professor identity x anxiety interaction (p = .923). Interestingly, however, onset vocal jitter predicted reduced levels of post-quiz attributions regardless of professor identity, b = -.34, se = .12, p = .007.

Meta-Analysis

Studies 1 and 2 find largely consistent effects with regards to key predictions concerning anxiety and quiz performance, and these trends survived even in the more rigorous empirical replications. To quantify this, we meta-analyzed the key evidence across the three studies, first in relation to the treatment effects on anxiety, followed by the treatment effects on quiz performance. All meta-analyses were performed using a random-effect model with the DerSimonian-Laird estimator of between-study variance, and used an inverse variance method for pooling effect sizes.

Effects on Anxiety (Vocal Jitter)

With respect to treatment effects on anxiety we examined the standardized mean differences (i.e., Cohen's *d*) in vocal jitter between conditions of stereotype salience, professor's formality and then performed a sub-group analysis that examined the moderating effect of professor identity. We did this for the onset and after-class vocal jitter scores but only the onset vocal jitter analysis yielded significant effects, so the results will focus on these for parsimony (the after-class vocal jitter analysis largely produced null effects).

Consistent with the stereotype threat assumption, we found that stereotype salience had a marginally significant but *small* positive effect on onset vocal jitter (anxiety), $d_{\text{Cohen}} = .28$, se = .14, $p = .052$, 95% CI = [0.00, 0.55], that is comparable in magnitude to the meta-analyzed ST effect in Flore and Wicherts (Flore & Wicherts, 2015). Professor identity also exerted a consistent effect so that, overall, exposure to ingroup professors led to less anxiety compared to exposure to outgroup professors, $d_{\text{Cohen}} = -.44$, se = .20, $p = .031$, 95% CI = [-0.83, -0.04]. Meanwhile, the main effect of professor's formality on onset vocal jitter (anxiety) was not consistent across the racial (Study 1 & 2) and gender (Study 3) contexts, and, consequently, the aggregated effect size of this treatment was also not reliable, $d_{\text{Cohen}} = -.08$, se = .21, $p = .707$, 95% CI = [-0.49, 0.33]. Although future research could investigate the role of formality in ST, it was included in the present research as a control variable to better understand the unique anxiety associated with stereotypes.

Importantly, professor identity consistently moderated the effect of stereotype salience across the three studies, QM(df = 1) = 15.91, $p < .0001$; so that the experience of anxiety when negative ingroup stereotypes were salient (vs. not salient) occurred primarily when students were exposed to an outgroup, $d_{\text{Cohen}} = .57$, se = .14, $p < .0001$, compared to an ingroup professor, $d_{\text{Cohen}} = -.28$, se = .16, $p = .084$ (see Figure 6). Hence, the evidence across three studies show that when impression management concerns are coupled with an outgroup evaluator, there is a consistent stereotype effect. However, when the same context is paired with an ingroup evaluator, an inoculative effect occurs (cf. Flore et al., 2018). This ST effect on vocal jitters was limited only to initial encounters, and seemed to fade over time. There was no evidence that professor identity moderated the null meta-analyzed effect of professor's formality on students' anxiety as reflected by their vocal jitter, $QM(1) = 0.27$, $p = .606$ perhaps due to the opposing pattern of effects in the racial and gender contexts for this treatment.

Errors in Quiz Performance

We meta-analyzed the unstandardized regression coefficients and associated standard errors that were generated from PROCESS (Model 3, Hayes, 2018), having standardized the predictors (i.e., subject efficacy, after-class vocal jitter [anxiety] and professor identity) and the outcome (i.e., incorrect answers) prior to analysis. Again, we considered professor identity and subject efficacy as moderators of the relationship between anxiety and errors in quiz performance (i.e., incorrect answers).

Consistent with past studies (Flore et al., 2018), anxiety undermined performance, in that the number of incorrect answers rose with increasing levels of vocal jitter, $b = .20$, z = 2.45, $p = .015$, 95% CI = [0.04, 0.36]. This meta-analyzed effect was moderated by subject efficacy and professor identity in a 3-way interaction, $b = .44$, z = 3.31, $p = .0009$, 95% CI = [0.18, 0.70]. A breakdown of this interaction revealed only a significant spotlight effect: receiving the ingroup professor "vaccine" caused very anxious students with low subject efficacy to generate a greater number of incorrect answers to quizzes that were posed to them relative to their less anxious counterparts, $b = .50$, $se = .14$, $z = 3.66$, $p = .0002$. This effect was absent when students likely experiencing a similar imposter syndrome were exposed to an outgroup professor, $b = -.12$, $se = .25$, $z = -0.46$, $p = .645$. No other reliable meta-analyzed effects emerged (see Figure 7).

General Discussion

Decades ago, Steele and Aronson (Steele & Aronson, 1995) advanced the thesis that situational salience of negative ingroup stereotypes can cause an increase in anxiety that undermines performance in domains that are tied to the stereotype. Of particular interest are stereotypes that portray women and racial/ethnic minorities as deficient in math and science-related fields. Although there are a number of explanations for this achievement gap, the impacts of stereotypes on motivation and performance has received marked attention. However, some recent negative tests of this idea (Flore et al., 2018), have cast doubt on ST as a robust explanation for the achievement gap often seen amongst students from stereotyped backgrounds (e.g. women). Studies that provided (un)supportive evidence for a stereotype-threat explanation for identity-based achievement gaps in STEM have often tested the relevant assumption under conditions that could be explained by other situational factors: (a) other sources of anxiety were frequently conflated in the testing situation (teacher's formality, exam fever, teacher social identity, emotional contagion and so on) and; (b) the primary mechanism of anxiety, theorized to cause ST effects, was often measured using self-reports that are vulnerable to normative pressures (e.g., feminist/egalitarian norms), rendering the actual causes of identity-based differences hard to discern.

Here, we addressed these issues in the context of testing the effectiveness of an identity-based "vaccine" (i.e., ingroup role models) on STEM outcomes of students from stereotyped backgrounds. We grounded our test in SIM's inoculation hypothesis and introduced a new perspective: the spotlighting thesis. In terms of key findings, the preponderance of the evidence indicates some support for ST as a psychological reality, in that: a) the salience of negative ingroup stereotypes largely increased anxiety, especially in an intergroup setting, but only during initial encounters with the outgroup, when impression management concerns were more relevant (see Studies 1 , 2, 3 & meta-analyzed results for onset vocal jitter); b) removing or minimizing this threat (e.g. via exposure to ingroup role models) largely reduced the number of incorrect answers to a quiz immediately following the treatment (Studies 2-3): A feat that lingered four weeks after this identity-based vaccine was administered (Study 2).

Inoculation versus Spotlighting Theses

One of the primary contributions of the current research is that it raises important questions about the boundary conditions of stereotype inoculation for students from stereotyped backgrounds. Indeed, a cornerstone of one of the most influential models in stereotype threat reduction within classrooms (i.e., SIM), is that ingroup role models can immunize students from stigmatized backgrounds from stereotype-related anxieties, enabling them to achieve better academic outcomes in those STEM fields affected by negative ingroup stereotypes. Much of the evidence from the current investigation corroborate these assumptions. Ingroup professors reduced students' anxiety when reminded of negative ingroup stereotypes (Studies 2, & 3), whereas outgroup professors did not serve this palliative function. In Study 2, ingroup role models also helped to reduce the number of incorrect answers that Asian students gave on a quiz posed to them, and this effect lingered four weeks from the initial treatment. In Study 3, Dutch women made fewer errors in a math-related quiz when taught by a female professor, provided their level of anxiety was low. That this latter effect emerged when situational experience of anxiety was low aligns with the ST perspective that eliminating situations that trigger threat/anxiety (e.g., through inoculation) helps to improve academic outcome of students from stereotyped backgrounds.

But the data departs from SIM somewhat with regards to students from stigmatized backgrounds who are likely suffering from an imposter syndrome (i.e., high anxiety and low subject efficacy). Across Studies 2 and 3, the evidence points to a harmful effect of ingroup role models for those students likely suffering from an imposter syndrome. Specifically, we show that an ingroup role model could place a spotlight on such students (even when students were exposed to lecture recordings online), causing them to achieve worse (not better) outcomes in STEM. We are not aware of any other study that has systematically documented the potential side-effect of this type of identity-based vaccine in both a classroom and online lecture scenarios, and we provide a novel acoustic tool for measuring anxiety that can guide future exploration in this area.

Policy Implications

There has been an increasing push in education sectors around the globe toward greater representation of women and minority faculty (e.g., affirmative action in the US, the Athena Swan awards in the UK). What implication might the current findings have for policy and intervention programs? Given that the current data concur with the burgeoning literature revealing that shared social identities can have palliative benefits (see Haslam et al., 2009), the temptation might be to power ahead with interventions that promote greater representation, especially in education where success or failure in STEM classes could impact future career choices and opportunities.

However, the present findings regarding the spotlighting effects suggests that the benefits might be more nuanced than the literature currently portrays, and any intervention should take into account both benefits and challenges. For example, while ingroup role-models reduce anxiety overall, the impact on the most vulnerable students—students with high anxiety and low self-efficacy—should be considered and addressed via additional supports. It should be noted that the spotlighting effects emerged during a brief encounter with a professor and the longitudinal data suggest that it could fade over time, so it is possible that prolonged exposure to positive role models could override the spotlighting effect. However, this will need to be investigated in future research.

Furthermore, some of the present data indicated that on some occasions, exposure to outgroup professors could actually offer tangible benefits for female students who may have an imposter syndrome, in so far as such situations may not evoke as much spotlighting as perhaps an ingroup professor context might (see Figure 4). Interventionists should exercise caution, though, in applying a broad-brush approach here because the spotlighting findings are novel and require more research to fully understand. Nevertheless, the current research suggests that adopting a more nuanced approach that recognizes the specific needs of subgroups of students from stereotyped communities could be fruitful. The shift in education to online modes of delivery in the COVID-19 era and beyond might provide an opportunity for this sort of nuance in the form of more tailored instruction.

Concluding Remarks

The answers to three key questions summarize the primary contributions of the current investigation. First, does the situational salience of negative ingroup stereotypes cause anxiety to increase amongst students from stereotypes backgrounds? The answer to this question is *somewhat yes*, based on the marginally significant meta-analyzed evidence. But this trend is mostly reliable when students are exposed to teachers with a different social identity to themselves. Second, does an identity-based intervention, such as exposure to ingroup role models, help to reduce anxiety and performance errors? The answer is, *overall yes*. Ingroup identity effects of professors were fairly reliable across the studies. Third, does this inoculation effect benefit all underrepresented students, especially students from stereotyped backgrounds likely experiencing an imposter syndrome? The answer to this question is *no*, based on the current data. Although such an identity-based "vaccine" seems useful for some students, it may not be as effective for those anxiety-prone students who doubt their place in the relevant STEM field. This latter finding calls for greater caution in both advocacy and intervention around stereotype-based underachievement in STEM for students who come from stigmatized backgrounds.

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Figures and Tables

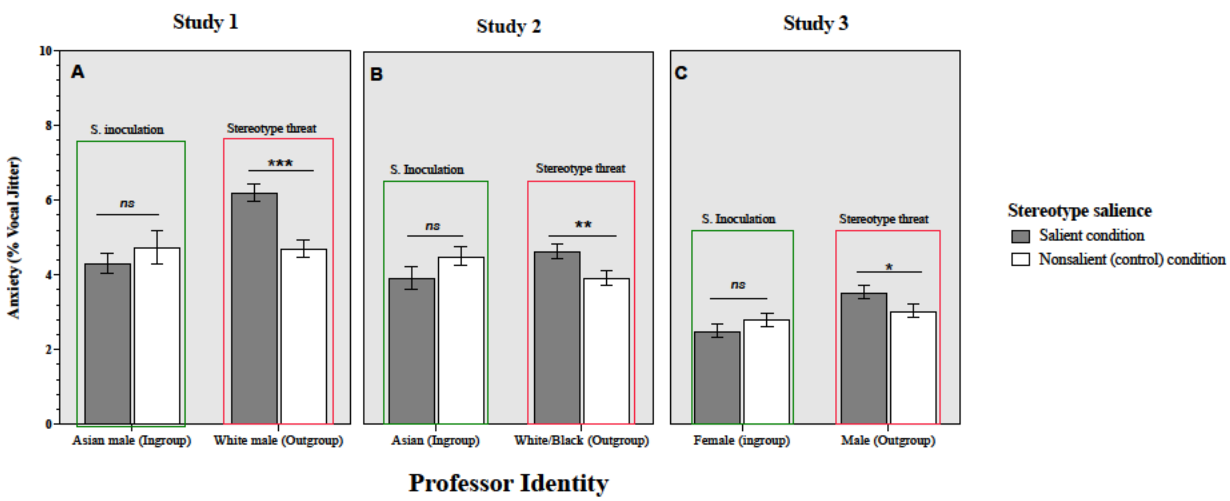

Figure 1. The effects of stereotype salience on students' vocal jitter (anxiety) when their professor was either ingroup or outgroup. *Note*: S.Inoculate = stereotye inoculation. Error bars re standard errors. *ns* = nonsignificant; **p* □ .050; ***p* < .010., ****p* < .001.

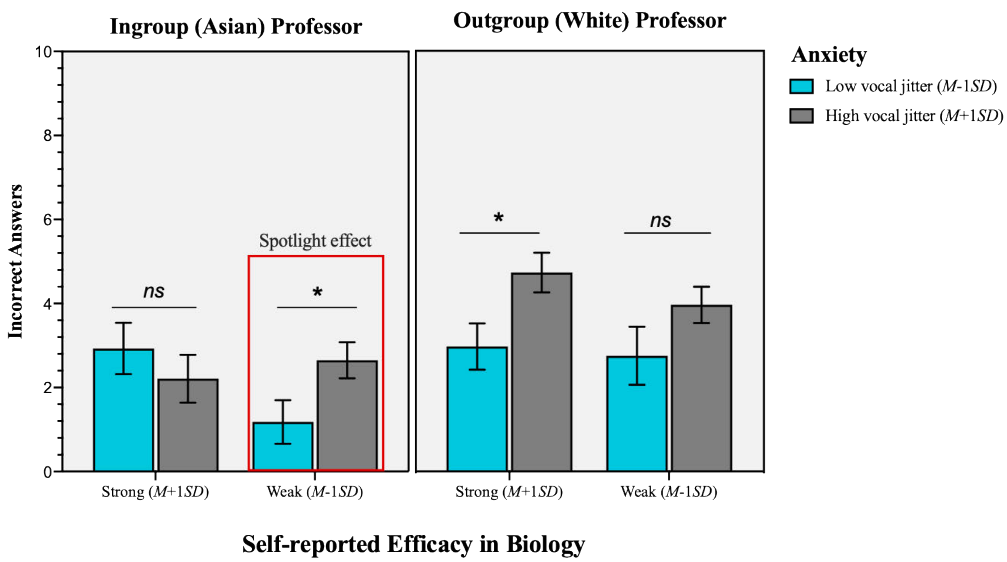

Figure 2. Number of inaccurate answers to a biology quiz as a function of anxiety (% vocal jitter) and biology efficacy (imposter feelings) when Asian students were exposed to ingroup vs. outgroup professor. Reported are estimated marginal means. Error bars are standard errors. *ns* = nonsignificant, *$p < .050$.

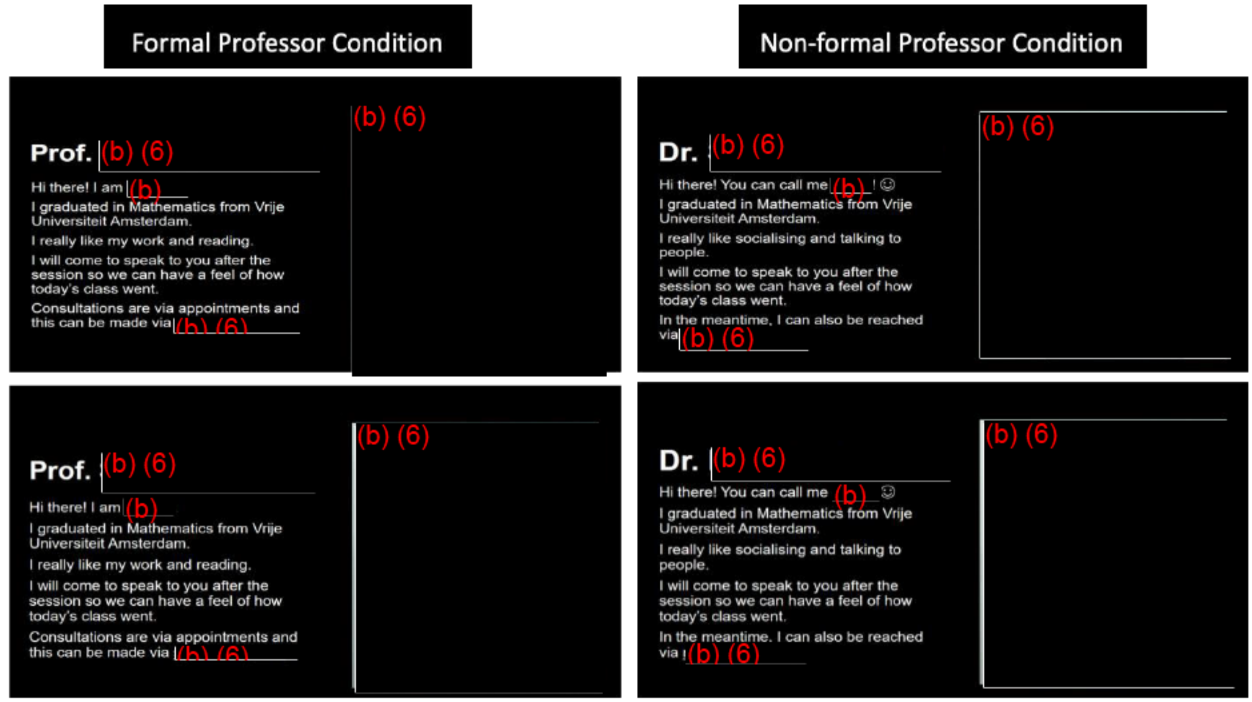

Figure 3. Manipulating professor's identity (male vs. female) and professor's formality (formal vs. non-formal) in Study 2. Images are presented with written permission from the individuals appearing in them.

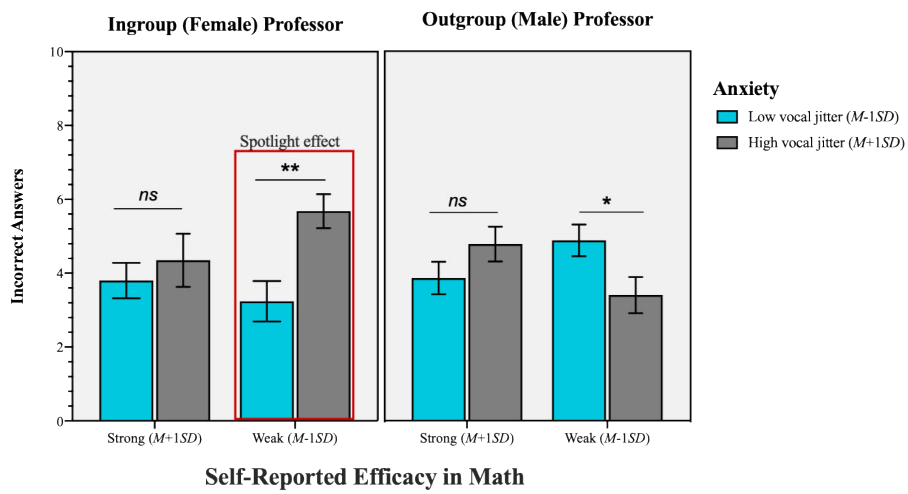

Figure 4, Number of inaccurate answers to a math quiz as a function of anxiety (vocal jitter) and math efficacy, when female students were exposed to an ingroup vs. an outgroup professor. Reported are estimated marginal means. Error bars are standard errors. ns - nonsignificant, $*p = .050$, $**p < .010$

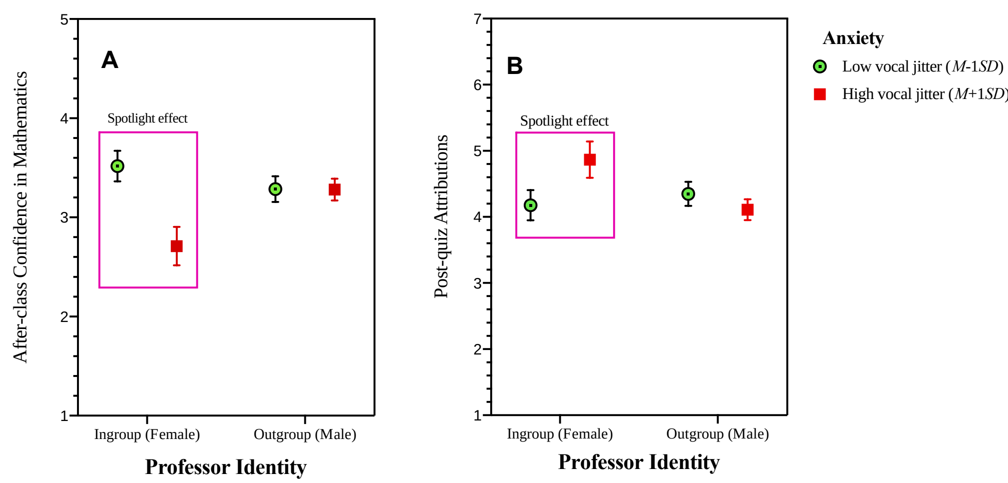

Figure 5. The interactive effect of professor identity and after class anxiety (vocal jitter) in predicting post-lecture confidence in mathematics (**A**) and post-quiz attributions (**B**). Error bars are standard errors.

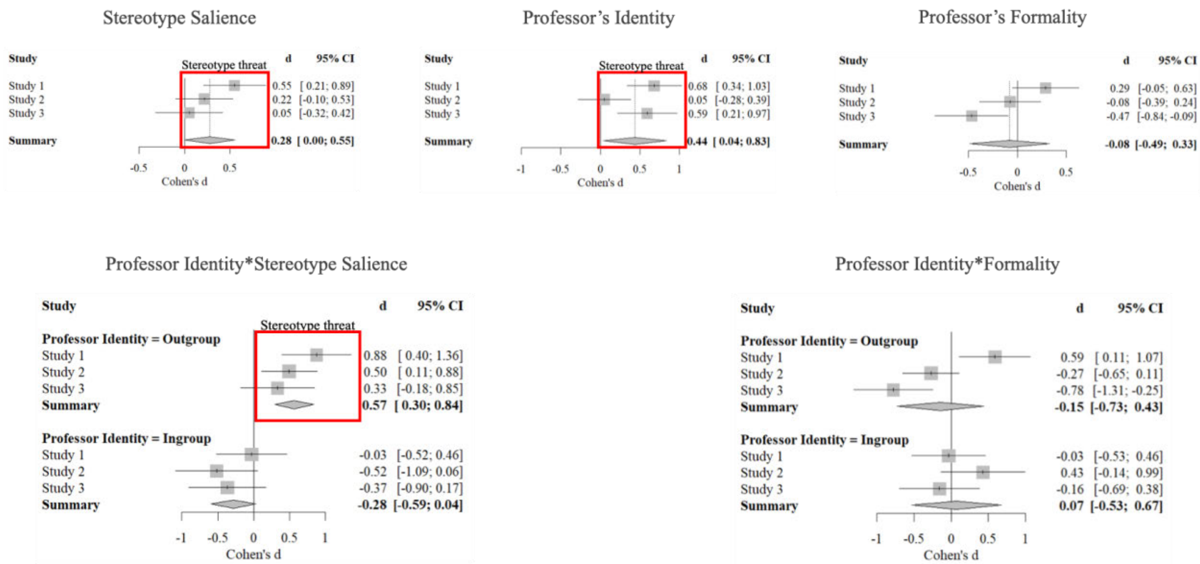

Figure 6. Meta-analyzed main and interactive effects of stereotype salience, professor identity and professor formality on students' onset vocal jitter (anxiety). Reference conditions are: nonsalient stereotypes, ingroup professor, and non-formal acting professor. RE Model = random effects model.

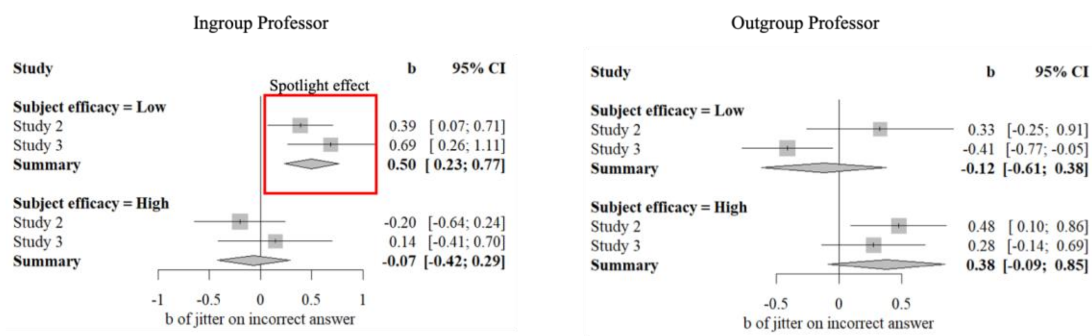

Figure 7. Meta-analyzed regression weights for the effect of anxiety (after-class vocal jitter) on errors in quiz performance when students with low and high subject efficacy are exposed to ingroup vs. outgroup professors.

Table 1. *Assumption/Manipulation Checks.*

	Number of stereotype-related word-fragment completions			**Self-reported teacher-related classroom anxiety**		
	Salient stereotype condition	Non-salient stereotype condition	d_{Cohen} [95% CI]	Formal condition	Non-formal condition	d_{Cohen} [95% CI]
Study 1	4.82 (0.51)	1.79 (1.18)	3.41 [3.26, 3.56]	3.06 (0.63)	2 34 (0.41)	1.33 [1.24, 1.42]
Study 2	4.38 (0.93)	1.33 (1.16)	2.92 [2.53, 3.31]	3.17 (0.77)	2 34 (0.62)	1.17 [0.90, 1.49]
Study 3	3.37 (1.05)	0.93 (0.76)	2.70 [2.19, 3.21]	3.65 (0.52)	2 33 (0.37)	2.94 [2.86, 3.02]

Note: Numbers in parenthesis are standard deviations, while numbers outside them are means.

Table 2. *The Effects of Professor Identity, Formality and Stereotype Salience on Students' Anxiety (Vocal Jitter).*

		Model 1			Model 2			Model 3			Model 4		
		No controls (raw data)			Bootstrap simulation (*N* = 20,000)			Controlling for TA's vocal jitter			Controlling for teacher-related anxiety		
		F	*p*	*ηp2*	*F*	*p*	*ηp2*	*F*	*p*	*ηp2*	*F*	*p*	*ηp2*
Study 1 (*N* = 138)	Professor identity (PI)	22.80	.000	.148	22.80	.000	.148	20.67	.000	.137	24.68	.000	.160
	Stereotype salience (SS)	14.88	.000	.102	14.88	.000	.102	13.59	.000	.095	14.68	.000	.101
	P1*SS	**16.04**	**.000**	**.109**	**16.04**	**.000**	**.109**	**14.31**	**.000**	**.099**	**15.15**	**.000**	**.104**
	Professor formality (PF)	9.31	.003	.066	9.31	.000	.066	7.36	.008	.054	10.65	.001	.076
	PI*PF	10.34	.002	.073	10.34	.001	.073	10.08	.002	.072	9.71	.002	.069
	Control variable	--	--	--	--	--	--	0.12	.736	.001	1.97	.163	.015
Study 2 (*N* = 163)	Professor identity (PI)	0.06	.805	.000	0.06	.805	.000	0.46	.498	.003	0.02	.890	.000
	Stereotype salience (SS)	0.94	.759	.001	0.94	.759	.001	.003	.959	.000	0.08	.782	.001
	PI*SS	**7.21**	**.008**	**.045**	**7.21**	**.008**	**.045**	**5.75**	**.018**	**.037**	**7.05**	**.009**	**.045**
	Professor formality (PF)	0.01	.906	.000	0.01	.906	.000	0.04	.846	.000	0.25	.620	.002
	PI*PF	3.15	.078	.020	3.15	.078	.020	3.95	.049	.025	2.68	.104	.018
	Control variable	--	--	--	--	--	--	1.36	.246	.009	0.44	.508	.003
Study 3 (*N* = 113)	Professor identity (PI)	12.32	.001	.103	12.32	.001	.103	12.61	.001	.106	9.49	.003	.087
	Stereotype salience (SS)	0.29	.590	.003	0.29	.590	.003	0.34	.560	.003	0.25	.621	.002
	PI*SS	**4.90**	**.029**	**.044**	**4.90**	**.029**	**.044**	**4.96**	**.028**	**.045**	**6.67**	**.011**	**.063**
	Professor formality (PF)	8.38	.005	.073	8.38	.005	.073	8.63	.004	.075	0.33	.566	.003
	PI*PF	4.64	.033	.042	4.64	.033	.042	3.91	.051	.036	4.70	.033	.045
	Control variable	--	--	--	--	--	--	0.36	.548	.003	0.84	.362	.008

Note. TA = Teaching assistant. Professor identity (-1 = ingroup, 1 = outgroup); Negative ingroup stereotypes (-1 = nonsalient, 1 = salient); Professor formality (-1 = non-formal, 1 = formal). Bootstrap simulation was conducted in Mplus (version 8), with missing values set at -99.

Endnote

[i] It is possible to argue from SIM's inoculation thesis that the effect of interest when it comes to quiz performance should relate to inaccurate answers provided by students who were both low in subject efficacy and anxiety when exposed to the inoculative presence of an ingroup (vs. an outgroup) professor. It is important to note that our analysis permits a single simple contrast because the model we ran (equivalent to a 2x2x2 factorial ANOVA) only has 1 degree of freedom. Nonetheless, when we examined the simple effect of professor identity at low levels of anxiety (after-class vocal jitter) and subject efficacy, we found, consistent with this alternative inoculation thesis, that inaccuracies were indeed lower in the ingroup (vs. outgroup) professor condition, $b = 1.61$, $se = .69$, $p = .021$ in Study 3. The equivalent simple effect analysis in Study 2 also followed a similar trend, $b = .77$, $se = .43$, $p = .072$. But there is at least one reason to treat these effects with some degree of caution: In both Studies 2 and 3, ingroup professors did not *reliably* reduce students' after-class vocal jitter (anxiety) relative to the outgroup professor (Study 2: $3.35 \pm .95$ vs. $3.29 \pm .76$, $p = .700$; Study 3: $2.32 \pm .10$ vs. 2.59 ± 1.25, $p = .059$, respectively for ingroup vs. outgroup professor contrast). So, although it is tempting to pronounce the foregoing effects as being supportive of SIM's inoculation thesis, it is important to note that the theory assumes that it is the reduced anxiety (i.e. immunity) offered by the inoculative presence of ingroup professors that should drive the effect. But, as we have stated elsewhere in the paper, this immunity only occurred at the onset of class, and the foregoing patterns could not be replicated when we used anxiety at onset of class to predict quiz performance.

ii The pre- and post-quiz confidence in mathematics for highly anxious students in the ingroup professor condition were respectively, $2.96 \pm .19$ vs. $2.71 \pm .19$, $p = .017$; while the equivalent estimates in the outgroup professor condition were, $3.48 \pm .11$ vs. 3.28 ± 1.25, $p = .001$. It is interesting that confidence in mathematics was greater for students who were exposed to an outgroup (male) professor than to an ingroup (female) professor both at the pre-test stage ($p = .019$) and post-class measurement ($p = .012$). This suggests, consistent with the spotlighting thesis, that the mere sight of an ingroup (female) professor dampened female students' confidence in mathematics and this effect lingered after the class.

[iii] The pattern was similar when we reversed the roles of anxiety and professor identity: in the ingroup professor condition, anxious students' self-serving attributions were marginally higher than the corresponding attributions amongst their counterparts with low levels of anxiety, $b = .33$, $se = .20$, $p = .093$. Meanwhile this anxiety effect was absent for those students who were exposed to an outgroup (male) professor, $b = -.12$, $se = .10$, $p = .266$. In fact, a follow-up mediational analysis in which the main and interactive effects of professor identity and after-class anxiety were specified as predictor, with attributions as mediator and inaccuracies in quiz performance as outcome, revealed that (a) the self-serving attributions explained greater number of inaccuracies in quiz performance of those high (vs low) anxiety students who were exposed to an ingroup (female) professor, $b_{IE} = 1.08$, $se = .72$, 95% CI = [0.01, 2.93], but not those exposed to an outgroup professor, $b_{IE} = -.38$, $se = .44$, 95% CI = [-1.69, 0.22]. When we reversed the roles of quiz performance (now as mediator) and post-quiz attributions (now as outcome), the indirect effect of exposing anxious students to ingroup professors was nonsignificant, $b_{IE} = .12$, $se = .08$, 95% CI = [-0.004, 0.32], as was exposure to outgroup professors, $b_{IE} = -.02$, $se = .02$, 95% CI = [-0.09, 0.02]: confirming that self-serving attributions are the mechanism that drives the spotlighting performance impairment, and not the other way round.

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Supplemental Material
[redacted]

Open Practices Disclosure form

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[redacted]

[redacted]: STEM RFI Response

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

The Benefits when integrating computer literacy within a STEM curriculum are the counteract the misguided notion that younger members, and older many older members, of our programs have little or no ability to demonstrate “real computational literacy”! my high school and community college students cannot identify the components in either their desktop, laptop, or portable device, and the role it plays in retrieving, inputting, processing, storing, or outputting data. The students have no concept of programming structure to better understand why certain functions must be done in a specific order, and why other functions may be done in any order. The use and function of any operating system and its role in providing security measures, as well as communicating with other device and peripherals is considered “magic” that “just does it”. Students do need to understand the standards applied to all computers, and the differences between an “administration-level” account and a “user or guest” account on the capabilities given to themselves, malware, or intruders to accidentally damage, alter, delete, or manage their data.

The main challenge I hear is when a department chair announces in a curriculum committee meeting that they are dropping our “Introduction to Computers” in lieu of the fact that their students are required to take an English class and, therefore, write a paper, the Chairs state that the students may usually “visit” the English Computer Lab and use the computers there to write their paper, and besides, “they all know how to send emails!” So this English class requirement qualifies, in their mind, as an equivalent experience to our “Introduction to Computers” Where students learn about how computer work from binary, to the IOT, to Operating Systems, Hardware Configuration, Workstations and Servers, a variety of Software Applications and their use in business, including labs on Word, Excel, PowerPoint, and Digital Photography image manipulation and the differences between RAW, jpg, tiff, and other images. Databases and the differences between Flat File and Relational Databases. And Basic programming for robotics. This is hardly the equivalent experience of writing a paper and not even learning how to use “word count” to evaluate your progress on an assignment.

21. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.

Years ago I was Co-PI on an NSF Grant at [redacted], the purpose of the grant was to create a 1-year Information Technology “First Step” certificate that could be taught at all 54 community colleges in Texas, and recognized that it offered complete transferability to any of the other community colleges. A student could transfer to a specific institution that offered a specialized program that may not be offered at their home institution such as CISCO, GIS, NETWORKING, INFORMATION SECURITY, CLOUD COMPUTING, etc. for their second year. I was also a Co-PI in an NSF program to create Virtual Cyber Security Labs with 32 other community colleges across the country. These Labs were hosted at [redacted].

22. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.

The Texas Workforce Education Manual (WECM) offers a catalog of more than 41 courses available to all community colleges in various STEM fields for use at all community colleges for STEM-related certificates, and degrees, and workforce continuing education.

23. What technologies and resources do you currently use (*e.g.,* apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

We have developed our own physical labs and projects that are used for our Windows and Linux Servers classes and the Server Integration Class, the Firewalls and Network Security class and the virtualization class. We even have a couple of private virtual clouds that are standalone resources within one of our three labs. These were built and configured by our faculty of use in one of the server classes and also in the virtualization course. We are also a CISCO academy and use the resources provided by the CISCO Lab housed on our campus for student instruction at the college and in our dual-credit program at several high schools in the region. Our current lab houses more than 125 Servers that were either donated by industry or purchased through Perkins funding, and more than 50 workstations, all for just use in our labs. Our faculty have created the physical and virtual labs for our students using these resources.

I am responding specifically to the Request for Information focus on the following element of the Federal STEM Education Strategic Plan: Increase diversity, equity, and inclusion in STEM.

Seeing beyond the biases of my upbringing was a gift from mentors. People who showed me how to see with my own eyes, to challenge mythical versions of history, to respect the dignity of every person and to read for myself the documents defining the principles upon which our nation was founded.

I suspected early on that the history of the nation to which I continue to pledge allegiance was skewed. The significance of the gift of looking at the facts and making my own conclusions fully revealed itself to me around 1959. When I was an awkward, introverted pre-teen with severe self-confidence issues, Mr. Lee Prettyman Jr., the Director of Aquatics at the Hartford, Connecticut YMCA taught me to swim (read gave me confidence and skills to survive and thrive) and regaled us with stories of SCUBA diving on shipwrecks and encountering sharks, moray eels and octopods. Years later, I found a feature article on the legendary SCUBA diving instructor and explorer in Ebony Magazine. As a swimming instructor, he would always single out those youngsters struggling the most (like me) during free swim for frentoring = friendship/mentoring. He wouldn't let anyone fail. It was in his nature. He had my back and I admired him more than anyone. Being in and under the water became my escape - I felt buoyed and empowered by it. Mastery of water became my superpower and he was responsible for it.

I'll never forget the pain and anger that I saw in his eyes in the YMCA pool when some non-African American youngster said something (perhaps the n-word?) that he heard. It hurt him and it hurt me to see him hurt. Because of him I became a marine biologist and used SCUBA as a research tool. I would like to think that what I did with my professional life was a form a repayment in some small measure for what this giant of a man did for me.

I reckon that learning about the history and contributions of the victims and descendants of the African diaspora is as important as anything in this country, and in the world, right now. Would Charles Darwin have wanted to travel to South America as the ship's naturalist on the HMS Beagle if he had not heard stories of ecosystems and culture of south America from his taxidermy instructor at the University of Edinburgh, John Edmonstone, a former slave born and raised there? Would a sick Robert Peary have gotten to the North Pole and lived to reap the rewards if Matthew Henson, the African American and only non-Inuit to master dog sledding and life on the ice, had not literally carried him there?

I hoped that telling my marine biology students about the triumph and tragedy of the life of Dr. E.E. Just would inspire them. I believe that it did because some of them would offer observations like 'If he could do that then, I can do this now'.

Ernest Everett Just was a person of color born in Charleston, South Carolina in 1883. Mary Just, his mother, founded Maryville across the Ashley River and sent young Ernest north to get a proper education at Kimball Academy and Dartmouth College in New Hampshire. He excelled at both. After earning a doctorate degree and with impeccable academic credentials, no major university in the U.S. would hire him because of his color. He was an early eco-developmental biologist who studied cellular processes using fertilized sea urchin eggs at the Marine Biological Laboratory at Woods Hole, Massachusetts in the summer. Most biology classes and courses still use his sea urchin model in textbook chapters and laboratory manuals. Because he and his wife were rejected socially there, he engineered ways of working at marine laboratories in Europe where the egalitarian spirit existed and where high-achieving African Americans were celebrated. When Nazi Germany began dominating France, he was arrested and deported to the U.S. His spirit broken, he died of pancreatic cancer in 1941 at the age of 58. He had over 50 scientific publications including two books.

We learn in the academic biography 'Black Apollo of Science: The Life of Ernest Everett Just' by Kenneth R. Manning, that he was surprised that socializing and football was such an important part of college life at Dartmouth. The recent admissions scandal at universities in the U.S. shows us how little things have changed. Elite universities have had a business model that included big donations from the wealthy who expect to their sometimes academically-marginal offspring to be admitted in order for them to rub shoulders with other offspring of the wealthy and powerful - the aristocratic model, if you will. A meritocratic and access model is more aligned with the spirit of the democracy created by the Constitution of the United State of America, as I read it.

Higher education in the U.S. did not become accessible to the non-wealthy in a significant way until the son of a New Hampshire blacksmith who wanted to go to college but could not afford it got wealthy and powerful as a businessman. Justin Morrill was elected to congress and sponsored First Morrill Land Grant Act of 1860 establishing the basis of federally-assisted agricultural and mechanical schools. A second in 1891 required southern states that denied access to public higher education to African Americans to use some of the funding for that purpose or not receive it. The result was separate systems of higher education including the founding of Georgia State Industrial College in Savannah. It later became Georgia State College, Savannah State College and then Savannah State University.

The history that I was taught in school as a youngster was not entirely what really happened. It was what those in power and control selected to be used in classrooms. It instilled patriotism but it also justified the unjustifiable. That's just the way it was to be. It wasn't OK then and it isn't now. Though we have made progress in telling the whole story, for reasons all to clear and painful, the meager rate must increase at a greater pace. Our stories are who we are. There should be no guilt or blame felt by the descendants of either those who suffered or those caused the suffering inflicted by institutionalized racism and its policies. The more we share our stories with others and the more we ask them them share their stories with us, the closer and stronger we become as individuals and as a nation.

[redacted], is [redacted] [redacted]. He received a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring from Dr. France Cordova, Director of the National Science Foundation, and Mr. Michael Kratsios, Deputy Assistant to the President, White House Office of Science and Technology Policy, on [redacted] in Washington, D.C. He and his wife [redacted] (b) (6) moved to [redacted] permanently in October 2019, in part to escape rapidly increasing climate change threats of living in the coastal zone of the southeast coast of the U.S. which he explains in a recent community leaders climate change forum interview produced by SCTV and available at [redacted] or Google '[redacted]'

I am a PAEMST awardee and previous K-5 STEM teacher. The questions I responded to are 9, 18, 21, and 24. The responses are included only from the perspective of a STEM teacher.

- Develop STEM Education Digital Resources
  - Question 9
- Develop and Enrich Strategic Partnerships
  - Question 18
- Build Computational Literacy
  - Question 21
- Community Use and Implementation of the Federal STEM Education Strategic Plan
  - Question 24

https://www.federalregister.gov/d/2020-19681/p-42 and https://www.federalregister.gov/d/2020-19681/p-58

- 9. What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website?

To have resources useful for teachers, the resources need to be aligned to the standards that the state has adopted.

- Federal virtual website that has a pull down of webpages by state that include:
  - State standards
  - College and Career pathways K12
  - Links to state Department of Education webpages that hold K12 STEM support
  - Action Plan Models; professional learning communities
  - Instructional materials and library media resources; on demand virtual lessons by state standard
  - Links to state standards-aligned STEM units and resources
  - Interactive models or videos for:
    - Scope and sequence by grade level standards
    - Scope and sequence by integrated cross curricular grade level standards
    - Scope and sequence by vertical grade level standards
    - Scope and sequence by vertical integrated cross curricular grade levels standards
      - All scope and sequence pathways will cover the grade level standards the student will be tested in along with others
    - Explanations for each standard and benchmark; include mini-professional learning teacher tutorials for discrepant and confusing standards
    - Explanations for how standards and benchmarks build and overlap each other while integrating with other content areas
    - Classroom/lab physical room set up models; virtual and brick

  - Lists of classroom/lab expendable and permanent materials and tools by standard
  - Resources to replenish expendable materials ($ and businesses to order from)
  - Units, lesson, labs for individual standards
  - Units, lessons, labs for integrated standards
  - Multiple forms of formative, interval and summative standards assessments
  - Multiple forms of integrated formative, interval and summative standards assessments that match the scope and sequence pathway
  - Link to communicate assessment results and future plans to remediate to the community

CPALMS https://www.cpalms.org is the repository for the Florida K-12 standards, resources, courses, curriculum mapping, professional learning, student tutorials and much more. There are standards-aligned lesson plans across the CPALMS platform which is updated and maintained constantly. A tab for Model Eliciting Activities is included in the Resources tab that holds multiple STEM units. There are videos in the Perspectives tab that share interviews with local scientists that speak about their careers, career pathways and the skills needed for success. It is a remarkable tool and model.

Other ideas and links that could be included:

- Public Broadcasting System (PBS) standards aligned resources for PreK12
- Free Hotspot availability by state
- The STEM TL webpage link
- NSTA and NCTM webpage links
- Universities and other higher education organizations holding grant partnerships with K12 educators i.e., Thompson Earth Systems Institute: Scientist in Every Florida School from University of Florida https://www.floridamuseum.ufl.edu/earth-systems/
- Any federal, state or local STEM organization with resources or opportunities for virtual or face to face field trips or apprenticeships listed by state i.e., Solid Waste Authority in Palm Beach County https://swa.org/390/Virtual-Lessons

https://www.federalregister.gov/d/2020-19681/p-54

18. How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities?

- Television and online advertisements for teaching positions and other areas of need with online support to connect people who respond to the ads
- AmeriCorps style trainings with on the job learning
- Provide virtual kiosks with highly engaging information in easy to access areas; libraries, state buildings, universities, high schools
- Online social platform ads with training and job description attached

- Begin initial career introductions with opportunities to try out different skills and trainings in elementary school; make this embedded, not just a one day “Career Day”. Let the young students be exposed to and explore their passions and creativity consistently
- Offer a college or career track of education with the opportunity to change mid-stream with the understanding that it may take longer to complete school, but the career choice will be more satisfying for the student
- Add to the K12 yearly system another system based on skill attainment with local job opportunity upon completion, take away the “I am 12 years old so I am in 7th grade” requirement
- School funding changed to match programs offered; traditional funding still available for traditional schools
- Provide opportunities for choices to be trained in many different local job skills so that finding employment or changing jobs is easier
- Provide opportunities to practice what has been learned upon completion of every term through apprenticeships and on the job access for shadowing and training. Opportunity to change courses if apprenticeship reveals that the person is not suited or doesn’t like it
- Provide paid classroom training and paid onsite apprenticeship that leads to a job
- Offer college credit and free tuition attached to apprenticeship during study and a job after completion of certificate or graduation
- Recruit like the armed forces especially for high needs areas
- Combine difficult jobs with engaging topics that will help a person feel that they are make a difference
- Change/update or create a “younger” USA jobs website (and any other federally managed interactive websites) to appeal to younger people that is attractive and easy to navigate (icons, avatars, apps, etc.)
- Set up a Roosevelt-style model to fix the old and build the new American infrastructure that includes training, education and jobs
- Every student has a path to follow with rewards of higher education or immediate salary sponsored by local agencies

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.

- Florida is releasing the B.E.S.T. standards in Math that will be used to integrate computational literacy into STEM education K12. Please visit www.cpalms.org to view the new standards ready to be implemented in 2022-2023. Experts in mathematics from across the U.S. and Florida collaborated to align grade level standards and topic introduction to meet career and college preparation pathways. The new standards will be integrated into science, computer science and other content areas through real life problem and project-based units and lessons. Trainings will be obtained across the state and through school districts.
- https://www.cpalms.org is the repository for the Florida computer science (CS) standards. This website deserves special attention because the computer standards are being implemented in districts and schools across the state. Teachers are being trained and certified to teach

integration of the computer science standards across the core subjects and specialized CS courses.

https://www.federalregister.gov/d/2020-19681/p-62

24. Please describe how your organization has used the Federal STEM Education Strategic Plan. How does your work align with the goals and pathways identified in the Strategy?

- I can see the actions from the STEM Education Strategic Plan being taken at the state level. Please see the Back to School Newsletter that highlights many of the programs and initiatives Florida is involved with that are available for STEM students, teachers, schools and districts. As a STEM teacher, knowing that the college and career pathways and opportunities being used to guide students through K12 matriculation are being developed and implemented in our state is proof that the strategic plan is working. https://info.fldoe.org/docushare/dsweb/Get/Document-8941/dps-2020-74a.pdf

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Comment On: NSF_FRDOC_0001-2546
Request for Information: STEM Education

Document: NSF_FRDOC_0001-DRAFT-0446
Comment on FR Doc # 2020-19681

Submitter Information

Name: [redacted]
Address:
[redacted]
Email: [redacted]
Phone: [redacted]

General Comment

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

As before the pandemic, one of the greatest challenges in STEM education is the attraction and retention of qualified teachers. COVID-19 has highlighted the inequities between schools, and none so much as the lack of qualified STEM educators. I am currently teaching a remote physics course for students in four small Arizona communities on top of my daily duties as a physics teacher in [redacted]. I do this so that these students have access to a physics course, a course that is the foundation for all other sciences.

We cannot educate effectively, online or in-person, without passionate and dedicated teachers with both content and pedagogical knowledge. Invest first in this infrastructure before we can build upon it.

PUBLIC SUBMISSION

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Comment On: NSF_FRDOC_0001-2546
Request for Information: STEM Education

Document: NSF_FRDOC_0001-DRAFT-0445
Comment on FR Doc # 2020-19681

Submitter Information

Name: (b) (6) [redacted]
Address:
(b) (6) [redacted]
Email: (b) (6) [redacted]
Phone: (b) (6) [redacted]
Organization: [redacted]
Government Agency Type: State

General Comment

I am a parent of 3 children in K-12; a professor in an early childhood education program where I teach the math and science methods courses; a STEAM resource teacher in a public elementary school and have been developing a new STEAM program; an advisor for a local children's science museum on virtual programming to help them stay afloat during COVID and am on their STEM Advisory Council.

"Future Opportunities in STEM Education, questions 1-2" (prek-12, schools, teachers/administrators)
I have found that one of the largest barriers are access to broadband and computers. I think our school district has worked to overcome it by providing laptops and devices to those who need. However, the school district cannot change the family's access to broadband. Another barrier is engagement. Teachers struggle to make the learning interactive. Students have multiple distractions when attempting distance learning and adults at home are often multi-tasking with their own work demands and unable to consistently supervise.

"Future Opportunities in STEM Education, questions 3 & 5" (prek-12, schools, teachers/administrators)
I have had success with using interactive strategies in my online teaching. I use a variety of Google Slides and Google Slides with Pear Deck for my presentations so my students (graduate/undergraduate and elementary school) can participate throughout the presentation. I have been fortunate to participate in professional development through my university (Online Teaching Initiative, OTI) and in the local public school district where I am a part-time STEAM resources teacher. These types of methods should

be shared widely so teachers (prek-12 and graduate/undergraduate) can make their teaching more experiential, engaging, and interactive for students. An additional affordance of teaching online is that more students participate in my classes using these strategies (quieter students are willing to write on the slides and there is accountability for all students to participate since they need to write their name or initials by their responses). The virtual ecosystem also lends itself well to different alternative assessment strategies that provide meaningful information about how and what my students have learned (e.g., Padlet, FlipGrid, Infographics, e-Essays, interactive timelines).

"Develop STEM Education Resources, questions 9-10" (prek-12, schools, teachers/administrators)
They types of resources I would hope to find on a STEM education website would be virtual field trips so students could engage in experiential learning even during the restrictions of distance learning. The virtual ecosystem has many affordances and students are able to "go" places unimaginable (the depths of the ocean, the planet Mars, and to different museums all over the world, such as the Louvre). There are there other places that would provide incredible learning experiences of global significance for students that have been untapped. For example, in my recent ITEST proposal, I detail how to develop AR/VR learning experiences for elementary students, specifically English Learners, inside managed bee hives so they can learn about these fascinating creatures while also learning about important conservation and food security issues. It is this type of immersive, problem-based, real world learning that engages students and peaks their interest in STEM and eventually STEM careers.

"Build Computational Literacy, questions 21-22" (prek-12, schools, teachers/administrators)
I recommend developing computational literacy through "unplugged" computer science activities. For example students can learn about algorithms and code through learning experiences that entail developing step-by-step instructions for others to follow (e.g., navigating an obstacle course, coding a robotic pet, drawing a monster). These types of learning experiences do not require a computer yet they teach the fundamental concepts for coding and more advanced computational thinking.

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Comment On: NSF_FRDOC_0001-2546
Request for Information: STEM Education

Document: NSF_FRDOC_0001-DRAFT-0442
Comment on FR Doc # 2020-19681

Submitter Information

Name: [redacted]
Address:
[redacted]
Email: [redacted]

General Comment

Dear Administrators,

I am a Baha'i-inspired vegan and I strongly encourage the implementation of a curriculum that encourages the transition from factory farming to biodynamic farming, a return to family-owned farms, and the elimination of the oligopoly of the farming industry in the United States.

This article may be helpful: https://medium.com/stem-and-culture-chronicle/title-1fa2f1a4c8

Sincerely,

[redacted]

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Comment On: NSF_FRDOC_0001-2546
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Document: NSF_FRDOC_0001-DRAFT-0441
Comment on FR Doc # 2020-19681

Submitter Information

Name: (b) (6) [redacted]
Address:
(b) (6) [redacted]
Email: (b) (6) [redacted]
Phone: (b) (6) [redacted]
Organization: [redacted]

General Comment

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

Hello,
My name is (b) (6) [redacted] and I am teacher, Senior Lead, CBE (Competency Based Education) Lead and Summer STEM lead at [redacted]. [redacted] is a [redacted] High School. This is our 2nd year as a CBE school and 1st official year as a [redacted] designated STEM school.
Being in various roles at [redacted], I have been able to analyze data from multiple sources. The gap that Ive experienced is developing a diagnostic assessment to determine student growth since many students were not able to take the SAT. Also, the development of an assessment aligned to STEM standards, allowing schools and school districts to accurately determine student growth in STEM skills and competencies.

Thank You,
(b) (6) [redacted]

[redacted]: STEM RFI Response

Increase Diversity, Equity and Inclusion in STEM

12. *What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?*

On June 3, 2020, [redacted] convened a [redacted] and charged the group to synthesize and prioritize the recommendations that had been made by students, staff, faculty, and community members in the days following the murders of George Floyd, Breonna Taylor, Ahmaud Arbery, Tony McDade, and several other unarmed Black Americans. [redacted] instructed the Task Force to be bold and thoughtful with their recommendations, to adopt the pace of a sprint rather than a marathon, and to complement other important work already underway on [redacted] community partnerships.

The Racial Equity Task Force released its report, [redacted] on [redacted]. On [redacted] the [redacted], accepting and endorsing the twelve key initiatives to improve racial equity at [redacted].

In their report the Task Force acknowledges that these twelve initiatives are a substantial undertaking for staff and administrative leaders who are already managing so much. It would certainly be simpler to target one or two problems in isolation and hope that everything else would fall into place. But the drivers of change are interrelated and interdependent. For example, campus climate affects the ability to recruit diverse students and to achieve and sustain compositional diversity of the faculty, which, in turn, affect the nature of curriculum and research.

Among the initiatives the four most directly related to increasing the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM are the following:

1. Making an immediate, significant financial down payment towards the systemic change required to do this work over the next five years is critical to catalyzing other changes.
2. Ensuring a transparent, consistent system of metrics and assessment will help us have a high impact return on this investment in racial equity. We must hold ourselves accountable and ensure that our actions follow through on our intentions.
3. As a public institution, we should serve the [redacted] equitably—so our student population should strive to reflect the racial and economic demographics of the [redacted], which will require bold commitments to recruitment and retention.
4. A lack of diversity amongst faculty is one of the main reasons people (regardless of racial identity) consider leaving [redacted], and most certainly harms our ability to attract top students. Doubling the amount of underrepresented minority faculty by 2030 would be tremendously beneficial to all aspects of the University.

These initiatives build upon the important work already being done at the University. For example, the [redacted] which is funded by a $3.2M grant from the National Science Foundation. The goal of [redacted] is to increase the number of women faculty, including URM women, in the STEM and social science disciplines. [redacted] has worked to create an empowered, participatory community that draws on the collective capacity of women faculty, their colleagues, and administrative leadership allies to identify and ameliorate the structural and cultural barriers to women's full participation in academic STEM careers. Through several clearly defined initiatives, [redacted] has engaged all faculty in open and authentic dialogue about a shared and inclusive future for the institution. As a result, much of [redacted] work has been codified in:

- Formation of the Directors of Diversity and Inclusion (DDI) program, which now boasts 32 DDIs across the University;
- New search protocols, including faculty search seminars, to ensure equitable searches;
- Establishment of a Dual Career Program, housed in the Provost Office;
- New promotion and tenure guidelines;
- Training and development activities for faculty and staff (including [redacted] which offers interactive performances around issues of equity in the workplace and classroom, and the OpEd program, which promotes faculty publication in media);
- Seminal social science results, including an ethnography project that collected oral histories of women in STEM;
- Research-based interventions to render institutional physical environments more welcoming, as well as more safe, for diverse groups; and
- Multiple publications, from journal articles and books to op-ed pieces in national venues.

[redacted] has integrated these initiatives into strategic efforts to improve and enhance the lives of women faculty in STEM/SBE. [redacted] material is now archived and fully searchable by interested researchers.

The remainder of this response provides additional information on the four initiatives from the Racial Equity Task Force report that directly relate to increasing the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM.

Initiative 1: ENDOW EQUITY at [redacted].

Goal: Dedicate the necessary financial investments for racial equity: – $100-150 million immediately for investments and spending over the next 3-5 years, $500-650 million in perpetuity by dedicating SIF resources for a permanent quasi-endowment, and $100-150 million collaboratively through challenge matching funds (50%) that incentivize targeted philanthropy (50%).

Suggested Implementation Partners: Board of Visitors; Office of the President; Chief Operating Officer; EVP and Provost; Office of Advancement; Division for Diversity, Equity, and Inclusion, Alumni Association

Recommended Strategies: [redacted] history confirms that without adequate resources, well-intended plans will never be realized. Racial equity ought to be a priority, and these efforts therefore must be adequately resourced, both in the short term and long term. The greater the resource commitment, the more credibility this effort will have and the greater the positive difference it will make. Without a substantial commitment of resources, the overall equity effort risks being dismissed as "just-another-exercise" and exacerbating longstanding frustrations among underrepresented groups and many others at [redacted]. What's more, the initiatives summarized in this report will demand a combination of saving money by greater results-oriented discipline (e.g., discontinuing programs that do not add value), higher impact on the investments already being made, and new investments.

<u>Initiative 2: Launch the EQUITY SCORECARD</u>

Goal: Develop a scorecard of institutional racial equity goals that are posted publicly, reviewed annually, and used in leadership performance evaluations.

Suggested Implementation Partners: Office of the President; Division for Diversity, Equity, and Inclusion; COO; Human Resources; Deans and senior administrators (all units)

Recommended Strategies: Leaders in higher education and healthcare, like most organizations, pay attention to what is measured. If the academic, career, and well-being outcomes of historically underrepresented faculty, staff, students, and alumni are not assessed regularly then they are not likely to get adequate leadership attention as indicators of institutional performance. Racial equity, among other dimensions of equity, can be an important indicator of an organization's performance. Measuring racial equity, on an equity scorecard, for example, permits leadership to monitor progress and performance along key measures of inclusive excellence. We recommend that [redacted] adopt an equity scorecard at an aggregate level that draws upon scorecards within each school and major operational/administrative division, including the Medical Center.

To implement the Equity Scorecard will require an investment in data infrastructure, visualization, and analysis. The Division for Diversity, Equity, and Inclusion, in partnership with the Office for Institutional Research and Assessment, the Vice President for Student Affairs, University Human Resources, the Provost's Office, and other networks and offices at [redacted] can assemble the data necessary to evaluate the equity indicators on an annual and longitudinal basis. With the support of the Division for Diversity, Equity, and Inclusion, University-affiliated organizations such as the Alumni Association, the University Investment Management Company, and the many other University-related foundations are also invited to participate in the equity scorecard process as part of their annual reporting or other public transparency initiatives.

The following table summarizes an example student lifecycle indicator set across multiple dimensions of inclusive excellence.

Key Metric/Indicator	Equity Disaggregation Analysis by:
Recruitment Contacts	Race/ethnicity
Applications	Gender identity
Admission Offers	Sexual Orientation
Yield Rates	Economic Status
Enrollment	Age
Net Price	First-generation Status
Unmet Need	Military Veteran Status
Retention Rate	Disability Status
Program of Study	Athlete Status
"Gateway" course completion/performance	Immigration Status
Sense of Belonging	
Experience of Bias	
Perceptions of being Valued	
Effective Mentoring & Advising	
Trust in the Institution	
Transfer Rate	
GPA	
Learning Outcomes Assessments	
Graduation Rate	
Cumulative Debt	
Loan Repayment Rate	
Graduate Education Rate	
Employment Rate	
Academic Employment Rate	
Median Earnings	
Public Service	

Initiative 3: Commit to [redacted] in student body demographics

Goal: Recruit, admit, and support an undergraduate population that reflects the racial and economic demographics of the [redacted].

Suggested Implementation Partners: Office of Undergraduate Admission; Schools and The College; Student Financial Services; Division for Diversity, Equity, and Inclusion; Equity Center; Office of Student Affairs; Office of African American Affairs, Office of Advancement, [redacted], and other partners

Strategies: Racial equity with respect to the composition of [redacted]'s student population requires us to rethink, redesign, and replace policies and practices that perpetuate historical underrepresentation of certain racial groups.

Research indicates that three primary factors influence students' college choice decisions: a) institutional prestige, or perceived academic reputation; b) cost of attendance and/or availability of financial aid; and c) culture or fit. Drawing upon this research, as well as [redacted] admissions survey data, we make the following recommendations to advance our goal of attracting and attaining a more representative student body:

1. *Address the Cost Barrier:* A recent [redacted] study indicates that students from historically underrepresented groups are more likely than other groups to perceive [redacted] cost and

culture factors negatively. Likewise, [redacted] more frequently encounters negative perceptions or reactions associated with cost of attendance from out-of-state students who absorb higher tuition costs and weaker financial aid packages.

2. *Address the Culture/Fit Barrier:* We must address culture/fit concerns at [redacted], particularly among prospective African American, Latinx, first-generation, and low income students, more than a few of whom report that they perceive that "[[redacted]] is a school for rich white kids."
3. *Expand Recruiting Efforts:* While we work to address cost and culture, we can simultaneously improve University-wide efforts to recruit historically underrepresented students to apply and enroll. To better attract these students, the University needs to develop sustained early-identification and intervention efforts.
4. *Improve applicant evaluation and admitting procedures:* The University must remain committed to offering holistic and comprehensive review of applications, in an effort to promote and advance a racially equitable system of admission. Graduate and professional schools should affirm that their mission statements support a similar holistic approach to admissions, including a recognition of the compelling interest of promoting diversity within the schools and across the greater University.
5. *Improve Retention and Completion Supports:* Retention pertains to everything from student academic support to the student experience and overall wellness and happiness. For the past 25 years, the African American retention and graduation rates are the highest of any public institution in the United States. Nevertheless, African American graduation rates still lag behind those of white students.
6. *Ensure a University-Wide Student Life-Cycle Commitment:* It should be an institutional commitment and priority to ensure that students from historically underrepresented groups feel welcomed and supported in their efforts to thrive.

Initiative 4: Launch INCLUSIVE FACULTY INITIATIVE

Goal: Reform search, hiring, mentoring, promotion and retention practices and double the number of underrepresented minority faculty—currently approximately 200 out of a total faculty of 3,000—by 2030.

Suggested Implementation Partners: Provost, Deans, and Department Chairs, Division for Diversity, Equity, and Inclusion

Recommended Strategies: [redacted] suffers from a chronically and disproportionately low number of faculty from historically underrepresented populations. Despite various initiatives to close this gap in faculty hiring and retention, however, the proportion of [redacted] faculty who identify as African-American, for example, has hovered between 3-4% for the past 10 years. This underrepresentation is problematic as a matter of governance because decision-making on curricular and academic matters is largely vested in the faculty. It is also problematic as a matter of education and academic service, as minority faculty provide a disproportionate share of the mentoring for minority students. [redacted] must change existing practices and adopt new strategies, requiring leadership attention, commitment, accountability, and financial resources, to achieve a composition of faculty that is more representative of the world in which we live.

There are four main elements to building an equitable and inclusive faculty: hiring, mentoring, promoting, and retaining. We also recommend a fifth item: building a pipeline.

HIRING FACULTY– There are several tools and strategies that [redacted] should immediately employ, including:

1. Establish Goals and Expectations.
2. Use Data for Accountability and Decision-making.
3. Better Educate Search Committees.
4. Introduce New or Supplemental Faculty Lines to Encourage Inclusive Excellence Hiring.
5. Refine Targeted Hiring Programs.
6. Improve Cluster or other Cohort Hiring Programs.

MENTORING FACULTY – [redacted] can significantly improve the quantity and quality of mentoring it offers to faculty to improve their ability to navigate traps faced frequently by members of underrepresented groups. We recommend the following:

1. Improve Mentoring for New Faculty.
2. Protecting and Crediting Time.

RETAINING FACULTY – [redacted] must work harder and smarter to retain existing faculty. To achieve this, we recommend the following:

1. Establish a Faculty Defense Fund.
2. Conduct a Regular Pay Equity and Market Audit.
3. Commit to the Hard Work of Culture and Behavior Change.

PROMOTING FACULTY– We recommend a wholesale review of [redacted] Promotion and Tenure policies. Because of the importance of this recommendation, we have highlighted it as its own initiative for this report.

BUILDING A PIPELINE – Investing in the future of equitable teaching and research, not only at [redacted] but beyond. To achieve this, we recommend the following:

1. Embrace the Opportunity to make [redacted] a “Pipeline University.”
2. The Provost can work with the schools to create a set of postdoc positions in areas of strategic importance to the University where the positions are explicitly anticipated (and advertised) to lead to a faculty offer, subject to satisfactory performance.
3. The College should be encouraged and resourced to expand its Dean’s Doctoral Fellowships and Bridge to the Doctorate Program initiatives.
4. Establish a distinguished visiting junior faculty program (“super-postdocs” with research funds and small teaching expectations) to attract the best candidates.

Responses from some of the member societies of the [redacted] to questions #6, 12, 20, 21, and 22.

Future opportunities in STEM Education

#6. *What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?*

[redacted], working with [redacted] and [redacted], is collecting information on the impact of COVID-19 on mathematical science departments this fall. Data that societies would like to see collected:

- How often and to what extent is science being taught during the TK-12 school day?
- What opportunities do students have to engage with 21st science and mathematics content and literacy in relevant ways?
- How is instruction of mathematics in higher education changing to include high-quality research-based pedagogy, culturally-relevant mathematics, ethnomathematics?
- How is STEM defined by teachers, schools and districts?
- Is STEM synonymous with Science?
- Does STEM instruction occur only when integrated across Science, Technology, Engineering and Mathematics? Are individual disciplines "stem"?
- It is important to understand the data on persistence (or drop-out) of women and underrepresented populations at all levels (including elementary and high school students through tenured professors).
- Publication data on all academics, but particularly on women and underrepresented.
- Participation rates over time in research collaborations, conferences, and seminars.
- What mitigation strategies are underway at various levels (students/faculty), what measures of effectiveness are being used and what are the outcomes.
- information/data that provides insight into how rural or economically disadvantaged students (who may not have the same access as other students in urban areas or who are financially stable) or students in single-parent families are performing or persisting should be collected

Increase Diversity, Equity, and Inclusion in STEM

#12. *What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?*

MoMath. The National Museum of Mathematics has run online programs targeting underrepresented groups, specifically inviting female students and Black students to attend. In short, these programs bring accomplished mathematicians from underrepresented groups together with participants, in intimate sessions during which the mathematicians share their personal stories and the participants are welcome to ask questions of all sorts. Our hope is that we can encourage students to view mathematics as a place that will be welcoming to them, and as a career path in which they can be successful. You can see more about these programs at nolimit.momath.org and arc.momath.org.

TODOS. The organization provides professional development and resources about mathematics through the lens of equity, social justice, emergent bilinguals, latina/o/x students, other marginalized population of student that calls for changes in the mathematics that is taught and how the mathematics is taught. Membership includes educators in TK-12 and higher ed. Success is measured through social media, increase in membership numbers, website visits

AWM. The purpose of the Association for Women in Mathematics is to encourage women and girls to study and to have active careers in the mathematical sciences, and to promote equal opportunity and the equal treatment of women and girls in the mathematical sciences.

Everything we do is done with the intention of increasing diversity, equity and inclusion in STEM. The methods we use include building community, establishing mentoring relationships, raising visibility of underrepresented populations through meeting, outreach and advocacy, and engaging women at all levels.

Specific Programs
Research Networks: focused on establishing research networks for women by fostering research collaborations at conferences and AWM Workshops.
Success is measured by participation numbers, publications and follow-up activities.

Mentor Networks: designed to provide mentoring opportunities to girls and women. Students who are interested in mathematics or are pursuing careers in mathematics are matched with mentors, both men and women.
Number of matchings is recorded and annual surveys of mentors and mentees are collected.

Student Chapters: Membership in student chapters is open to all regardless of gender identity or expression, race, color, religion, age, national origin, sexual orientation, or disability. Check out what the chapters are up to and see how you can get involved or start one below.
There are over a hundred AWM student chapters nationwide making waves in the mathematics community.

Outreach: Essay Contest, Sonya Kovalevsky Days, National Math Festival. Our members are present and volunteer at events to raise visibility and serve as role models for girls interested in mathematics and science.

SIAM. SIAM has established a Diversity Advisory Committee. The committee acts as a steering committee to provide oversight for the development of the Workshop Celebrating Diversity at the SIAM Annual Meetings. The committee sets the general guidelines for the Workshop so as to present a consistent presence at the annual meetings. The guidelines give an overview of the format of the Workshop Celebrating Diversity, including whether it is run as a separate meeting or is blended into the annual meeting.   The committee is encouraged to bring to the attention of the SIAM Council other opportunities to promote diversity within the community served by SIAM.

The committee is available for consultation on diversity issues that come to SIAM's attention through the membership or the activities it sponsors. This may include help in developing topics for articles in *SIAM News*, providing counsel to the SIAM Committee on Programs and Conferences and chairs of conference organizing committees, and assisting in collection or management of data related to questions of diversity. SIAM has expanded its capacity in addressing issues of diversity and inclusion by creating a new position, Vice-President for Equity, Diversity and Inclusion (EDI) , that will go into effect January 1, 2021. It is expected this position will review and advance EDI efforts throughout all of SIAM.

Build computational literacy

#20. *What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery*.

TODOS. Computational literacy broadens the scope of relevant mathematics made accessible to students, it supports the de-emphasizing of the memorization of procedures or time used to teach knowledge-level or low cognitive demand mathematics, while creating opportunities to obtain deeper conceptual understanding of topics, problem-solving, mathematical modeling . Challenges: "Technological resources are not a replacement for teaching; rather they are tools to aid us in meeting our instructional goals and to help us foster relationships from afar." (TODOS Commentary: Equity Considerations for Access, Design, and Use of Technologies for Teaching Mathematics). The misunderstanding of computational literacy and its purpose and how it works in tangent with other disciplines.

SIAM-NCTM-COMAP joint Committee on Mathematical Modeling/SIAM
Benefits: Computational literacy enables people to make informed quantitative decisions. There can be no doubt that this can improve the quality of life for citizens in general. Computational Literacy connects to mathematics curriculum by emphasizing algorithmic approaches to problem solving while also providing opportunities to explore how and why to engage with authentic data sources; highlighting the need to learn classical mathematical tools. Additionally computational literacy enhances mathematics by providing insight and approaches for communicating mathematical thought.

However, integrating computational literacy topics into STEM classrooms, including math classes, faces significant challenges because few teachers have experience with computational literacy topics. As a result, K-12 teachers need support from administrators and opportunities for professional development in the area. Researchers in math education, math educators and teacher leaders need support to build best practices and curriculum so that future teachers enter their classrooms prepared to highlight computational literacy. Furthermore, students may not have equal access to computational resources or support at home to complete activities, there are so many tools to choose from, it is hard to know where to begin, there is a need for established and vetted curricula and assessments.

#21. *What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.*

TODOS. Data literacy, the quantitative nature of the world warrants the need to provide students the ability to use the data to improve their communities and own quality of life. To be able to defend themselves against the use of data to oppress their communities and self.
Computer science, the ability to design and analyze algorithms, to be able to determining what problems can be solved with computers and the complexity of the algorithms needed that solve the problem also provide students the skills to interact with, question and contribute solutions to the misuse of algorithms.

SIAM-NCTM-COMAP committee on Mathematical Modeling: Mathematical modeling can require the use and analysis of data/simulation to make decisions or predictions and promote computational literacy while allowing students to have ownership over their problem solving. Math modeling allows for students to explore interdisciplinary open-ended problems with an emphasis on communication and collaboration addressing numerous 21st century skills.

#22. *What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.*

TODOS. Not aware of existing programs, content, curriculum or education opportunities that integrate an antiracist/social Justice lens, integrates stem disciplines and literacies at grade-appropriate levels or that frame mathematics as more than computational algorithms or algebraic manipulation and is cohesive.

SIAM-NCTM-COMAP committee on Mathematical Modeling: The Math Modeling Hub is a place for collaboration and sharing modeling curriculum and support for teachers who want to integrate modeling into their classrooms: https://qubeshub.org/community/groups/mmhub

SIAM The SIAM Mathworks Math Modeling Challenge is a resource for teachers and students (juniors and seniors) to get started in math modeling. Their webpage is rich in resources with examples, guidebooks, videos, and ways to connect with people for support. They also have provided teacher professional development workshops in math modeling.
https://m3challenge.siam.org/

Similarly, COMAP has a plethora of examples and resources on math modeling:
https://www.comap.com/highschool/contests/himcm/index.html

Another resource we were pointed to is the Foundations of Applied Mathematics as a project that demonstrates a successful combination of programming and traditional instruction. From their site https://foundations-of-applied-mathematics.github.io/ When used in concert with the free supplemental lab materials, this book teaches not only the theory but also the computational practice of modern mathematical methods, inviting students to engage deeply with the mathematical ideas and guiding them to technical proficiency while answering the age-old question “When am I going to use this?”

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Request for Information: STEM Education

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General Comment

As we consider how to better support communities of color through STEM education, representation and context are critical. Through our work with NBA Math Hoops, we have scaled a program that is relatable and allows students of color to authentically see themselves in their learning. In 2019, Black and Latinx students outgrew all other participating students in the program by 5-6x, as part of our annual third-party analysis. Unfortunately, when surveying the field, we struggle to find a large number of peers that share our vision for inclusiveness. We strongly encourage future STEM funding opportunities to reward those who create inclusive context for our communities of color.

NSF Request for Information Responses: STEM Education

[redacted]

These responses are representative of the [redacted] and tie to the work done by the [redacted] through the [redacted].

Responses:

- Future Opportunities in STEM Education, questions 1, 6
- Increase Diversity, Equity, and Inclusion in STEM, question 12
- Develop and Enrich Strategic Partnerships, question 18
- Community Use and Implementation of the Federal STEM Education Strategic Plan, question 24

Future Opportunities in STEM Education, question 1
Written by the [redacted]

COVID-19 helped highlight several digital barriers to education, including STEM education. Several of these obstacles are preventing effective and efficient access to quality education, let alone STEM education.

The first issue is universal broadband access. Students are limited in their capacity to engage educators without broadband access, even if students received educational resources through a thumb-drive or borrowed computer. Many students and some educators were limited in their bandwidth to communicate, limiting educational resources and any sense of reliable measures for student success.

Quality education presented virtually also became a hardship for many schools. There was a considerable equity gap between schools that were more used to implementing educational technology and those who have not had as much experience with online learning tools and techniques. Educators, students, and even parents more familiar with virtual tools benefited considerably compared to families or schools just introducing technology to help replace or compliment educational experiences.

Lastly was the quality of online educational resources for educators. Identifying quality programming and assessments to help continue the school's efforts to educate youth took considerable time. This curricular search delayed our capacity to adapt because there was a lack of vetted, reliable, quality resources available, especially without spending a fair amount of funding and time to prepare educators.

Future Opportunities in STEM Education, question 6
Written by the [redacted]

[redacted] collects information through both the [redacted] and the [redacted]. The data currently tracks general siloed scores within the disciplines; however, we collect little data in STEM specific categories except for STEM enrollment in post-secondary programs and STEM graduates from post-secondary institutions. It would be helpful if there were a universal way to procure the data that would show us STEM engagement, whether formal or informal, at the PK-12 level and resilience at the post-secondary level. It would help to see the touchpoints while students are in the public education setting and how these various opportunities may have better-prepared youth to enroll and succeed in their STEM programs at the post-secondary level. We lose many children through this pipeline. It would help if these youth's initial interests were better supported and see themselves through the programming towards STEM degree/certification success. A universal model to track individual students would be better than looking at the enrollment numbers versus percent obtaining a final degree in a STEM field.

The potentially larger issue is a consistent definition of what counts as a STEM career and, therefore, a STEM major. If we are to collect and analyze the data, common terminology and descriptions would help collect and interpret data. As long as the Federal Government maintains inconsistent definitions, it is hard for the state to declare a consistent definition.

Increase Diversity, Equity, and Inclusion in STEM, question 12
Written by the [redacted]

The State is currently engaged in ways to make STEM more accessible for all [redacted] youth. Numerous areas need change and support to ensure that all [redacted], especially those underserved and underrepresented in STEM programming, see themselves as STEM capable and competent students. These changes will be the only way to help them identify the pathways and opportunities that would most likely lead to their success. One of the first approaches is looking at Governor School programs' admissions policies and reaching further down into the feeder systems, helping create the experiences that would help support students' interests and enthusiasm for the topics. Taking a page from some of the National leaders, such as Jeff Weld's work, we decided to form regional hubs or networks to help reach localized audiences. STEM Hubs would help create a more regional support system and highlight local STEM jobs/careers and create regional champions for STEM. It is essential to develop this relevance to help make the concepts more tangible. It also helps to build up support within the community and family structure. If we spark a child's excitement, that interest needs support before that enthusiasm wanes. Localized hubs would be a more tangible contact for resources and events realistic for families throughout a relatively large state.

Develop and Enrich Strategic Partnerships, question 18
Written by the [redacted]

Work-based Learning is a significant initiative of the [redacted] and the [redacted]. It is essential in [redacted] that we to help students identify potential career pathways and learn how to apply better the skills procured in a formal classroom setting to a real-world environment.

Work-Based learning is not interpreted the same across the [redacted]. Different businesses, schools, and even variances between high school and college change work-based learning expectations. Establishing more consistent outcomes and a protocol to initiate some conversations would support the program's growth. [redacted] is developing their plan; however, it would be helpful if guidelines were better established at a Federal level, helping create consistency between companies that stretch beyond state boundaries.

Writing legislation that would make businesses feel more secure in allowing youth in high school, typically younger than 18, participate in real-world work scenarios would support more work-based learning opportunities. Many companies feel limited in what experiences they can provide students due to regulations or potential litigation. Federal policies to help curb these concerns would enable more youth in their participation.

Another concern is the ability to pay youth. Many students cannot participate as a result of transportation or the need for part-time employment. This restriction limits the students that are capable of participating, creating inequities in opportunities. Payment for work-based learning would go a long way to eliminate unnecessary boundaries that prevent some from taking advantage of this enriching experience.

COVID has impacted participation in the spring of 2020, ending many programs as many employees were laid off or furloughed from these same businesses. It is too early to see the full impact of these relationships for the 2020-2021 school year; however, there will likely be fewer work-based learning opportunities this upcoming year. Hands-on, in-person experiences generate value in work-based learning experiences, many of which are highly regulated at this time.

Community Use and Implementation of the Federal STEM Education Strategic Plan, question 24

Written by the [redacted]

The Federal STEM Education Strategic Plan was used to help develop the decision statement to create a [redacted] STEM Education Commission, resulting in developing a STEM Education Commission Final Report/Plan. Jeff Weld, one of the authors/editor for the Federal STEM Plan, presented at a [redacted] STEM Summit [[redacted] helping us secure the interests and assist us in defining the Commission's goal in the development of a [redacted] focused STEM initiative. The culminating result is a [redacted] STEM Education Commission Final report with suggestions for the next steps. This Final Report proposes a unified vision, mission, and goals for a STEM literate culture and workforce in [redacted]. [redacted]]

The Federal STEM Education Strategic Plan would be of more assistance if common language were created and shared between Federal Agencies. There appears to be some variance between the definitions of STEM, STEM Careers, and even students of need between the different agencies. If [redacted] could identify one consistent definition for specific terms used at the Federal level, it would further help us create a common language in our STEM growth. Universal terminology is one of the more considerable weaknesses that need addressing if we continue our growth and advancement in STEM.

[redacted]

[redacted]: STEM RFI Response

The [redacted], managed by [redacted], is a multi-state STEM network that provides an accessible platform to share, analyze, and disseminate quality STEM education tools to transform education, increase the number of STEM teachers, and increase student achievement in STEM. The network is composed of leading STEM organizations across 19 states. Additionally, the [redacted] and the [redacted] are managed by [redacted]. Our portfolio is built on over a decade of research on successful STEM collaborations, and seeks to nurture and scale effective science, technology, engineering, and math (STEM) learning opportunities for all young people.

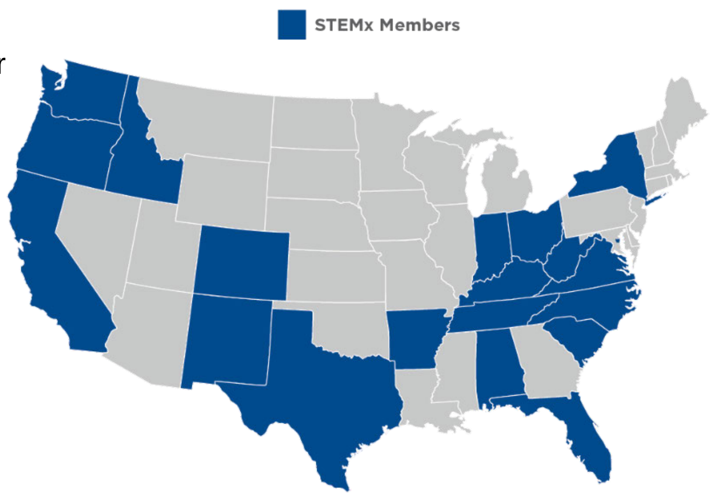

Figure 1. [redacted]

The responses to the following questions were collected from the [redacted] members during a network convening in September 2020. [redacted] staff compiled the answers and prepared the following responses to the OSTP STEM RFI.

<u>Future Opportunities in STEM Education</u>

8. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful? (Education system: preK -12; addressing: teachers/learners/community partners, policy makers)

[redacted] members reported the following interventions were successful responses to the COVID-19 shift to virtual education in Spring 2020. (Similar interventions from various [redacted] members are grouped together).

1. **Facilitating conversations and spaces for teachers to connect and share ideas.** The PAST Foundation started a teacher chat for teachers who needed an outlet to vent and run ideas by one another and talk about challenges and common struggles. The Ohio STEM Learning Network (OSLN) created STEMthusiasts, a community of practice for STEM teachers transitioning to virtual learning; Indiana STEM Network hosted a series of webinars to connect teachers to resources, and learn technology tools, i.e. Google extensions and education apps.

2. **Create/Curate Resources: [redacted] members reported creating a number of resources for teachers and families. Below are some examples:**
   https://www.pastfoundation.org/stem-streaming
   www.nmsteamhub.com
   https://www.tsin.org/covid-19-steam-resource-hub
   https://www.futureengineers.org/startasmile

3. **Partner with other organizations to continue to focus on and support STEM**. South Carolina STEM Network partnered with SEL4SC to connect SEL to STEM education. Virginia continued collaboration with the state STEM commission to advance the conversation on the value of STEM literacy and published an article elevating the importance STEM literacy should have.

Barriers: Overall, [redacted] members pivoted to provide programming, engagement, and advocacy in a virtual setting, and reported that most of those efforts were successful. However, some members elected to cancel events that required a high degree of hands-on, or place-based interactions—because switching those programs to virtual would significantly diminish the quality or overall impact of the planned program. Other members reported that lack of equitable access to Wi-Fi/broadband was a barrier to engagement, while some organizations reported that it was challenging to determine which program offerings would be the most valuable (and original) when so many schools and organizations vying for user attention. Lastly, the biggest barrier reported was funding reductions, particularly in workforce development funding lines.

Increase Diversity, Equity, and Inclusion in STEM

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success? (Education system: preK -12, and adult; Target population(s) for intervention: teachers, students, adults)

[redacted] members reported the most successful outreach methods targeting underrepresented groups included:

1) Leveraging organization's Employee Resource Groups (ERGs) to connect with community members they represent
2) Incorporating mentorship programs and career panel discussions with local schools to promote student self-identity in STEM fields, and
3) Evaluating and adjusting admissions and application policies/processes to remove barriers for these students.

Target Populations: rural students, students of color, female students, and students with disabilities

1. **The Tennessee Rural STEM Collaborative incorporated data driven tools, such as the Lumina Foundation's *Stronger Nation Report*, to identify rural counties across Tennessee that have low educational attainment rates beyond high school in STEM**

fields. The intention is to recruit rural educators in these counties with the goal of increasing student interest in postsecondary STEM fields. To evaluate the effectiveness of this strategy through student surveys, teacher logs, and annual reporting measures, TSIN partnered with the Center for Research in Educational Policy through the University of Memphis.

2. **The National Renewable Energy Laboratory prioritized funding to compile and deliver kits of energy-related materials to Title 1 schools across Colorado**, identified through the percentage of students that qualify for free and reduced lunch, to facilitate transdisciplinary learning experiences through "The Grid" program for grades 4-8. This program included parental/guardian support to help families better understand the benefits of STEM education in traditionally underserved communities. Pre/Post surveys are an effective tool to capture evidence of success.

Engage Students Where Disciplines Converge

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach and how does it benefit your students' learning? (Education system: preK -12; addressing: teachers, learners and community partners)

[redacted] members are hyper-focused on leveraging transdisciplinary learning and engineering design as a vital part of their outreach efforts.

1. **State-wide Design Challenges:** Each year, Ohio and Tennessee host a design challenge where students collaborate to create workable solutions to the key issues facing their communities. Any school may participate. The 2020-21 #STEMpowersOhio Design & Entrepreneurship Challenge explores the topic of Energy through our partnership with the Ohio Energy Project. This effort is provided with the support of Constellation Energy, a company that serves more than two million customers across the continental United States

2. **STE(A)M Resource Hubs:** In partnership with the SEA, TSIN developed a series of STEAM-connected transdisciplinary learning activities for students and teachers. The learning content aligned to STEM CTE clusters and followed an integrated framework: MakerMonday – students use the engineering design process to develop a solution, WonderWednesday – students use sketchnoting and other tools to generate authentic questions, FutureFriday – students explore careers related to the topic and CTE cluster connection.

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way? What specific delivery mechanism work well for you (e.g., online course, webinar, in-person workshop)? What technology tools would be helpful for you when using a transdisciplinary approach? (Education system: preK -12; addressing: teachers, learners and community partners)

[redacted] members reported the following PD approaches were successful based on survey data and participant feedback. Similar characteristics from various [redacted] members are grouped together.

- **Placing the teacher in the role of the learner** so that they experience the learning process similar to the student experience before implementing in the classroom.
- **Modeling transdisciplinary learning skills:** collaboration, researching from multiple sources, learning guided by essential/overarching questions.
- **Integrating multiple content area standards and modeling applied learning.**

Program example that incorporates the above characteristics:

The Innovative Leader's Institute (ILI): Year-long cohort program for administrators that seek to cultivate a STEM culture school-wide. The ILI provides participants opportunities to network with other building-level leaders from across the state, visit innovative STEM Designated Schools to examine different models of STEM integration, and share best practices and resources with the expectation of having an immediate impact on leader practice and preparedness for STEM School Designation. The TSIN and OSLN manage separate versions of this program in their respective states.

Manufacturing and Engineering Externship Program (MEEP): Teacher professional development program managed by TSIN and OSLN. Tennessee and Ohio K-12 teachers participate in summer externships at local manufacturing and engineering work-sites, to gain a better understanding of needed skills in various workspaces. PBL training is provided for participating teachers to equip them to lead PBL lessons in their classrooms, based on their externship experiences. Students will gain exposure to STEM career fields through the PBL lessons.

Develop and Enrich Strategic Partnerships

18.What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization adjusted in response?
(Education system: preK -12; addressing: teachers, counselors, industry partners and federal agencies)

[redacted] members provided the following best practices for successful WBL programs:

- **Adult awareness of pathway programs:** provide teacher externship programs, counselor information sessions, so they can appropriately refer students to WBL programs, and reinforce work skills in the classroom.
- **Define expectations and set structures that support WBL programs:** employer should have well-defined expectations of what the student can do while on-site; create systems to handle age-restrictions, provide transportation to work-sites, offer pay to participating students; provide mentors for participating students so they can overcome obstacles while at the work-site.

Federal agencies should prioritize WBL for K-12, instead of exclusively focusing on college-level placements.

Covid-19 implications for WBL programs: some programs were canceled due to employer closures; some programs shifted to online engagement opportunities; members reported that support for WBL programs diminished in light of layoffs and furloughs – as it is difficult to justify students working when layoffs are occurring.

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began? (Education system: preK -12; addressing: teachers, counselors, community stakeholders)

[redacted] members have seen tremendous success due to the diversity of stakeholders engaged in candid conversations that allows for the opportunity to **1) build a common language** among stakeholders, **2) build an awareness of synergistic work and common barriers** across organizations, and **3) openly sharing best practices and lessons learned** to greatly increase advocacy and impact. Successful characteristics included:

- **Adopting a shared set of values and/or focus areas connected to stakeholder priorities.** When there is a robust network of advocates for STEM education in place this work survives, grows, and thrives despite the complexities.
- **Sustainability planning** is another critical component of successful ecosystems as leadership transitions, external influences, and shifting priorities all impact the educational landscape. When there is a robust network of advocates for STEM education in place this work survives, grows, and thrives despite the complexities.
- **Having a forward-thinking strategic plan that is flexible and adaptable as needs arise** shapes the ability of a STEM ecosystem to pivot and adjust the collective approach when unforeseen challenges arise – such as a global pandemic.

Private Sector: Successful STEM learning ecosystems leverage private sector partners routinely and fold them into the programmatic and strategic planning process to determine where their support will have the greatest impact. Many states in the [redacted] have regional STEM hubs that serve areas of their respective states. These hubs and district/school level partners benefit from consistent leadership that provides clarity around workforce development goals and essentially being a primary point of contact to connect those with the skillsets and resources to support STEM education nationally.

COVID-19 Supports: Since the shutdown of many school systems, our partners have conducted listening tours, virtual professional learning communities, and been a source of support as the educational community has needed to retool and rethink the way they approach STEM instruction.

<u>Build Computational Literacy</u>

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention. (Education system: preK -12; addressing: teachers, counselors, curriculum writers).

Computational Thinking (CT) – CT encompasses a set of processes that defines a problem, breaks it down into components, and develops models to solve the problem, then evaluates the result, iterates changes, and does it again.

- CT is increasingly seen as a set of broadly valuable thinking skills that helps people solve problems, design systems, and understand human behavior, and that **can be learned at a very young age without involving computer coding.**
- In an increasingly technological and complex global economy, CT needs to be an integral element of all education, **giving every learner the capacity to evaluate information, break down a problem, and develop a solution through the appropriate use of data and logic.**
- **CT skills are transferable to any other curriculum area** but are particularly relevant to developing digital systems and solving problems using the capabilities of computers.
- Our partners have leveraged both **unplugged (without a computing device) and plugged (with a computing device) activities** to bring computational thinking into their classroom. Unplugged CS activities can transcend deep barriers in rural and urban communities in terms of access to technology, broadband, and/or functional devices while exposing students to CT practices.

1. The TSIN and OSLN have expanded CS exposure through the Code.org Regional Partnership Program, training hundreds of teachers in grades K-12 to incorporate CS curriculum that includes CT practices and unplugged activities.
2. The TSIN has developed synchronous/asynchronous online courses for educators who serve grades K-8 that incorporate CT thinking and the CS state standards into core content areas of ELA, Math, Science, and Social Studies. Further solidifying the idea that CT is a valuable set of thinking skills applicable to any content area or career field.

Community Use & Implementation of the Federal STEM Education Strategic Plan

24. Please describe how your organization has used the Federal STEM Education Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?

[redacted] members report that the Federal STEM Education Strategic plan has been a valuable tool to create a common understanding of language, set organizational and state-level goals that are aligned to the Federal plan, and as a way to emphasize the value and importance of Collective Impact. [redacted] members report that they share the plan consistently with State Education Agencies, legislators, and stakeholders; use it to justify future funding; and guide current priorities. West Virginia reports using the plan as the basis for the state STEM initiative. When the plan was first released, [redacted] hosted a series of webinars to share various sections of the plan, so members could align their priorities and strategies to the plan. We posted the plan on the [redacted] website, and the plan was viewed 475 times.

Please direct any comments or questions to [redacted]

[redacted]

[redacted]: STEM RFI Response

I represent a non-profit STEM organization. I am responding to the following questions: Future Opportunities in STEM Education question 1, Increase Diversity, Equity, and Inclusion in STEM question 12, Develop and Enrich Strategic Partnerships question 18, and Community Use and Implementation of the Federal STEM Education Strategic Plan question 24.

Future Opportunities in STEM Education question 1)

As a result of the COVID-19 pandemic, most schools and informal education institutions (including all [redacted]) were forced to close in March 2020. Most students finished the academic year learning from home, using internet-connected devices provided by parents or schools. This situation continued through the summer, and it now seems that most students will continue to learn from home for at least the first half of school year 2020-21. Even if schools open in spring 2021, they may forego field trips and other in-person, informal education programs due to budget and time constraints or continued social distancing requirements. This means that students may have significantly less opportunity to engage in STEM-themed programs normally delivered by [redacted] and other informal education institutions during a school year.

Given this situation, we see three significant barriers: 1) devices and connectivity, 2) student isolation, and 3) reduced access to informal STEM education. We are taking steps to address all three issues.

DEVICES & CONNECTIVITY: Our greatest challenge is related to student access to computing devices and internet connectivity. According to the Center for Democracy and Technology, out of the 50 million children learning remotely, between 15 and 16 million children lack adequate internet connectivity. The Household Pulse Survey found that 4.4 million students lack consistent access to a computer. As we switched to virtual programs from in-person field trips, our programs are now limited to school districts and individuals that have access to computing devices and internet connection. To implement programs, some of [redacted] are lending devices, hotspots, and other equipment to families and school districts.

STUDENT ISOLATION & REDUCED ACCESS TO INFORMAL STEM EDUCATION: Students are losing a lot by not being able to interact in-person or engage in hands-on STEM education via informal STEM education providers. Children begin to think logically and understand concrete concepts through play (Piaget, 1976). The hands-on aspects of play encourage students to explore and absorb concepts fully as they apply what they learn. Due to social distancing, students cannot play with their peers. In addition, it is well-known that students gain a deeper understanding of STEM when they engage in hands-on activities and work in collaboration with peers. Informal STEM education providers like [redacted] specialize in delivering play-based, hands-on, experiential STEM education.

To address these barriers, [redacted] is creating programs that help students collaborate and play in a virtual world. Virtual Missions are participatory simulations for 5th-8th grade students that are delivered via the internet. Virtual Missions leverage videoconference functionality embedded in our web-based platform, enabling informal [redacted] educators to deliver the experience to students attending school virtually or in-person.

Virtual Missions put STEM concepts into the context of an exciting space mission. Each mission includes a ~one-hour participatory simulation in which students role-play as scientists and engineers who collaborate to analyze data, solve problems, and ultimately achieve an exciting goal. Each team is presented with standards-aligned STEM concepts and they communicate, collaborate, and problem-solve together as they explore Mars' moons or launch a rocket to the Moon. These missions were developed in partnership with NASA and U.S. commercial space companies.

Increase Diversity, Equity, and Inclusion in STEM question 12)

[redacted] serves over 250,000 students a year, primarily through our network of [redacted]. Our programs are designed to serve a typical class, which can include high-need, typical, and gifted students, as well as underserved and/or underrepresented students including minorities and girls, and students from rural and low-income communities. We operate in 40 communities in the US, from inner city neighborhoods (e.g., Ferguson, MO; lower Manhattan, NY) to rural towns (e.g., Hazard, KY; Kenai, AK; Woodstock, IL) to locations with high minority populations (e.g., Harlingen, TX, Ferguson, MO, Downey, CA, Las Cruces, NM). [redacted] overall constituent distribution is 50% female, 13% African American, and 18% Latinx. Every [redacted] serves schools with high minority student populations. Over 60% of the students the [redacted] serve are from Title I schools, meaning that most [redacted] students come from low income households.

Our programs are group experiences designed for a typical school class; a class can include students with a range of prior experiences and educational needs, including students underrepresented in STEM such as minorities, girls, and students from rural and low-income communities. Our theory of change is: Participatory simulation deepens student engagement in STEM. Through role-play and exposure to a range of STEM occupations, underrepresented students get a sense of who they could become if they stay engaged in STEM. When they are successful in a participatory simulation, it increases their self-efficacy in STEM (the sense that "I can do it"). This empowers underrepresented students and drives them to want to learn more. If they want to learn more, they will achieve more.

Our program designers follow the Universal Design for Learning (UDL) principles to ensure an experience where students can self-select and customize how they digest and interact with the presented STEM content. We also incorporate feedback from Diversity and Inclusion experts and teachers that work with underrepresented and underserved populations.

[redacted] measures student engagement, STEM career awareness, self-efficacy, and 21st century skill development. We analyze the data for different sub-groups of students to understand if and how our program impacts those groups, which gives us the opportunity to make program improvements.

Develop and Enrich Strategic Partnerships question 18)

[redacted] does not place students in internships or apprenticeships. However, we introduce students to STEM careers through our programs. Our [redacted] have served more than 5.5 million students since 1986. We have alumni in STEM occupations who cite a [redacted] simulated STEM mission as the experience that set them on their paths. Ms. France Jackson, for example, experienced our simulated STEM missions as an elementary and middle school student in South Carolina. She says, "I wouldn't be where I am today" without the [redacted] experience. Today, she is one of the first two African American women to have earned a Ph.D. from the Computer Information and Systems Engineering Department at the University of Florida. She now works for Intel Corporation. We have thousands of alumni like France Jackson.

We have traditionally designed [redacted] missions for middle school aged students as this is the time when students begin making decisions about their education and career paths. However, education experts and industry leaders are now emphasizing the importance of planting the seeds for STEM engagement and careers at a younger age. While most children are enthusiastic about STEM when they are very young, research shows they lose interest in the subject over time. By eighth grade, 50 percent of students proactively decide STEM is not for them (Huneycutt, 2013), narrowing the potential workforce pipeline to half. Many students – especially girls – begin to make choices about their future engagement in science as early as age nine (Murphy, 2011). Given this, we are beginning to focus more effort on engaging students in elementary school through our Classroom Adventures and Virtual Mission programs. By developing programs for elementary students that leverages our decades of experience with simulated STEM missions, [redacted] is furthering contribute to positive STEM learning experiences for young students, setting them on a path for success and interest in STEM careers.

Community Use and Implementation of the Federal STEM Education Strategic Plan question 24)

[redacted] is aligned to the Federal STEM Education Strategic Plan's vision to build strong foundations for STEM literacy, increase diversity, equity, and inclusion in STEM, and prepare the STEM workforce for the future.

[redacted] programs are live role-play simulation experiences in which a class of ~30 students work together to achieve a unified goal. The experience is driven by a story line; the students are the lead characters, role-playing as scientists, engineers, and other STEM professionals. The simulation is driven by software that explains STEM concepts using computer animations and interactive tools, and it prompts students to communicate, collaborate, and problem solve together in small teams and as a group.

[redacted] integrates real data and visualizations from federal agencies such as NASA and NOAA to ensure that the missions are aligned with current science findings. [redacted]

[redacted] also incorporates assets and visuals from leading American companies in STEM industries (e.g., Northrop Grumman, Blue Origin, Raytheon, Aerojet Rocketdyne, Lockheed Martin, Boeing). For example, we worked with Blue Origin to come up with a storyline and incorporate assets in Destination Moon, one of our new Virtual Missions.

[redacted] missions are designed to serve a typical class, which can include students with a range of prior experiences and educational needs, including students underrepresented in STEM such as minorities, girls, and students from rural and low-income communities. Our program designers follow the Universal Design for Learning (UDL) principles to ensure an experience where students can self-select and customize how they digest and interact with the presented STEM content. The use of role-play allows students to incorporate their own backgrounds and cultural knowledge into the STEM career they are representing. We incorporate feedback from Subject Matter Experts (SMEs) on our Advisory Board to ensure the design of our programs specifically addresses the needs of learners that are under-represented in STEM, including minorities and rural students. Designers will focus on best practices in diversity, equity, and inclusion for underserved students, as well as content leveling and developmentally responsive teaching practices to be used in interactive tools and media. We continuously review student outcome data and refine our programs to increase impact after they are initially built. Our goal is to help shape a student's identity, showing them that they can become a STEM professional or STEM-engaged citizen, regardless of their race, gender, or socio-economic status.

Feedback for Federal STEM Plan as representing [redacted]

Engage Students Where Disciplines Converge

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience?

As an organization, we provide professional development for teachers that focuses on the Engineering Design Process. We encourage teachers who have developed a design-based activity to share it with other teachers at conferences and workshops, and as documents to download.

What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities?

We teach that technology is the study of how humans design and produce the things that extend human potential and solve for the needs and problems of people; from remote history to microcontrollers.

What approaches do you use to teach transdisciplinary learning?

Under ideal circumstances, working with other teachers to divide a design problem into areas that apply to each topic, culminating with a convergence of the knowledge from each discipline solving an authentic problem.

Why do you use this approach (e.g., more engaging for students, school/ administration promotes transdisciplinary learning) and how does it benefit your students' learning?

This approach engages students, empowers them to make decisions on their own, and requires them to research interdisciplinary content.

14. How has your ability to teach transdisciplinary concepts to your students changed in recent months because of the shift to remote teaching and learning? What teaching modalities have you employed to deliver transdisciplinary instruction virtually?

Teachers are all struggling to provide content in context for students. Many are making videos of parts of lessons, engaging students in online synchronous discussion, and assigning hands-on design challenges that use things found around the typical home. Students must document the design process as they work through the problem, testing their devices and evaluating what they would change.

15. What training have you/your organization received in any of these approaches for teaching STEM education: transdisciplinary, integrated, convergence, or engineering design, etc.?

Opportunities for using the Engineering Design Process are embedded in professional development sessions at conferences and in workshops. Some teachers have earned an Integrative STEM Master's degree from Virginia Tech. Elementary teachers learn the design process through conference, workshops, and a class offered through James Madison University.

Please describe the training, if any (including university coursework or professional development), that helped you/your organization prepare to teach STEM using an integrated or transdisciplinary approach.

Many teachers learned to use the Engineering Design Process in on-the-job situations while working with students. It is reflective of problem solving methods many studied while at universities.

The use of the process in workshops and conference sessions reinforces it. Teachers are looking for engaging, authentic problems for students to solve.

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way?

Professional development that includes all teachers would be helpful. The ability to have planning with teachers of multiple subjects assists greatly in integrative STEM.

What specific delivery mechanism work well for you (e.g., online course, webinar, in-person workshop)?

In-person workshops are most effective. Online courses or webinars may be helpful as well/

What technology tools would be helpful for you when using a transdisciplinary approach?

The ability to video lessons and provide them to students who did not attend would be extremely helpful. Lessons on the same design problem being videoed to include all teachers involved in the lesson would be great.

1. What COVID-19 related digital barriers (*e.g.*, access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

   The generation of online teaching content suitable for replacement of live laboratory instruction and project-based learning in engineering has been the most difficult COVID-19 challenge. Resolving this barrier has only been partly achieved. We are barely scratching the surface because generation of this content is time, personnel, and resource intensive.

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (*e.g.*, virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (*e.g.*, pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

Our faculty's creativity in addressing the need identified in q. 1 has been nothing short of amazing. In the spring, with < 2 weeks for planning, the following hands-on, active learning content was created:

- *3D printers were sent to each student in a CAD/CAM course for use in project-based learning within this design course. Students designed and fabricated unique fidget spinners, and the course culminated in a group project involving metrology, conducted completely remotely, of a chronometer where the bed of the 3D printer served as a simulator of winds and waves of a ship on which the chronometer was installed. (https://www.flickr.com/photos/thayerschool/50326446823/)*
- *In a material science class, students designed and tested Charpy impact testers using materials available locally in a hardware store*
- *In systems classes, many innovations came out of spring-term remote instruction. A faculty member redesigned a "black box" systems lab so that it could be done remotely using the AD II Discovery Board (which now has been out of stock since early summer). Many instructors sent lab kits. The sheer amount of labor needed to kit the parts and send them to students is daunting for any educational institution.*

[redacted]

- *A mechatronics course instructor taught a lab class completely online. The five labs culminated with balancing a mini-segway made from Lego parts.* [redacted] *"Debugging" one-on-one with students was more effective over Zoom than live.*
- *In an introductory project-based class, our machine shop fabricated parts for students to build prototypes and sent them to students who worked in groups over Zoom on design and testing* [redacted]

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

Despite creative solutions identified above, the lack of our usual live "thread" of hands-on learning through our curriculum may leave a generation of students without the experiences needed to be lifelong innovators in engineering. Generally, in live instruction, students are often fearful of equipment with which they have little experience. We provide lab instructors to work through this giving all student confidence in STEM regardless of their background. One lab instructor is insufficient for online lab instruction, and given that my institution is well-resourced, I can imagine that other institutions that are not so well-resourced are in a dire situation.

We measured success using traditional methods – course evaluations – but interjected a survey in the middle of every spring term class to obtain feedback from students (anonymously). Yes, assessment is important, but when the demands placed on one's *time are so great, the question of "how am I going to assess?" cannot be the priority. We were and still are battling a ship rolling in heavy wind and waves.*

5. What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.*, utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

   In my opinion, the most beneficial professional learning for educators would be creating online "hands-on" learning experiences that are engaging and accessible to all students.

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

7. What experience does your school system have with interoperable learning records or precision learning systems? If used, please share any barriers, solutions, or other information relevant to their effectiveness particularly related to digital barriers and the impact or effectiveness related to distance education. How were these concepts used or modified in response to COVID?

8. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

(Answer to the last question: Time.)

[redacted]

[redacted]

(b) (6) [redacted] For all responses below we are [redacted] employees that address preK-12 formal education with a particular focus on science, career and technical education (CTE), STEM, and computer science.

Future Opportunities in STEM Education, questions 1-6

Digital barriers include: inequitable broadband access across the state, student experience or comfort with technology (especially elementary), and lack of parent experience among some populations. Barriers have been partially resolved for the start of the 2020-2021 school year, as districts have had time to plan support for students and parents and acquire additional technology. However changing learning models (e.g. distance, hybrid, and face-to-face) have made large demands on staff and hindered in-depth planning.

A barrier for CTE teachers specifically, has been the struggle to translate their traditionally hands-on courses to a virtual environment. Teachers have faced challenges with software platforms for online curriculum that are not compatible with some student devices and some of the alternative online curriculum or apps were blocked by districts over concerns for security. Due to the need to address general technology issues, some district technology departments have not been able to meet the specific content needs of CTE teachers. These challenges have continued into the 2020-21 school year.

Potential solutions for CTE and other hands-on STEM courses would include simulations and/or remote control systems that would allow students access to lab equipment would enhance remote education. However with the focus of technology purchases on general core instruction, there is a lack of support for these systems or simulations.

Some students have experienced improved and increased interaction with their teachers. Teachers have learned new techniques and improved their ability to use technology for remote instruction. In CTE, teachers have been reevaluating and prioritizing essential technical skills. A re-emphases on accurate measurement and design processes have been valued as students are prepared to transition from secondary to post-secondary programs.

Distance learning has been especially difficult for English Learners (EL) and special education students. Providing some in-person or one on one tutoring can help those students having difficulties. While several interventions have been explored, they are more about mitigation and attempting to not increase the STEM opportunity gap among populations rather than addressing the issues to decrease the opportunity gap.

Teachers would most benefit from training in effective instructional practices related to their content areas in supporting quality learning time. Time for planning and collaboration to consider alternative approaches to teaching is important. For many STEM and CTE courses any approach is going to be less effective than in-person instructions when lab experience is central.

Develop STEM Education Digital Resources, question 9

There are some helpful open educational resources related to content areas like Open SciEd that are high quality but don't fit every situation. There are also simulations that can be manipulated by students like PHEt. Minnesota is working on a CTE resource site that will be launched by early December for all CTE disciplines at the secondary and postsecondary levels. The [redacted] is working with the [redacted] and the various CTE associations to create this resources site. Some CTE resources are listed below:

Career and Industry Information

- Build Your Future: Careers in the construction industry
- Construction Careers Pathway (CCP) Alliance: Construction trades information
- Explore The Trades: Career resources about the trades of plumbing, HVAC and electrical
- IEEE History of Technology: Technology career exploration and activities
- Minnesota Careers in Automotive Repair and Service (MNCARS): Career information about auto industry
- Minnesota Manufactured: Career information about manufacturing
- Trades Hub: Resources for the trades and manufacturing
- 218 Trades: Trade information in Northern Minnesota

Curriculum Resources and Providers

- Aircraft Owners and Pilots Association (AOPA): Free aviation curriculum
- Amplify Science: Interactive tools for engineering
- Auto Shop 101: Automotive electrical training support for technicians, students, and teachers
- AWS Safety in Welding: Free online course for safety in welding
- CareerSafe: Online OSHA 10 training
- Code.org: Free resources for students to learn computer at home
- CompuScholar: Coding, web design, computer skills, and game design courses
- Geigle Safety: Free OSHA 10 training, payment only when printing out certificate
- ITEEA Open Access At-Home Resources: At-Home lesson plans and activities
- Khan Academy: Free accounts to access courses
- Lincoln Electric Welding: Online resources for welding training and careers
- MakerBot: Online, self-paced certification program
- Miller Online Welding: Online welding curriculum
- National Geographic CTE program: Digital learning tools for CTE in cooperation with Cengage/Mindtap
- OnShape Free: Free computer-aided design software system
- OSHA Academy: Free access to Safety Training

- Planner5D – Free 2D &3D Home Design Tool
- Reality Works: Free lesson plans for welding, STEM, or employability skills
- Scratch: Free website for block-based visual programming language
- Siemens Solid Edge: Free professional 3D CAD software
- Siemens STEM/Engineering Curriculum: Free online engineering curriculum
- Tinker CAD: Free, easy-to-use app for 3D design, electronics, and coding
- Titans of CNC Academy: Free CAD/CAM and CNC Machine Training Online
- VEX CODE VR: Free block-based coding for a virtual robot

[redacted] Distance Learning Resources

These resource sites were collected by the Centers of Excellence.

- Advanced Manufacturing
- Engineering
- Transportation
- Information Technology
- Northern Agriculture
- Southern Agriculture
- Minnesota Technology and Engineering Educators Association (MTEEA)

Increase Diversity, Equity, and Inclusion in STEM, question 12

Minnesota teachers have access to the [redacted] through the [redacted] which includes a focus on increasing teachers in rural locations and from underrepresented racial or ethnic groups in the teacher workforce. Some CTE programs are using Educator Rising (https://educatorsrising.org/) as a means to promote CTE teaching to interested students.

Engage Students Where Disciplines Converge, questions 13, 14, and 16

The [redacted] support teachers, schools, and local educational agencies (LEAs) who provide integrated STEM opportunities to their students by promoting content area integration, problem-based learning, and phenomena-based learning. Integrated STEM provides students with opportunities to explore relevant questions and problems based in the natural and design world.

Distance learning has made it difficult for STEM teachers to collaborate as needed with other teachers across disciplines. In addition, with the hands-on nature of integrated STEM teachers have had difficulty figuring out ways for students to complete projects.

In-person workshops are the most effective method for supporting STEM teachers however, synchronous online workshops and webinars have been useful during the distance learning period.

The [redacted] has worked with a small pilot group of schools to utilize computer science as an integrator while also providing for enriched opportunities for students in computer science through a U.S. Department of Education Jacob K. Javits Gifted and Talented Students Education Program grant (Award #S206A190022).

Build Computational Literacy, questions 20-22

One of the greatest benefits of integrating computational literacy within other content areas is that it introduces all students to computer science and computational thinking and can provide real world examples of how computer science is integrated into other content areas. This is particularly helpful in reaching traditionally underserved communities because it doesn't rely on student interest or funds for an additional educator. The [redacted] has taken steps to integrate computational literacy practices into the state academic content standards review and revision, but there continues to be challenges. The challenges of integration include: providing professional development for K-5 classroom teachers and 6-12 content teachers that is relevant to their content area(s), rigorous, and accessible; funds for instructional resources and equipment upgrades; and scheduling time in an already busy school day.

The computational thinking practices laid out in the K-12 Computer Science Framework (https://k12cs.org/navigating-the-practices/) should be integrated in other content areas in K-12. The overlapping ways of thinking with math, science, and english language arts can easily be highlighted. These overlaps include; developing abstractions, using appropriate tools (including digital tools), attending to precision, making sense of problems and persevering in solving them, analyzing and interpreting data, and communicating and collaborating. Integrating computational literacy through a combination of computational thinking practices and computer science concepts is important to build a foundation in K-6 and grow understanding outside of computer science classrooms in 6-12.

The Framework for K-12 Science Education Practices (https://www.nextgenscience.org/framework-k-12-science-education) includes mathematics and computational thinking and provide supporting resources for incorporating these practices into science classrooms. The Framework for K-12 Trades & Industry Education (in development) will include supporting resources for incorporating mathematics, science and computational thinking. In addition, the CSTA standards are integrated into IT/Computer Science programs in Communication Technologies as well as more generally in Construction, Manufacturing, and Transportation.

[redacted] is a mission-driven nonprofit organization that is transforming the learning experience for millions of PreK-12 students and thousands of teachers across the U.S. [redacted] offers five distinct curricular programs that come together to form comprehensive PreK-12 pathways in computer science, engineering, and biomedical science, providing hands-on learning opportunities from the first day of preschool through senior year. [redacted] teacher training and resources support teachers as they engage their students in real-world learning. More than 12,000 elementary, middle, and high schools in all 50 states and the District of Columbia offer [redacted] programs.

The following responses reflect [redacted] position as a developer of STEM curricula and teacher professional development. This document includes responses to the following:

- Future Opportunities in STEM Education – Questions 2 and 5
- Engage Students Where Disciplines Converge – Question 13
- Develop and Enrich Strategic Partnerships – Question 18
- Build Computational Literacy – Question 22
- Community Use and Implementation of the Federal STEM Education Strategic Plan – Question 24

Question 2 Response:

To support schools across the country during the global COVID-19 pandemic and beyond as many schools have restructured their learning environment, [redacted] prioritized two major initiatives.

[redacted] Core Training, a training experience in which teachers receive a credential to teach specific courses, was converted to a completely online experience for summer 2020. The robust and interactive professional development experience is now offered with increased flexibility in the training format, expanded resources, and engaging high-quality course content. More than 6,000 teachers participated in the experience in summer 2020; fall, [redacted] opportunities are also available. Expertly trained Master Teachers facilitate and deliver the online learning experience through a dynamic mix of live sessions, as well as interactive and collaborative cohort-based opportunities that help build lasting professional learning communities. Completing [redacted] Core Training empowers credentialed teachers to provide meaningful learning experiences for their students that reinforce the in-demand, transferable skills needed to thrive in an evolving world.

[redacted] has also developed a [redacted] – spanning a full suite of tools from webinars to embedded curriculum enhancements to [redacted] for a variety of audiences – in order to continue to serve students and teachers whether learning takes place in school classrooms or from home. Curricular enhancements embedded in the existing [redacted] instructional method and delivery platform provide alternative activities for students in a distance learning environment. These enhancements remain hands-on and minds-on, where students engage with supplies and equipment that are safe and feasible to transport for use at home, including Chromebook-compatible software to maximize accessibility. This enables students to continue developing the knowledge, skills, and objectives found in our existing curriculum while helping them to achieve their educational milestones despite potential changes in their learning environment. [redacted] is currently reviewing each course to add new direct instruction for the students to successfully complete work in a remote setting, as well as new facilitation instructions to support teachers' needs related to virtual instruction.

In addition, [redacted] has published a series of guest blog posts written by Dr. Kathryn Kennedy that focus on distance learning for both educators and students, including [redacted] , [redacted]

Question 5 Response:

In the wake of the COVID-19 pandemic, [redacted] created a series of webinars for educators in our network highlighting best practices for digital learning. The webinars covered topics including:

- Creating Community in Distance Learning (teachers cultivating student-to-student interactions)
- Building Relationships in Distance Learning (teachers cultivating relationships with their students)
- Providing Student Supports and Effective Feedback in Distance Learning
- Engaging and Motivating Students in Distance Learning
- Ensuring Equity, Accessibility, and Access in Distance Learning
- Assessing Students in Distance Learning
- Developing and Assessing Transportable Skills
- Timing and Pacing Expectations
- Digital Notebooks
- Collaboration/Small and Large Groups
- Transportable Skills and How They're Being Infused
- End-of-Course Assessments and Transportable Skills

Question 13 Response:

Integrated STEM and engineering design are integral to [redacted] programs. Transformative student learning is the backbone of the [redacted] experience.

Problem-solving is central to [redacted] curricula, with the activity-, project-, and problem-based (APB) approach built into all [redacted] programs. The APB approach leads students to successfully tackle problems. A scaffolded approach leverages collaborative learning to allow students to build skills over time. Students are introduced to the problem at the beginning of the unit or module, acquire the knowledge and skills to address the problem, practice the knowledge and skills, and then transfer the knowledge and skills to attempt to solve the problem. Problems are designed to maximize student transfer and application of newly acquired knowledge and skills and promote creative problem-solving. Above all else, APB is a learning progression that sets up students for success in developing solutions to complex challenges that give students opportunities to demonstrate knowledge and skills.

Science, technology, engineering, and mathematics are integrated and applied in the transformative learning experiences. The topics are not learned or assessed in isolation within the [redacted] programs. The engineering design process is central to PreK-12 instruction within [redacted] curricula.

- [redacted]: In this program that provides full coverage of Next Generation Science Standards, students in grades PreK-5 apply their knowledge of the engineering design process in addition to technical knowledge and skills to define and provide solutions for engineering challenges. See [redacted] for additional information.
    - Key Learning Objective: Follow a step-by-step method to solve a problem.
    - KS1.1.1: Define a simple design problem reflecting a need or a want.
    - KS1.1.2: Brainstorm possible solutions to the problem.
    - KS1.1.3: Use evidence to compare and explain the effectiveness of different design solutions.
    - KS1.1.4: Evaluate a model solution through observations and/or measurements and consider what revisions to the initial model are needed.
- [redacted]: Students in grades 6-8 build on their elementary experience and apply their knowledge of the engineering design process in addition to technical knowledge and skills to define and provide solutions for engineering challenges.
    - Key Competency: Problem-solving and Process Thinking
        - Problem-solving, inquiry, and process thinking are mindsets that help teams define problems, pursue viable and ethical solutions, and/or optimize systems.
    - Key Learning Objective: LO1.1 Persistently apply an iterative process to solve a problem or create an opportunity that can be justified.
    - KS 1.1.1 Describe major steps of a design process and identify typical tasks involved in each step.
    - KS 1.1.2 Define a problem and justify the pursuit of a solution to the problem.
    - KS 1.1.3 Identify appropriate design requirements (criteria and constraints).
    - KS 1.1.4 Generate ideas or build upon other ideas to innovate.
    - KS 1.1.5 Evaluate solution ideas against the design requirements and justify the best solution to pursue.
    - KS 1.1.6 Persistently design and develop the solution.
    - KS 1.1.7 Develop and implement a plan to test and evaluate a potential solution to verify that it meets all design requirements.
- [redacted]: Students in grades 9-12 apply an iterative, systemic approach to problem solving.
    - Key Learning Objective: O2.1 Apply an iterative design process to creatively address a need or solve a problem.
    - KS 2.1.1 Synthesize an ill-formed problem into a meaningful, well-defined problem using relevant information.

- KS 2.1.2 Define measurable visual, functional, and structural design requirements (criteria) and realistic constraints against which solution alternatives can be evaluated and optimized. [Note that criteria and constraints should include considerations of cost, safety, reliability, manufacturability, and aesthetics, as well as possible social, cultural, and environmental impacts.]
- KS 2.1.3 Apply effective techniques and appropriate guidelines to generate multiple creative ideas and potential solutions to a problem.
- KS 2.1.4 Carry out a plan to compare competing solution ideas and justify the selection of a solution path with respect to design requirements and constraints.
- KS 2.1.5 Develop a potential solution and implement a plan to test and evaluate the solution with respect to design criteria and constraints.
- KS 2.1.6 Identify design flaws of and potential enhancements to a proposed design solution.
- KS 2.1.7 Strategically iterate steps of the design process to improve and optimize a solution.

[redacted]'s five distinct programs come together to form comprehensive PreK-12 pathways in computer science, engineering, and biomedical science. A sample of topics designed around interdisciplinary STEM and engineering design process include:

- Aerospace
- Mechanisms
- Architecture
- Electronics
- Robotics
- Agriculture
- Sustainability
- Manufacturing
- Human centered design
- App development
- Physical computing
- Biomedical innovations and interventions
- Elementary Next Generation Science Standards address with an interdisciplinary STEM and engineering design process approach

Hands-on investigations and design challenges are integrated throughout [redacted] programs, helping students build on their understanding and gain independence in the learning process. The learning experience is designed so students apply real-world knowledge and skills including in-demand transportable skills, such as problem solving, critical and creative thinking, collaboration, communication, and ethical reasoning and mindset. Students overcome setbacks and experience failure as part of the rigorous learning experience to reflect overcoming challenges they may experience in their careers. Developmentally and educationally appropriate tools and technology are incorporated into the learning experience. The tools and technology prepare students with relevant skills and documentation techniques reflect both educational and industry best practices to promote metacognition and reflection as well as build toward professional practice.

Question 18 Response:

In 2018, [redacted] and the U.S. Department of Labor partnered to develop the [redacted] These guidelines provide a comprehensive apprenticeship skills and knowledge framework that schools and industry can customize to meet local apprenticeship needs. Apprenticeship opportunities offer schools and districts another way to extend career and technical education beyond the classroom and empower students to gain real-world industry experience before leaving high school.

Beyond this work with the U.S. Department of Labor, [redacted] has experienced successful work-based learning partnerships with industry leaders such as Lockheed Martin and Toyota. In 2014, Lockheed Martin launched a high school engineering internship program at their Fort Worth Aeronautics facility in partnership with [redacted] and the Arlington Independent School District in Texas. The program offers a student workforce experience continuum that begins in high school, continues in college, and leads to employment with Lockheed Martin upon graduation from college. The program's success led Lockheed Martin to expand the program to include two additional business areas at five facilities across the country. [redacted] has partnered with Toyota since 2010, providing the PreK-12 portion of the [redacted] for the Federation for Advanced Manufacturing Education (FAME), which has since come under the stewardship of the National Association of Manufacturers and the Manufacturing Institute and is scaling nationally.

Barriers to participation in work-based learning include age limits, lack of flexibility in hours worked, lack of locations for participation, and unpaid experiences. Department of Labor and other federal agencies can actively network to let industry and corporate partners know about pre-apprenticeships and apprenticeship assistance provided by the Office of Apprenticeship or other federal partners. Also, working with engaged local and regional workforce development boards that have active partnerships with schools and post-secondary institutions can accelerate the creation of work-based learning opportunities and in some cases even turn non-registered apprenticeships into registered apprenticeships.

Question 22 Response:

[redacted] helps students develop computational thinking and problem solving as its computer science pathway scaffolds student learning, empowering them to build and grow their skill sets as they advance through the PreK-12 continuum. For example, in the [redacted] (PreK-5) module Spatial Sense and Coding for PreK, students create code that will lead them to the location of a hidden item. In [redacted] middle school unit Computer Science for Innovators and Makers, students choose to design and create a wearable safety device, an engaging art installation, or a mechanical dispenser to solve a problem. In [redacted] high school course Computer Science Essentials, students develop a program that directs a group of self-driving vehicles to navigate an arbitrary environment. [redacted] recently released a white paper, [redacted]

[redacted] (attached), exploring the invaluable knowledge, skills, and experience that students gain in computer science classrooms.

As part of [redacted] Core Training and ongoing professional development opportunities, teachers investigate computational thinking and consider the developmentally appropriate approach for facilitating this mindset with students. Additional teacher resources include:

- [redacted]

Question 24 Response:

[redacted] supports the three Goals for American STEM Education laid out in [Charting a Course for Success: America's Strategy for STEM Education]:

- Build Strong Foundations for STEM Literacy – [redacted] mission focuses on providing access to high-quality STEM learning that equips students with in-demand transportable skills.
- Increase Diversity, Equity, and Inclusion in STEM – P[redacted] endeavors to extend access to high-quality STEM programs to all learners and eradicate bias in curriculum and assessments.
- Prepare the STEM Workforce for the Future - [redacted] focuses on in-demand skills and awareness of careers in STEM fields through career exploration and career learning.

In addition, [redacted] programs align with the subsequent pathways and objectives articulated in the plan in a variety of ways.

- P[redacted] has a strong focus on *developing and enriching strategic partnerships*. [redacted] has partnered with industry leaders like Autodesk, AWS Educate, Chevron, John Deere, Lockheed Martin, Toyota, and Verizon to validate and inform curricula, provide opportunities for educators and students, and increase access to [redacted] programs across the country. [redacted] college and university provide [redacted] students with opportunities such as scholarships, preferred admission, and dual credit. In addition, [redacted] partnerships with STEM organizations also support the mission.
- [redacted] *engages students where disciplines converge* through an interdisciplinary approach to learning, specifically the APB approach detailed in the response to question 13. [redacted] Core Training and other professional development opportunities offered by [redacted] prepare educators to become facilitators and coaches, engaging students in relevant, true-to-life learning.
- [redacted] programs *build computation literacy* by going beyond computing to focus on computation thinking from PreK to high school graduation.

Please contact [redacted] (b) (6) [redacted] with any questions at (b) (6) [redacted]

[redacted]

Submitted on behalf of [redacted]

By:
[redacted]

Date: 10/16/2020

On behalf of the [redacted], please accept these responses to the STEfdM RFI questions. [redacted] appreciates this opportunity to submit responses to the Federal Register request for input related to the Federal STEM Education Strategic Plan and how it is being addressed in [redacted] education. Thank you, [redacted]

Future opportunities in STEM education

1. [redacted] - Broadband access at home for me to be able to work with a large group (25+) from home. Broadband access for my students - those working from the University - have been successful for the most part, students working from home face greater challenges from weak internet signal, old or outdated computers, lack of proper workspace & privacy at home (interruptions from children, family members, etc.).

[redacted] - I will respond to this survey from my grandpa role; observing and helping six elementary grandkids who are now learning exclusively from home. One home deals with slow internet, which causes student frustration and loss of learning continuity. Another home with adequate data speed struggles with juggling four kids on one pc.

[redacted] - Many of our education partners struggle to engage via digital platforms with industry. A few have asked for recorded videos or livestream videos about our technology, but this is difficult for us to pull off in a short amount of time.

[redacted]-OERs and DLMs were impactful for parents and teachers to provide virtual lessons for students. However, there were issues with internet access of availability and functionality.

2. [redacted] - I have been working on creating curriculum that emphasizes student created models and materials using low-cost materials and methods. I have found that when students create their own models and materials before working with them in an experimental activity, the academic and conceptual outcomes are superior for the students involved. Student created models and equipment also helps ESL students acquire vocabulary and fluency in communicating STEM concepts and experimental results. The 'Experience-First' methodology gives the ESL student a cognitive and kinesthetic framework that is a powerful scaffold for the acquisition of STEM vocabulary and improves fluency in spoken and written responses.

[redacted]- It would be helpful to set up a way for students to do a virtual internship or job shadowing with companies. I do not know what would be the best platform for this.

[redacted] - The use of add-on extensions e.g. "Pear-Deck" allows on-time monitoring of students as they are engaged with the presentation. Jam-board application and Canvas are also applications that allows real-time input from your participants, which allows timely assessment of learning.

3. Higher Ed STEM Professor Response: I have worked to develop hands-on methodologies for students and teachers in astronomy and physics. I have had success sharing these methodologies in several ways. First, in creating and disseminating curriculum via social media. A larger platform provided by a federal agency could disseminate these materials more efficiently and provide more teachers with access. Second, I have participated in online presentation of curriculum from live video streaming; these programs have also been recorded and made available on YouTube and other platforms. Again, dissemination via a federal agency could make these materials more widely available to the teachers that need them.

Academic Partnerships Manager for an Engineering/Manufacturing company-Zoom and YouTube have both been helpful in recent months and could be enhanced through a better strategy between industry and education partners (quarterly visits, lectures, or presentations).

[redacted]-The positive experience of using remote learning is that it's doable and we were all able to modify and adjust effectively. It's the new-normal.

4. [redacted]-One of the greatest challenges to providing STEM education opportunities, both for school districts and teachers, is the cost of materials. I have worked for many years developing low-cost materials and methods with the goal of creating STEM activities that cost less than $1 per child to implement. In both urban and rural schools, funding for STEM equipment and materials often form a perceived barrier to offering STEM opportunities to students. For teachers who are delivering instruction remotely, or for parents whose children are learning from home, cost is often a significant barrier. I believe that low-cost methodologies will be key to delivering STEM opportunities equitably to students in all areas of our country.

[redacted]-Greatest challenges are: teaching remotely to those who ARE NOT performing at grade-level; teaching remotely to those who are technology-challenged; teaching remotely to those who DO NOT have the resources available, e.g. technology device, internet, electricity and etc. No solutions identified, on-going issues. However, success may be measured by how well the student demonstrates mastery.

5. [redacted] - Low-cost STEM methodologies
Modeling in experiments and systems
Training in effective remote STEM curriculum delivery

[redacted]-Because of the lack of historical experience (this is our "First COVID"), I would emphasize the benefit of collaboration/chat groups devoted to specific challenges and solutions. Then, a group(s) to digest and compile

these discussions into practical problem/solution bulletin board and/or training sessions.
[redacted] -How to provide education remotely during these pandemic times. Technology-based lessons that provide adequate time for assessment and re-teach if necessary. (need time for follow-up and preparation for path forward)
6. [redacted] Insights data measuring student attendance [redacted]
8. Pk-12 science specialist response: Districts adopted a learning management system (E.g. Lincoln Learning). Additionally, many teachers attended summer PD on blended learning tools to assist with virtual teaching and learning.
Higher Ed Response: We converted our interactions to virtual platforms and provided as many digital resources as possible to our education partners.
[redacted]: Developed an [redacted] and developed a Lab Safety Guide based on recommendations from CDC for Science Classrooms.
Pk-12 science specialist response -Two distinct barriers were time and knowledge. STEM educators had little time to prepare and share what were the needs. . A knowledge barrier was the lack of technology skills and ability to engage students in authentic investigations. We were unable to take action because we did not know what teachers really needed

Develop STEM Education Digital Resources

9. [redacted] -Virtual Lessons and Activities; opportunities for students to display their creativity with a lesson topic (student involvement; student input)
10. [redacted] -I work primarily with pre-service teachers at the University.
[redacted] -I regularly work providing professional development in hands-on and low-cost STEM pedagogy with administrators and teachers around [redacted], although the Covid outbreak has severely curtailed these activities for 2020/21 school year.
I also work with working STEM teachers via social media and outreach on a variety of platforms.
[redacted] - I primarily interface with K-4 teachers and school administrators.
[redacted] High school, technical college, and 4 year college students interested in engineering and manufacturing.
[redacted] Science departments for K-12 schools in the [redacted]
11. Pk-12 science specialist response - No preference just as long it is user-friendly and organized. Categorized by the components for the Federal STEM Plan. The Nextgenscience.org is an exemplar website with components of standards being filterable. https://www.nextgenscience.org/

Increase Diversity, Equity, and Inclusion in STEM

12. [redacted] The [redacted] recruits from Business, Government and Industry. We strive to maintain a balance between these three groups and 13 regions of our State. Most recently, we partnered with the Clinton School to survey the STEM services provided throughout these 13 regions to determine duplications and under-served areas. The data has all been collected and we are deciding how best to use this information to maximize STEM impact. (See me for more info, if interested. (b) (6) [redacted]
Academic Partnerships Manager for an Engineering/Manufacturing company-We collaborate with academic institutions who have a high diversity rate.
[redacted] -Possibly social media, newspaper, radio and TV, etc.

Engage Students Where Disciplines Converge

13. Pk-12 science specialist response - The state is highly involved in several robotics programs (VEX, FIRST, Best) which helps make the STEM disciplines come to life. Many schools have courses designed around robotics and many use it as an after school program to involve community mentors to work side by side with students.
Pk-12 science specialist response - We participate in engineering capstone, senior design, and are currently designing an engineering design challenge. This approach stimulates student curiosity and offers a personal and creative component to the learning experience that increases student engagement.
[redacted] -Science has adopted NGSS which involves 3-dimensional learning with investigation skills and critical thinking applications. These standards provide opportunities for math and literacy connections.
14. [redacted] -This has been a challenge due to the fact that the majority of districts are using digital management systems with pre-planned lessons, activities and automated assessments.
15. [redacted] Received the Grasping Phenomenal Science Training along with GRC by Brett Moulding. In the process of developing a collection of STE integration professional learning workshops that will begin at grades K-2 and 3-5 and progress over time to include grades 5-6 and high school.
16. [redacted] -Integration of science , engineering, math and technology standards with other content standards like fine arts, health, and social studies is a focus of the professional development we are developing over the next few months to make available to K-5 teachers in the summer of 2021. Training focused on developing meaningful units of study that integrate ELA, math and science

are our first tier to develop and implement and then we will develop and offer professional development in the same line at the middle school and eventually high school levels over the next 3 years. If elementary teachers do not begin to feel more comfortable teaching science and engineering in early grades and if teachers do not know how to bundle standards together into meaningful community-based lessons, we will not build the STEM worker pipeline we need to be doing as an industrial nation.

Develop and Enrich Strategic Partnerships

18. [redacted]
Providing multiple engagement points, e.g., events, activities, and various learning platforms, F2F, virtual, hybrid, are key factors in successful work-based learning programs. Industries must be included in the design of content and delivery so that it fits within industry demand and constraints. Federal agencies can expand partnerships by providing workshops, resources (communication on what resources are available), and conducting industry surveys and incorporating them into resource planning for educators.

[redacted]The lack of knowledge, exposure, or experience leads to unsuccessful programs. The fear of COVID is also a leading factor that has impacted the success of providing a proficient educational environment that is conducive for all learning.

[redacted]Federal agencies need to fund organizations to train, certify, and help keep STEM highly qualified teachers K-12 employed. Federal website could be a place for interested individuals to find sources of funding and lucrative partnerships with local businesses to pursue STEM teaching certifications. Federal agencies could also help incentivize businesses to support local STEM programs for students and teachers.

19. [redacted]The role of the private sector in a successful STEM learning ecosystem is to contribute industry knowledge and alignment of curriculum around real-world industry challenges and requirements.

[redacted]Everyone is learning and remaining healthy while doing it.

Build Computational Literacy

20. [redacted]-The benefit is that you are providing another skill set for the student; however, student must be able to comprehend the content as well as have reliable technology source.

21. [redacted]-User-friendly online resources, accessible resources that are free to users; classroom applications.

22. [redacted]-BetterLessons, Middle School Chemistry and etc. Pear-Deck application, Google Classroom, Jamboard, Canvas and etc.

23. [redacted]-Common OERs, e.g. BetterLessons, Wonder of Science, Middle School Chemistry and etc. Pear-Deck application, Google Classroom, Jamboard, Canvas, Code.org, MIT App Inventor, Lego WeDo 2.0 (robots and coding)

Community Use and Implementation of the Federal Stem Education Strategic Plan

24. [redacted] is in the process of developing a K-12 STEM Model Program for school districts/schools that is built on the same 6 categories of the federal plan: curriculum, equity, strategic alliances, time and resource management, STEM leadership and communications/public relations. This program will include rubrics to help schools fully implement all 6 components across the district/school to earn a STEM School Designation. This program will also include business incentives to support K-12 STEM experiences for students and teachers and help to increase the STEM teacher pipeline in Arkansas.

RFI Request

Charting a Course For Success: America's Strategy for STEM Education

The goals of the Federal STEM Education Strategic Plan:

- **Build Strong Foundations for STEM Literacy;**
- **Increase Diversity, Equity, and Inclusion in STEM; and**
- **Prepare the STEM Workforce for the Future.**

Four pathways representing a cross-cutting set of approaches, each with a specific set of objectives for achieving these goals:

- **Develop and Enrich Strategic Partnerships;**
- **Engage Students where Disciplines Converge;**
- **Build Computational Literacy; and**
- **Operate with Transparency and Accountability.**

I am responding as a USA STEM teacher who teaches STEM at a public middle school to over 900 students. I also do STEM education training around the world (In person prior to COVID and virtually around the world during COVID.) I mention this because my responses will have USA context but will also share universal themes globally to findings I have with my STEM teaching colleagues around the world. It may give perspective on how better navigate STEM in the USA.

1. What COVID-19 related digital barriers (*e.g.*, access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

- Equitable connection to broad band internet is a universal concern. Many ISP providers and our school district have stepped up to provide service do decrease this digital divide. I do not know how sustainable this will be without ongoing funding to reduce equity issues with the digital divide.
- A bigger problem is parent/school partnerships. Parents lack the tools, training and stamina to teach at home or assist in teaching at home while students are learning remotely. I am currently working with the Buckingham University on A.I. in education. This may be an avenue to assist and reduce this problem moving forward.

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education?

- A bigger problem is parent/school partnerships. Parents lack the tools, training and stamina to teach at home or assist in teaching at home while students are learning remotely. Programs to assist parents or students to navigate at home learning and STEM pedagogy and value would be helpful.

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education?

- Since students and teachers were limited with in person physical connection and collaboration, I used this as a great opportunity to have students and teachers collaborate internationally on proposing STEM solutions to the United Nations Sustainable Development goals. This was a WONDERFUL opportunity to us a global pandemic as leveraged STEM teachable moment!
- Since most standardize mandated test would not be happening during COVID instruction, I leveraged that as an opportunity to provide more STEM lessons that were focused on Divergent Thinking (to solve global problems through STEM) than use traditional Convergent thinking (Teaching and learning to the standardized tests to see the one, unauthentic answer that our education systems have traditionally taught schools to instinctively do.).

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

- Our school has been blessed in that we were able to move to hybrid learning where we could connect and support students in person. This was vital. We lost kids during remote learning. Hybrid allowed us to build relations with those students that needed the most support (equity). Our greatest challenge was not being able to do that in our spring remote learning.

5. What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.*, utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

- Strategies for engaging parents and supporting them and connecting with students remotely. Students that come from challenging homes we just lost. Parents did not do much to make education happen in those situations. Frustrating for all.

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

- To me, the STEM is hands-on, physical collaboration and divergent thinking. It is hard to do that remotely. My data would be that it did not happen during the spring and in our hybrid model in this “low touch/no touch”, socially distanced environment, it is not happening very much either. No data on it but data on if it is happening at all would be good to know.

7. What experience does your school system have with interoperable learning records or precision learning systems? If used, please share any barriers, solutions, or other information relevant to their effectiveness particularly related to digital barriers and the impact or effectiveness related to distance education. How were these concepts used or modified in response to COVID?

- So FAPE laws under IDEA essentially forced most of my state to opt for no grading and to use "participation metrics" during COVID. Once parents and students realized that there was no real extrinsic motivation to engage in learning, they quit. This was our biggest barrier. We need to reframe education to show the value of the intrinsic motivation to learn and grow. Growth mindset.

8. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

- I have been involved in STEM ecosystems around our state for the past few years. I have found, in general, that they lack the capacity and will to connect with school systems. I do STEM trainings and keynotes extensively all over the state and even the country. I typically ask my audience (primarily teachers), "How many of you are connected with your STEM Ecosystems?" My typical response is that 1 or fewer hands go up in a large room. Soon there after I get other hands popping up with a follow up question to me….that question from the audience is, "What's a STEM Ecosystem?" THIS IS A HUGE PROBLEM!!!!! These Ecosystems have struggled to pull off school connections prior to COVID.

9. What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

[redacted]

[redacted]

[redacted]

[redacted]

10. Please describe your primary audience (*e.g.*, I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.

- I teach middle school STEM. The resource links I show above provide a variety of support systems for me and institutions I train.

11. How would you like to see resources categorized (*e.g.*, subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.

[redacted]

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

- Since Black Lives Matter movements, our district has just started a community equity committee. Other than that we have not done much.
- I am on our state's Science, Technology, Engineering, Environment & Ecology (STEM) Standards revision committee. On a state level, equity was a non-negotiable lens we were using as we developed our draft this summer.

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (*e.g.*, a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (*e.g.*, more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

- My response to # 3 has some bearing on this.
- My response to #12 has some bearing on this. In general, our state assessments under NCLB and now ESSA have been so discipline siloed, that it is difficult to get administrative, teacher, parent and student buy in to anything that deviates from siloed test performance. Our new state "STEM" standards hope to change that.

14. How has your ability to teach transdisciplinary concepts to your students changed in recent months because of the shift to remote teaching and learning? What teaching modalities have you employed to deliver transdisciplinary instruction virtually?

- My response to #13 has some bearing on this. I've taught STEM for 3 years (wrote the curriculum and implemented it). It is transdisciplinary but it is hard to get buy in because when students leave my 30 session contained class, they go right back to the pervasive siloed mentality that our school systems are entrenched in.

15. What training have you/your organization received in any of these approaches for teaching STEM education: transdisciplinary, integrated, convergence, or engineering design, etc.? Please describe the training, if any (including university coursework or professional development), that helped you/your organization prepare to teach STEM using an integrated or transdisciplinary approach. Why was that specific training helpful, and if not, what could be done differently?

- Little to non. Our intermediate units do some sporadic training. Most schools in our state do what I call "Random Acts of STEMness".
- I have been blessed to have been immersed in all that you mention in #15 solely because of STEM Revolution. [redacted] We do the systems changing training you mention in this question. We've been contracted with the United Arab Emirates Ministry of Education for the past few years to flip the country and economy to a STEM (STrEaM) system. The UAE has sent an astronaut to the ISS, sent a mission to MARS, opened the Gulf's only Arab run Nuclear Power Plant, plan a mission to the Moon and are leading the region in innovation. I'd say we are making an impact through STEM education! I feel like the USA does not have the same vibe I feel as the UAE has in tat regard.

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way? What specific delivery mechanism work well for you (*e.g.*, online course, webinar, in-person workshop)? What technology tools would be helpful for you when using a transdisciplinary approach?

- I am biased, but the approach that STEM revolution uses in the websites I listed previously are hands down the best approaches I've ever seen. The UAE and other countries would agree. They are developing an online approach now that is using one of the world's best virtual reality developers in the world for their platform.
- For my state, pending legislative adoption of our drafted STEM standards, we will need a HUGE amount of PD help and resources to implement our standards which will be in line with the flavor of this question (#16).

18. What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

- I am strongly connected with our state youth labor and industry board (I'm a member), our STEM Ecosystems, and Our state Chamber of commerce. I have more to say about this than I can say here. Please contact me for a conversation (b) (6) [redacted]

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

- As with my response above, I have more to say than I can say here. Let's talk. (b) (6) [redacted]

With all the questions below, again, lets talk. I have a great deal of insight on this as I was a leader in a state initiative specific to this. [redacted]

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.

22. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.

23. What technologies and resources do you currently use (*e.g.*, apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

24. Please describe how your organization has used the Federal STEM Start Printed Page 55326Education Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?

My district has not been interested in a strategic STEM plan. Again, we are entrenched in a siloed academic system to solely rock our test scores (Which we do). I so need to talk to you about this. We are not alone here. [redacted]

(b) (6) [redacted] STEM RFI Response

Introduction

I am a parent and member of a small community.

I am also a member of the [redacted]

The [redacted] was originally started by Abraham Lincoln in the 1800s.

It has been a very successful program that has brought knowledge to US citizens about gardening and environment through university extension service.

I thought this program could be enhanced through your STEM agenda.

Goal

Develop or select gardens to visit and learn from. Provide digital and online learning.

Category **Future Opportunities in STEM Education**

Q2. Existing program is [redacted]. Existing gardens would need to be selected or developed specifically for participation.

Age group k-12, adult and seniors.

Instructors can be selected based on interest in the topic of gardening and associated science and willingness to participate as well as degree of knowledge.

Page 2

Develop STEM Education Digital Resources

Q11. [redacted]

Q9. Plant identification applications such as the following.

https://youhadmeatgardening.com/best-plant-identification-app/

Vision

Provide tablets at selected gardens to be used to identify plants and learn about them.

Q12. Develop a university to K-12 connection so teachers can view what is offered.

Other groups could be directed through a website dedicated to STEM.

Parks and recreation could play a role here as well.

Almost any group would be welcome.

Page 3

Engage Students Where Disciplines Converge

Q13. Develop related disciplines within the master gardener program. This is done to some extent already but could expand to Weather, environmental issues, wildlife, chemistry etc.

Example,

Girl scout group goes to designated garden and each participant gets a tablet with a plant identification application to learn from during visit. Teacher leads and speaks.

Girl scout can later access virtual learning for related topics.

Speakers could be accessed through expanded master gardener program for in-service.

[redacted]

Subject: **The National Science Foundation (NSF) Request for Information (RFI) related to the implementation of the Federal STEM Education Strategic Plan, Charting a Course for Success: America's Strategy for STEM Education.**

From: [redacted]

Date: **October 16, 2020**

Introduction

Thank you for the opportunity to provide input on the implementation of the Federal STEM Education Strategic Plan. The [redacted] envisions excellent and broadly accessible education empowering students and engineering professionals to create a better world. To achieve this vision, [redacted] advances research, innovation, access, and excellence at all levels of education for the engineering profession. [redacted] is the only [redacted] representing the country's schools and colleges of engineering. Membership includes over 10,000 individuals hailing from all disciplines of engineering and engineering technology and comprising engineering educators, researchers, and students, as well as industry and government representatives. [redacted] work aligns with the goals and pathways identified in the Federal STEM Education Strategic Plan by connecting engineers and engineering technologists across academia, industry, and government.

In addition to the suggestions below, [redacted] recommends that NSF and OSTP provide grants to support community-based discussions with participants from colleges, universities, and professional societies on suggestions and ideas for ways to best implement the Federal STEM Education Strategic Plan.

Develop STEM Education Digital Resources, Questions 9 and 10

What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

A federal STEM education website should be designed with increased emphasis on the development of virtual spaces and tools that allow for more realistic engagement with physical systems and processes in science and engineering as well as examples in a wide range of contexts. [redacted] calls on federal agencies such as the Office of Educational Technology (OET) at the U.S. Department of Education and NSF to develop a website to provide these tools for students, as well as provide professional development and training resources for U.S. STEM educators at all levels. Providing teachers and faculty with content and pedagogical knowledge is critical to ensuring the future of STEM education. Efforts to understand and consider learning context, including how people learn, will make it possible to expand STEM education. STEM discipline expertise, encouraging teacher leadership, and utilizing emerging STEM teaching practices are some key components to fostering excellent teaching, and the federal government should provide resources through a STEM Education website to facilitate development of these skills in the U.S. STEM education workforce.

Although not dedicated to virtual resources https://www.linkengineering.org/ and https://www.teachengineering.org/ are examples of integrated resource and networking websites at the P-12

[redacted]

level. Comparable sites for higher education (community colleges, liberal arts colleges, and universities) should be developed.

Please describe your primary audience (e.g., I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience

[redacted] primary audience is engineering educators at all levels, researchers, and pre-college, undergraduate, and graduate students. Providing a federal STEM education website with increased emphasis on the development of virtual spaces and tools would serve engineering educators and students by allowing them to engage with each other and in learning, even if they could not be physically together or have to operate in different time zones. Virtual spaces and tools would be particularly useful for examining systems or phenomena that are ordinarily too fast, too slow, too large, too small, or too dangerous for accessing in real time and space. Furthermore, providing virtual tools through a federal STEM education website would expand access to resources that students and educators in under-resourced schools may not have had otherwise, could provide a more robust STEM education experience, and aid in ensuring engineering students have the skills necessary to be productive members of the STEM workforce.

Increase Diversity, Equity, and Inclusion in STEM, Question 12

What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

As articulated in our [redacted], [redacted] believes that the engineering profession cannot reach its full potential until groups that have been historically under-represented are fully and equitably included. Our vision is to create environments within engineering where no one is marginalized, and everyone is respected through the education, recruitment, retention, and advancement of historically under-represented groups in engineering education, engineering technology education, and the engineering profession. This includes pursuing inclusiveness in the pre-college, college, and industry environments as well as in professional engineering organizations.

To demonstrate our commitment to diversity and inclusion, [redacted] created the following:

- [redacted]: This initiative provides a way for [redacted] members to share ideas and resources, as well as peer support, for implementation of plans to promote LGBTQ+ inclusion in STEM at universities.
- [redacted]: This commission is responsible for reporting accomplishments regarding the Diversity Strategic Plan to the [redacted] Board. The current strategic plan is available [redacted].
- [redacted]: This dean-led initiative publicly recognizes those engineering and engineering technology colleges that make significant, measurable progress in increasing the diversity, inclusion, and degree attainment outcomes of their programs. This is a recognition program, not a ranking program, and it is possible for all institutions to receive formal recognition at the highest levels.
- [redacted]: This initiative includes Deans of Engineering that have committed to increasing diversity through the creation of programs that proactively increase the

[redacted]

representation of women and minorities in engineering, create partnerships between research-intensive schools of engineering and those that are not Ph.D. granting, and develop pathways between K-12 institutions or community colleges.

- [redacted] This initiative is funded through a 2018 NSF ADVANCE Adaptation award and provides tools and resources to support engineering deans in the recruitment, retention, and advancement of women faculty.
- Equity, Culture, and Social Justice Division: This relatively new division is a home for individuals who are interested in laboring with and for under-resourced and disenfranchised people seeking to engage in engineering at any level of education.
- [redacted]: This division supports programs focused on increasing the participation and career success of women students and professionals in STEM.
- [redacted]: This division provides support to active duty military engineers and veterans who wish to pursue academic engineering careers.
- [redacted]: This division works to increase the participation and success of ethnic minority populations underrepresented and underparticipating at all levels of engineering education and in the engineering profession.

[redacted] recommends the federal government expand support for and scale up programs that have shown the ability to foster organizational change and empowerment of women and underrepresented/underparticipating minority faculty at institutions, such as NSF's INCLUDES and ADVANCE programs. These programs that revolve around a mission to broaden participation in all sectors of the STEM research workforce, should be sustained in the long term as a resource to support transformational change at U.S. research institutions. The federal government should also establish a program like ADVANCE focused on supporting the recruitment, retention, and promotion of underrepresented minority faculty through evidenced-based systemic change.

[redacted] also recommends the federal government expand funding opportunities at federal agencies for Minority-Serving Institutions (MSIs) that have not traditionally been successful at securing federal funding and should facilitate partnerships between faculty at resource-challenged MSIs and established researchers at R1 institutions with the locus of funding being at the MSIs. This year, [redacted] ran a workshop for NSF's Directorate for Computer and Information Science and Engineering (CISE) on growing MSI participation with NSF. This workshop brought together over 90 faculty from fields within CISE with the goal of increasing the competitiveness and volume of proposals from MSI researchers to CISE core programs.[1] Community colleges are also an important pathway for women and minorities to engineering careers[2]. Finally, [redacted] recommends expansion of the NSF and NIH funding supplementals to bring women back into the STEM workforce to all federal agencies.

Furthermore, engineering technology (ET) programs have been identified as a particularly viable pathway for transitioning veterans, to engineering related careers;[3] and lowering barriers to hiring for ET graduates is one strategy to enhance veteran participation in STEM fields. ET has also been shown to be an inclusive, accessible option for underrepresented minority students, as noted by the National Academies of Science, Engineering, and Medicine report, *Engineering Technology Education in the United States.*[4]

[1] [redacted]
[2] https://www.nap.edu/read/11438/chapter/2#4, pp. 4-5
[3] [redacted]
[4] http://www.nap.edu/read/23402/page/6#.WxmCVmCRuAo.link, pg. 6

[redacted]

[redacted] encourages OSTP to include reducing federal barriers to obtaining skilled technical employment as a strategy under this priority. Baccalaureate ET programs are often overlooked in the federal conversation regarding the development of a skilled-technical workforce. Engineering technology majors are "hands-on" members of the engineering community, who have strong knowledge of technical components and work alongside engineers and technicians to handle the management and implementation of technologies and processes. However, despite their role, engineering technology graduates cannot easily be hired by federal agencies under current Office of Personnel and Management (OPM) rules. OPM currently requires additional experience and education for engineering technologists, versus engineers, that creates a significant barrier to employment. The federal government should be enabling and encouraging technical workers, not erecting barriers to their participation in the federal enterprise. Federal rules also send a strong signal to the private sector and states to reduce their barriers as well. [redacted] can serve as resource in addressing this issue.[5] Although NSF's Advanced Technological Education (ATE) program[6] – directed toward community colleges—is helping to improve technician education and the skilled technician workforce, a similar program focused on engineering technology programs at the baccalaureate level could significantly enhance the quality and number of qualified technologists to augment the engineering workforce.

Continued attention to two-year technician education programs, such as through ATE, is also vital for sustaining a valued component of the engineering professions. These programs also provide a pathway for women, minorities, and veterans to build a foundation for later continuance to engineering technology and engineering careers[7]. It is important to ensure that the pathway is connected via competency-based learning, stackable credentials, and transferrable credit.

Engage Students Where Disciplines Converge

How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

The engineering community strongly welcomes a focus on transdisciplinary and convergent STEM. Transdisciplinary study recognizes the application of ideas gathered from many areas of knowledge. Federal initiatives are critical to the advancement of this area as they can provide avenues to connect students to grand challenges and provide arenas to be exposed to other disciplines. The National Academy of Engineering *Grand Challenges* are a good example for how a community has set big goals to drive research and education forward.[8] [redacted] has fostered community discussions with industry[9] and engineering educators[10] to disseminate best practices to identifying and inculcating convergent STEM approaches.

The federal government has multiple opportunities to aid in the engagement of students where disciplines converge. [redacted] recommends NSF bring back the Young Scholars Program, which provided funding to

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5 [redacted]
6 https://www.nsf.gov/pubs/2017/nsf17568/nsf17568.htm
7 https://www.nap.edu/read/13399/chapter/2
8 http://www.engineeringchallenges.org/
9 [redacted]
10 [redacted]

[redacted]

institutions of higher education to create experiences for high-achieving junior high and high school students in the STEM fields and encouraged them to pursue careers in STEM. An NSF funded report on the experiences of participants in the Young Scholar Program found that the majority of participants had a very positive experience that led them to become more focused, more confident in their abilities, and more aware of the various fields of STEM. The majority of participants also indicated that participation in the Young Scholar Program reinforced their interests in pursuing a STEM career. In addition to revitalizing the Young Scholar Program, [redacted] recommends the expansion of the Research Experiences for Undergraduates (REU) program. Because the REU program supports active research participation for undergraduates on NSF funded research, it provides an excellent opportunity to engage students where disciplines converge, and because of this, should be expanded.

Additionally, the federal government should increase support for traineeships, which expose graduate students to convergent research on national priorities while strengthening institutional incentives to provide excellent education and mentoring. Several agencies such as NSF and NIH already use this mechanism. Other agencies such as DOD that do not currently have traineeship programs should look to create them to enable new approaches to training domestic graduate students on key priorities. Finally, the federal government should increase support for programs that leverage education research to build new tools for educators to be successful, such as the NSF Discovery Research PreK-12 and Improving Undergraduate STEM Education programs and the Department of Defense's National Defense Education Program, among others.

Develop and Enrich Strategic Partnerships, Question 19

If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

[redacted] has taken a variety of steps to support STEM education since the COVID-19 pandemic began, including running a NSF-funded survey of our members to learn how COVID-19 impacted their lives and their work in engineering and engineering education. We have also hosted a series of webinars on topics such as best practices for remote instruction and remote student support, as well as online professional development class for new faculty on how to successfully launch their careers. [redacted] also supports the STEM ecosystem through creation of publicly available K-12 professional development resources.[11]

The characteristics of success in the STEM ecosystem begin with the ability to recruit, retain, and support diverse students and to provide them with the tools they need to be prepared for and succeed in STEM careers. Furthermore, a successful STEM ecosystem provides multiple avenues to learning, such as through pathways programs with K-12 educational institutions and community colleges, mentorship programs, and work-based learning opportunities. In regard to STEM professionals, a successful STEM ecosystem continues to support diversity and respect for all through programs designed to recruit and retain underrepresented groups in STEM fields.

The private sector has many roles to play in a successful STEM ecosystem, including as a partner to universities in providing work-based learning experiences to STEM students and through committing to hire a diverse STEM workforce. [redacted] notes the extensive experience that the engineering and engineering technology communities have in partnering with industry. The federal government plays an important role enabling these collaborations through programs such as the Engineering Research Centers and Advanced Technological

[11] [redacted]

[redacted]

Education at NSF.[12] Cooperative education (co-op) and other work-based learning approaches have a long history within engineering education. While industry partnerships are important to advancing student skills and innovation, [redacted] encourages the federal government to continue to require very high standards of learning and quality to any new credentialing programs to ensure that students are not put at a disadvantage obtaining credentials that are non-transferable, low quality, or too narrow in applicability.

The private sector can also help provide industry-based opportunities for academic researchers. ASEE recommends NSF consider expansion of the Innovative Postdoctoral Research Fellowship (I-PERF) model to allow for the expansion of opportunities for early-career STEM postdoctoral researchers to work at start-up companies. This program aids in accelerating innovation of small businesses while providing post-doctoral researchers with entrepreneurial experience and is an excellent example of a successful public-private partnership to advance STEM.

[12] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5502

I am a STEM educator and a non-profit private liberal arts college.

Engage Students Where Disciplines Converge

Question 16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way? What specific delivery mechanism work well for you (*e.g.,* online course, webinar, in-person workshop)? What technology tools would be helpful for you when using a transdisciplinary approach?

Response:

Given the increase in STEM-leavers nationwide (STEM-leaver is a student who changes their intended major from STEM to a non-STEM major in the first two years of their program), we need to understand and implement best practices aimed at creating an atmosphere that fosters confidence, aptitude, and ultimately persistence, in STEM for all students. Estrada et al. (2010) reported that self-efficacy, albeit important, is neither the only nor strongest predictor of STEM persistence. Discovering and internalizing the values of the scientific community is a critical factor in persistence. Programs in the arts and humanities that focus on value and identity constructs, are more suited to provide a venue for this exploration. As such, developing transdisciplinary programs that provide experiences for learners to explore scientific values and identity, while developing content mastery and critical thinking skills, is certain to significantly impact persistence.

What professional development would help you teach in this way?

Overarching goals of transdisciplinary professional development (PD) should include:

- Capacity- and relationship-building across programs
- Prioritization of the most pressing issues facing education and STEM workforce in respective communities
- Creation of a consortium of educators

Place-based cooperative PD can achieve these goals and potentially create more immediate and sustainable change. This type of PD happens "on the ground" between peers and in real-time. It has a greater potential to be institutionalized because challenges unique to the institution and programs can be directly addressed. By moving PD into the classroom, a learning environment can be fashioned that allows students the means to reflect on the values of the scientific community while developing content mastery.

What might place-based cooperative PD look like? By way of example, I will describe it as it might happen in a course-based undergraduate research experience (CURE). Within a STEM CURE, an entire class of students is involved in addressing a problem or question that is important and unsolved by the research community. In this environment, students gain a sense for what it is like to work as a group toward a common goal and develop identities as researchers or scholars. It differs from experiential learning, more common in non-STEM disciplines, which relies on learning through a reflective process following the "experience", whatever that might be. By pairing a practitioner of non-STEM experiential learning with the facilitator of a STEM CURE, in the same learning environment, both partners can merge their experiences to provide a transformative experience to the students. This convergence gives the non-STEM educator a better sense of how a CURE is taught, while the STEM educator is left with an ability to integrate reflective learning within the CURE curriculum. Added value to this type of PD is that it can address the needs of the student population and be in line with an institution's own mission and goals. It is scalable and can be accomplished by under-resourced institutions of all types.

References

Estrada, M., Woodcock, A., Hernandez, P. R., & Schultz, P. W. (2011). "Toward a model of social influence that explains minority student integration into the scientific community": Correction to Estrada-Hollenbeck et al. (2010). *Journal of Educational Psychology, 103*(1), 256. http://dx.doi.org/10.1037/a0022809

[redacted]

Response to the NATIONAL SCIENCE FOUNDATION
Notice of Request for Information (RFI) on STEM Education

Submitted by [redacted]

Response Comments

Future Opportunities in STEM Education

[redacted] (Q1, Q4, Q8)

To address the issues of the digital divide intensified by the COVID-19 pandemic, [redacted] worked with [redacted] to build the [redacted]. This initiative provides learning solutions designed to fuel education during this critical time by supporting several thousand students and families in Title I schools in the United States impacted by the pandemic. Students received critical at-home and in–the-classroom learning resources, including internet connectivity, technology devices and hands-on STEAM learning solutions.

Through this initiative, these companies are collaborating to help schools create more equitable learning environments and support students during the pandemic and beyond. [redacted] and CDW-G provided a total of $5 million in personal computers, software, configuration services and digital learning resources. They are provided stipends of $4,000 to each awarded district to address home internet connectivity for kids in need. As part of the grant, underserved families in 17 states received support, with nearly 15,000 devices and 7,500 LEGO Education solutions being delivered to 45 School Districts.

[redacted] (Q2, Q5)

Artificial Intelligence (AI) technology is rapidly accelerating with new tools, technology and applications requiring workers to learn new skills. To fill this need, [redacted] plans to increase its [redacted] program to teach as many as 30 million current and future workforce members about AI by 2030. [redacted] partnered with MCCCD in Arizona to launch the first Intel-designed artificial intelligence (AI) associate degree program in the United States. The Arizona Commerce Authority will also provide a workforce grant of $100,000 to support the program. It will enable tens of thousands of students to land careers in high-tech, healthcare, automotive, industrial and aerospace fields. The program's first phase is being piloted online at Estrella Mountain Community College and Chandler Gilbert Community College in fall 2020. As physical distancing requirements are lifted and the concerns of the COVID-19 pandemic decrease, classes will begin in-person at both campuses.

The AI program consists of courses that have been developed by MCCCD's faculty and Intel leaders based on Intel software and tools such as the [redacted]

[redacted]

and [redacted]. [redacted] will also contribute technical advice, faculty training, summer internships and [redacted] mentors for both students and faculty members. Students will learn fundamental skills such as data collection, AI model training, coding and exploration of AI technology's societal impact. The program includes a social impact AI project that is developed with guidance from teachers and Intel mentors. Upon completion, MCCCD will offer an associate degree in artificial intelligence that can be transferred to a four-year college.

It is without doubt that Artificial Intelligence (AI) is bringing disruption across industries and education is no different. With it's potential to boost rates of profitability by a significant amount (about 14 trillion USD economic boost by 2035), AI adoption is just beginning across the industry. The federal government can play a role by funding community college programs that will increase AI workforce readiness and can serve as reskilling centers for workers. Community colleges systems can be the catalyst of making AI technology skills accessible to as many workers nationwide as possible. Increasing investment in programs such NSF Advanced Technological Education (ATE) program would help close AI skills gap. With an emphasis on two-year Institutions of Higher Education (IHEs), the focus on educating technicians in a wide array of industry with AI skills will help drive our nation's economy. The program focus on developing partnerships between academic institutions and industry is the right model to build new AI skills sets for future and existing workforce.

The Q-12 Education Partnership (Q2, Q5)

[redacted] joined the Q-12 Education Partnership, through the Office of Science and Technology Policy and the National Science Foundation. in October 2020. [redacted] will serve as a member of this partnership by helping to support America's educators to ensure a strong quantum-remote learning environment, from providing educators in classrooms and out of school programs the tools for "virtual" hands on experiences, to supporting pathways to quantum careers, to facilitating connections with communities serving youth that can benefit the most from access to these resources. Together, we hope to foster a range of collaboration and training opportunities to increase the capabilities, inclusion, diversity and number of educators and students who are ready to engage in the quantum workforce.

Develop STEM Education Digital Resources

[redacted] (Q1, Q2)

The [redacted] program helps participants build technology and essential skills, using a unique design thinking curriculum and learning approach. The hands-on methodology begins with character development, engaging empathy and communication skills, encourages creative and locally relevant design and prototyping, and takes participants through a series of progressive skill-building in an accessible way so that no prior technology or coding experience are required.

[redacted]

[redacted] activity challenges help close critical education and skills gaps through skills development and hands-on innovation supporting participants to: 1) Build their technology skills, 2) gain tenacity and confidence, 3) create locally-relevant tech, 4) apply innovation that responds to a community or personal challenge, 5) gain essential skills toward STEM education or in preparation to land a job in any field, 6) enter post-secondary education – whether vocational training, junior college, or four-year program, and 7) become entrepreneurs. Intel is currently working on making these materials available online at no cost and open to the public.

The [redacted] deliver model is comprised of more than 20 customized modules and 35+ hours of content and activities, delivered by specially trained [redacted] employee volunteers. [redacted] uses a Train-the-Trainer model to prepare cohorts of lead facilitators to build capacity at partner organizations and schools. The program curriculum is ideal for middles school, 6 – 8th grade, and can be customized and used in elementary level or high school and beyond.

Increase Diversity, Equity, and Inclusion in STEM

Refer to [redacted]

Engage Students Where Disciplines Converge

Refer to [redacted].

Develop and Enrich Strategic Partnerships

Million Girls Moonshot Movement (Q18, Q19)

The [redacted] joined STEM Next Opportunity Fund, the Gordon and Betty Moore Foundation and the Charles Stewart Mott Foundation to launch the Million Girls Moonshot. This is a transformative, nationwide movement designed to close the persistent gender gap in STEM fields by engaging 1 million girls in STEM pursuits through innovative and high-quality, afterschool learning opportunities over the next five years.

The Million Girls Moonshot is not another STEM program. It is a collaborative, nationwide movement involving a wide range of cross sector partners that is designed to break down the systemic barriers that have kept girls and youth of color out of STEM for too long. The Million Girls Moonshot is unique in both its scale and approach. By leveraging the 50 state afterschool networks, the Million Girls Moonshot has the potential to reach more than 10 million youth and 100,000 afterschool programs across the country. The collective impact approach, involving a wide range of charitable organizations, technology leaders, the afterschool networks and educators in local communities ensures that pathways are created to support girls through transition points and opportunities, keeping them engaged in STEM learning through middle school, high school and beyond. Additional partners in this movement include NASA, Technovation, National Girls Collaborative

[redacted]

Project, CSforALL, JFF, Techbridge Girls and more are joining every day to provide grant funding, in-kind resources and mentors. Just as the original "Moonshot" nearly 60 years ago united the nation behind a common goal and advanced scientific achievement, so too the Million Girls Moonshot will "move the needle" and truly change the trajectory of women and girls in STEM in the U.S.

This new movement is more important now than ever. The COVID-19 pandemic has hindered learning opportunities for students and exacerbated the digital divide and the engineering skills gap among school-age children and youth of color. The Million Girls Moonshot will help advance this progress by ensuring that youth of color and those living in underserved communities will have access to high-quality STEM education that can unlock greater opportunities throughout their lives. By equipping girls with the Engineering Mindset, the Million Girls Moonshot positions them to be able to solve the problems stemming from this pandemic. We welcome more partners to join the movement! Learn more at milliongirlsmoonshot.org.

[redacted] and Oakland Unified School District (Q18, Q19)

Since 2015, [redacted] has partnered with McClymonds and the Oakland Unified School District to develop and improve computer science and engineering courses. As part of [redacted] five-year, $5 million investment in two OUSD schools, [redacted] helped launch new engineering and computer science pathway programs for students at McClymonds, encouraging them to pursue future education in science, technology, engineering and math (STEM) fields. Enrollment in computer science classes has seen a 14-times increase two years into the program. The collaboration will affect 2,300 students and graduate 600 in the disciplines. The initiative is multifaceted, with programs for students including work-based learning, mentoring and internships, along with education and awareness for parents, and professional development support for teachers.

In 2018, 31 McClymonds graduating seniors completed the engineering pathway program and are off to college in the fall. Students plan to attend universities including the University of Southern California, the University of California-Los Angeles, the University of Nevada and the University of Hawaii. Their success demonstrates that with support and investment, school districts can dramatically improve educational outcomes and prepare students for success in today's high-tech workforce.

[redacted] (Q18, Q19)

[redacted] believes in the power of STEM education and understands the journey to obtain an academic degree is challenging and wants to do its part to help make that process a bit easier. [redacted] has invested in several scholarship programs through nonprofit organizations and universities where it further contributed millions to ensure students receive the best opportunities and education necessary to prepare them to enter STEM fields after graduation.

[redacted]

The universities for the program were chosen based on the total amount of engineering and computer science majors graduating from them, because of their focus on helping under-represented minorities succeed in STEM education, and due to their proximity to our normal bases of recruitment. Each scholarship recipient must have and maintain at least a 3.0 grade point average for continued eligibility. Scholars are encouraged to experience at least one internship prior to graduation, and [redacted] will offer an internship opportunity and/or a full-time job to each scholar after successfully completing an interview.

[redacted] scholars benefit from ongoing development during their [redacted] internships that prepare them for careers post-graduation. Working on exciting ground-breaking projects, sessions with executives, workshops on resume writing, and interview coaching are all part of [redacted]. It's a great opportunity to set students' careers on a solid path while still in school.

[redacted] past and current partner non-profit organizations include the National GEM Consortium, Semiconductor Research Corporation (SRC), Undergraduate Research Opportunities (administered by SRC), Hispanic Foundation of Silicon Valley, United Negro College Fund, Great Minds in STEM, the American Indian Science & Engineering Society, Historically Black Colleges and Universities, and Georgia Tech.

[redacted] (Q18, Q19)

[redacted] believes technology opens the doors to opportunity, and we are committed to empowering girls and young women through technology and hands-on STEM experiences. Through SWC U.S., we are connecting middle school girls to hands-on technology experiences to inspire them to become innovators and encourage their interests in technology, engineering, and computer science. We are focusing on programs and collaborations and collective impact that emphasize hands-on STEM activities, use peer mentors and role models, and make a clear connection between technology careers and real-world applications that drive positive social impact.

In the spring of 2019, the [redacted] announced $1.25 million in grants to 27 partner nonprofit organizations collaborating on 11 projects in California, Texas, Oregon and Washington. The grants aim to help these organizations provide innovative, hands-on experiences that expose middle school girls and their families to STEM fields in fun and exciting ways.

These new grants followed a $1 million investment in 2017 and 2018 for the pilot program of [redacted] U.S. implemented in Arizona. The collective impact achieved was transformational and inspired us to scale up. For instance, the Phoenix College TEC is for Girls! program found, through pre- and post-program surveys, that the share of

[redacted]

participating girls who envisioned themselves going to college rose from 24 to 78 percent, with a similarly impressive increase in their confidence in science and technology subjects. Earlier this year, the [redacted] [redacted] was recognized by Phoenix College for the "TEC Is For Girls" program being implemented in the Cartwright School District in Arizona. The Program is designed to introduce young American Indian, Black and Hispanic girls to TEC careers in fun and interactive ways.

[redacted] (Q18, Q19)

The [redacted] camps are made possible through private-public partnerships between the [redacted], the U.S. Department of State and Girl Up, a campaign of the United Nations Foundation. Since 2015, the camps have drawn more than 700 girls from more than 20 countries to build their confidence, leadership and technology skills. [redacted] is the leading industry sponsor and strategic foundational partner for this collaboration. Through the [redacted] the [redacted] helps to provide participants with tools to 1) develop innovation & technology skills, 2) focus on applying technology for a safer and more secure world, and 3) offer the participants a window to see themselves as future global technology leaders and innovators. During the camp, participants develop team projects using technology and skills learned at the camp to address real-world problems in their communities. Past host countries include Rwanda, Peru, Malawi, Namibia, Georgia, Kosovo, and Estonia.

In 2019, the first [redacted] camp in the U.S. focusing on a local community and held in Bend, Oregon was successfully implemented. The camp included 54 girls in grades 7-9 from underserved communities.

Build Computational Literacy

N/A

Community Use and Implementation of the Federal STEM Education Strategic Plan

N/A

From: [redacted]
Sent: Sunday, October 18, 2020 11:12 PM
To: NSF CoSTEM <CoSTEM@nsf.gov>
Subject: [EXTERNAL] - [redacted]
STEM RFI Response

Hello Fellow STEM Stuart,

My name is [redacted] [redacted]. As a STEAM educator since 2010 I've had the pleasure of being apart of many hands on K-6th grade STEAM workshops with companies such as Hour of Code, Sphero, Lego, EcoLife Conservation and Google. I recently had the opportunity to train in JavaScript at the Amazon San Diego hub. My view as an educator is progressivist. The pedagogy I use to successfully achieve my "why" for students stems from inquiry based learning and expeditionary learning models. I believe hands on learning is essential for figuring out tomorrow's problems and foster strong independent and successful people with 21st century skills. The way I approach learning in my STEM room is very student centered and derived in giving students experiences where I challenge students to learn by doing. I enjoy students to discover what they love, I want students to fuel their curiosity, wonder, and joy, to not only learn but, to find what it is they are passionate about. In my classroom students understand I am an expert, but that I am also a learner. I've noticed a tremendous amount of engagement from my practice.

Federal STEM Education Online Resource question 2

There is a cutting edge private company in STEM education called [redacted] [redacted] [redacted] mission is to teach children STEM and entrepreneurship thinking through project-based learning while combining e-commerce and e-learning. The company also provides a network of national industry leads, for students to learn from. They have figured out a way to bridge **STEM industry leads, teachers and students.** I've noticed that schools are looking for ways to incorporate specials like STEM. Currently, most are sub par, with STEM being taught asynchronously (not very much accountability). [redacted] offers a 4 part hybrid (synchronous & asynchronously) model that explores STEM and creates leaders (ages 10-18) in the fields they want to specialize in. The problem I'm running into is finding funding for schools to experience this new age of STEM learning. The program is incredible, please don't hesitate to call me, if you have any questions, I'd love to share my experiences in STEM and with [redacted]

Best Regards,
[redacted]

From: [redacted]
Sent: Saturday, October 17, 2020 10:29 PM
To: NSF CoSTEM <CoSTEM@nsf.gov>
Subject: [EXTERNAL] - NIST, STEM and the metric system (SI)

This is admittedly a "canned" letter from a metric web site regarding the US and the metric system but it reflects at least a part of myself and my wife and our views on the adoption of the SI in the USA, so it makes the sentiment no less valid.

I ask you to please become more vocal to our lawmakers regarding adopting the SI in the United States. We can start by removing obsolete and proprietary American units from consumer packaging to acclimate Americans to this modern, rational and internationally embraced system of measure.

GO METRIC, AMERICA!
The World Is Waiting...

From: (b) (6) [redacted]
Sent: Sunday, September 13, 2020 12:30 PM
To: NSF CoSTEM <CoSTEM@nsf.gov>
Subject: [EXTERNAL] - (b) (6) [redacted] STEM RFI Response

Category and Question

Increase Diversity, Equity, and Inclusion in STEM

STEM education practices and policies at all levels should embody the values of inclusion and equity. All Americans deserve access to high-quality STEM education, regardless of geography, race, gender, ethnicity, socioeconomic status, veteran status, parental education attainment, disability status, learning challenges, and other social identities. For each response below, please indicate the education system or career experience for which you are responding.

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

Currently, I serve as a teacher and instructional coach in a district in [redacted]. In my current district, an Equity, Diversity, and Inclusion Committee was formed at the beginning of the 2019-2020 school year. I serve on the committee and we meet biweekly. Membership consists of Board of Education members, district senior leadership, educators (principals, teachers, etc.), and community members. One community member, a female, who works for GE, and I discuss the need for STEM to be an area of focus but it is typically not included. There is a STEM specialist employed by the district. As an [redacted], I rarely see him. He may be more involved at the secondary level but rarely at the elementary level, which is exactly what I worked to advocate for during the [redacted]. I would like to share more information on what the district targets with STEM efforts but the truth is, that I have not seen much, if anything at all, being done to increase the recruitment, retention, inclusion, achievement, or advancement of individuals that are underrepresented and underserved in STEM. As of 2019, I am in a new district after serving in my previous district for 19 years. One of the reasons I left my previous district is because of their lack of support for STEM efforts. If there are areas of focus with STEM at the secondary level, I am not aware so even if they are happening, they are not regularly published. I also am unable to share how any interventions may be evaluated. I selected this question to highlight the continued inequities of STEM at the elementary level and am happy to provide more information on my district, experiences, etc. if needed.

Respectfully,

(b) (6) [redacted]

Submission 1

clearlly this federal agency knows nothing about remote learning. it is seeking to take the time of all those across the usa who have been trying to teach using remotelearning to educate themselves at our taxpayer monies and dollars. i think since this agncy is clueless, it shoudl be shut down as far as having any authroity o education of stem. clearly,it knows zero about teaching math or science through remote, why are taxpayers being asked to fund in the billions of dollars a learning curve for this agency, which is obviiously clueless. htis iis totally wassteful spending. lets let the us dept of education ne engaged instead of duplciating everything with this dept which has nothing to do so they ihvade other depts. this commetn is for the public record plese receipt. (b) (6) [redacted]
(b) (6) [redacted]

Submission 2

upblic commetn on federal registet

1. library and schools closed. no access to magazines, newspapers to keep up to date with what is gong on in the world.
2. access to full library and school services
3. have found abiility to attend meetings via zoom and other programs and telephonically whereas travel to attend meetings would be impossible
4. mental strain from zero physical and menatal contact with other people. distance is distance.
5. math is not good for teaching over cable. many subjects are too dry to be taught by cable zoom classes. maybe history can be taught
6.urrent events. the way lockdown is forcing americans to be taken away from any personal contact and to have their rights to a free society completeluy obliterated. americans have been put into fiefdom. and to spy on each other.
7. nothing
8. nothing. 9 nothing.
10. you dont in any way have to be stem literate to be innovative. many with 7th sgrad educations have been shown to be extremely innovative. that is a special skill soem have.

11 - nothing l2 nothing. 13 nothing l4 nothing l5 nothing. 16 catching the interest in self and selfish interests is one main attractant to this learning. that is a key to teaching effectively.
16 nothing l7 nothing l8 have to be inimical to each student to get ahead and claim interest
19 nothing
20 extreme need to be able to understand how the computer works in all its facets that is extremely miportant.

21 nothing 22 nothing 23 nothingthis cmometn is for the pubilc record please receipt. (b)(6) [redacted]

Submission 3
public comment on federal register

i believ this should be the work of the us dept of education primarily, not this secondary duplicative agency. i believe this agency should be combined with us dept of education and not be a separate expensive agency.

1. 1. no inclass instruction

2. if there are sound teaching methods that work, put them online free for those interested. why arent they there already. why arent teaching programs for grades kindergarten through college already on line free for those interested. with all the costs of all these studies you are forever funding, we could have had an entire teaching practicum on line free already.
 anybody who doesnt have a compute can go to the library and watch free and learn and have no excuse for not learning. every single subject in the usa taught should already have such a class on line for those who are poor. that will help everybody, in english language. then anybody at any level of enrichment can learn. why dont we have that now. its not that expensive to film a working class of merit and put it on line. if we find a better one in the future, we can replace.
3. remote learning in most cases is not as effective as in person classes but if you are really interested ni learning it can work.
4. there are zero.
5. ted talks are a good example of what works.
6. no data should be collected during this pandemic. wait until over. it should be over right now except for political scamming.
7.every single grade should be filmed and put on line now. kinder to college for free.
10 taught adults
15 All engingeering, physics, classes and such should be taught in usa by somebody who can truly speak english and explain in english. stop the import of foreigenrs who cannot b eunderstood by students. far too often the teacher is hte problem.not the student. . you must teach in teh language of the students.

The following comments represent input from:

- Organization: [redacted]
- Division: Education
- Prepared by [redacted]
    - [redacted]
    - [redacted]

In response to the RFI specified by:

- Agency: National Science Foundation
- Document Number 2020-19681
- Pages 55323-55326
- Document Citation 88 FR 55323

We will provide responses to the following items:

- Future Opportunities in STEM Education, question 2 and 8
- Engage Students Where Disciplines Converge, question 13
- Develop and Enrich Strategic Partnerships, questions 18-19

Our Perspective:

We are an architectural and design practice. Within the firm, our [redacted] focuses on issues related to educational planning, space-making, and teaching practice.

We employ architects and designers who partner with a variety of entities within the education landscape: public schools and districts, private schools and networks, parochial schools and dioceses, and informal and/or non-traditional educational organizations in both the non-profit and for-profit sectors.

We closely collaborate with a STEM education non-profit housed within our [redacted] studio: [redacted] In conjunction with STEAM Studio we provide professional development opportunities for teachers and maker-focused learning experiences within the on-site makerspace.

We also employ in-house education researchers and master teachers who develop educational tools and conduct robust studies to inform design and support learners. Our research includes a study with middle school teachers, highlighting themes emerging from their instruction efforts in the midst of the COVID-19 shift to emergency remote instruction.

Future Opportunities in STEM Education, question 2:

"What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (*e.g.*, virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (*e.g.*, pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas."

These comments are intended primarily for K-12 education.

Traditionally, education infrastructure and organization has been built around physical space – educational entities are defined by the school building or group of buildings that house their programming. The widespread shift to remote instruction has revealed that this physical model is only one of the many ways we can organize education. In an online setting, if students are already fragmented across physical locations, it is of very little consequence whether they are across town or across the globe.

Thus, the notion of multi-nodal programming is an educational concept that would enhance remote education. This recommendation targets state and federal policy – and its adjacent funding mechanisms – in terms of areas needing change to meet the shift in educational approach. Many program evaluation paradigms and grant competitions include explicit and implicit assumptions about how programs can be built, funded, and evaluated; these assumptions de-incentivize or outright disqualify designs leveraging remote instruction's distributed setting.

- Policymakers should revise standards and requirements for educational programs (especially teacher certification programs) to accommodate remote and hybrid training options. These revisions should expand definitions of "field hours", "course hours" and other terms that require a place-based component.
- Funding agencies should revise grant proposal requests that are space-agnostic to include language to explicitly consider distributed, remote programs for funding.
- Funding agencies should create targeted grant opportunities to explore the educational value and affordances of learning in distributed spaces (at houses, in multi-home locations like apartments or dorms, in public common spaces, etc) during remote and hybrid instruction.
    - These explorations should include partnerships across academic levels (K-12 & higher education partnerships) and between education-industry partnerships.

Future Opportunities in STEM Education, question 8:

"What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?"

These comments are intended primarily for K-12 education.

[redacted] researchers collaborated to design and implement timely research related to COVID-19 emergency remote teaching in the spring of 2020. This research focused on the experiences of private middle school educators.

We learned that teachers, administrators, and schools focused on solving problems to provide speed in instructional delivery, recreation of community atmosphere via online supports, and the continued pursuit of academic quality. The initial shift to remote instruction came suddenly, and school leaders worked to act quickly and decisively to provide educators parameters for operation through the remainder of the semester. The focus on clarity (in a moment of enormous uncertainty) dramatically improved teachers' sense of control, agency, and general mental well-being. Community supports like frequent digital communication and direct instructional assistance for students also helped teachers feel connected and reduced feelings of burnout.

Other members of the [redacted] ecosystem, such as the non-profit educational organization [redacted], housed in our [redacted] office, pivoted to operations relevant in the remote format. Prior to COVID-19, [redacted] provided student experiences in a maker space supported by expert teaching personnel. In the remote environment, [redacted] has begun developing mobile programming and remote services to continue to meet the needs of community students in a decentralized educational environment.

A significant barrier in providing things like distributed support is the access to institutional resources – primarily work time. With our K-12 partners, teachers have almost universally acknowledged the value of having highly-involved administrators to support them and their students. However, the need outpaces what existing administration can meet within the workday, given their other obligations. Federal funding directed to student services in direct support of learning would likely yield tremendous value for students. This should include both administration-level work time and counselor-level work time, and the time should be available to support both teachers and students.

Engage Students Where Disciplines Converge, question 13:

"How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (*e.g.,* a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (*e.g.,* more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?"

These comments are intended primarily for K-12 education.

[redacted] emphasizes the use of transdisciplinary learning through our prioritization of project-based, problem-based, and phenomenon-based learning – the group here collectively called PBL. Any of the PBLs require a rich, authentic anchor. Such an anchor necessarily requires opportunities to consider multiple disciplinary questions, often within overlapping activities. Mathematical modeling and biological processes arise together in an ecology project. Addressing the problem of sustainable farming requires engineering processes, soil chemistry, and agricultural technology discussions, all happening in parallel. The essence of each of these examples is identifying an anchor for the PBL which is complex enough to contain opportunities to prompt student thinking in multiple disciplines.

These lesson materials don't easily classify to a single educational silo. What we hear from our higher education and workplace partners consistently emphasizes the need for flexible thinkers; the days of single-subject experts are gone.

These projects have two equally important benefits. One, PBL leads to measurable improvements in student learning, achievement, and attainment. An extensive body of research shows that PBL implementation, when held to reasonable thresholds of contemporary quality, actually outperforms other learning methodologies (direct instruction, scripted curriculum packages) on standardized assessments and measures of attainment. Ironically, these assessment metrics are held up as justifications for those same competing methodologies. With a PBL approach, students develop more knowledge, in more flexible and interconnected contexts, in a more durable state over time.

The second, but equally important, benefit of PBL is the development of parallel educational dimensions not directly measured on the high-stakes exams. Enterprise skills, which are eagerly sought after by employers, are more effectively developed in PBL contexts. Similarly, student connections to community, citizenship and character qualities, and other socio-emotional outcomes are also much more effectively developed through PBL compared to teacher-centered or prescribed curricular approaches.

Develop and Enrich Strategic Partnerships, questions 18:

"What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?"

These comments are intended primarily for K-12 education.

[redacted] has worked with education partners through the [redacted] initiative and learned the value of strategic partnerships focused on compelling, complex problems. Our [redacted] connected middle school students, collegiate engineering and physical therapy students, and STEAM professionals to meet a mobility need within the community where the students lived.

The [redacted], and others like it, emphasize a broader conception of learning than the siloed definitions of subjects all too common in K-12 education. We start with the "why" – defining a shared purpose for the students and educators immediately. We also provided training on essential professional skills, such as design thinking and metacognitive monitoring.

Federal agencies should recognize the importance of developing the process and partnership when building work-based learning programs. Connecting willing work and education partners is only the first step of a more complex process in building a valuable program.

Federal agencies should…

Funding planning and collaboration time for educators is essential to map the curricular value in the program in ways extant evaluation programs can recognize and acknowledge. Industry partners need funding and networking with educational experts (researchers and practitioners) to design autonomy-supportive processes and robust project prompts to share with participating students. The burden of pedagogy development in a work-based learning program can't exclusively fall to the education partners; to fully develop a successful work-based learning program, industry partners need to be working with learning experts connected to the industry context.

Develop and Enrich Strategic Partnerships, questions 19:

"If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?"

These comments are intended primarily for K-12 education.

The [redacted] STEM learning ecosystem defines success in terms of recruitment and retention numbers for STEM programs. This metric not only means successful attracting participants in each cohort of students, but also an ability to attract a representative sampling of students from their larger educational community (with attention to demographics like gender, race/ethnicity, or socioeconomic status). Further, these metrics include upstream interest among recruiting pools (ex: for a middle school STEM program, how much interest and experience exists among feeding elementary schools). They also include downstream measures like future program matriculation and career interest.

Another pressing concern for STEM learning success is the representation of the learning experience for scholarly, industry, or otherwise professional practice. Successful STEM programs engage students in lab practices aligned to the evolving needs of industry (rather than "classic" educational lab curricula). This alignment extends to up-to-date processes for design thinking, modeling, and critical thinking for engineering students. It also extends to robust mathematical thinking in computer science, game theory, or more familiar mathematical disciplines such as number theory or statistical reasoning (rather than "classic" calculation or rote procedural practice). In every case, matching the learning experiences to real world experiences is essential to successful programs. Private sector partners should provide support in making these kinds of connections to real-world applications, in both creative direction and instructional implementation.

Our STEM ecosystem, including the non-profit educational organization [redacted] housed in our [redacted] studio, and our professional development work, has focused on leveraging the opportunities present in the disruption of space since the COVID-19 pandemic. Classroom assets have largely been unavailable since the pandemic reached North America – and even in returns to face-to-face teaching, social distancing and capacity constraints render many past investments in technique and equipment inapplicable. However, students can benefit from learning in their homes and around their neighborhoods. Local parks, common spaces, and other community assets can play a new role in STEM education not previously feasible, and many of our partnerships have attempted to identify what opportunities may exist in this distributed format.

[redacted]

STEM RFI RESPONSE for NATIONAL SCIENCE FOUNDATION

The [redacted] is pleased to submit this response to the RFI from the National Science Foundation on STEM Education.

[redacted] answers draw on our organization's experience in curriculum development and enrichment programming that offer new ways to teach, learn and explore cutting edge science and engineering. In 2007 with [redacted] and the partnership of award-winning high school teachers, [redacted] began converting modern research questions into hands-on laboratory content and problem-based learning modules that align with many educational priorities as well as to national science standards. Established as an independent non-profit organization in 2011, [redacted] now supports teachers and students in nearly every US state and more than 30 countries around the world.

To complement our flagship classroom curriculum, [redacted], [redacted] has traditionally offered three out-of-school-time programs: the [redacted] and our Summer Professional Development for teachers. When COVID forced schools to close in March, [redacted] rapidly re-imagined its curriculum. Our transition to online learning stays true to the best of what [redacted] teaches, namely

- a team-based approach to creative problem solving,
- legitimate biotechnology skill building,
- meaningful data analysis, and
- professional quality communication.

We plan to continually offer these online programs through COVID crisis and beyond. They sustain and expand our goal of providing life-changing science education for all.

Questions addressed in this response:

FUTURE OPPORTUNITIES IN STEM	**Q 8**	**STRATEGIC PARTNERSHIPS**	**Q 18, 19**
STEM ED DIGITAL RESOURCES	**Q 10**	**COMPUTATIONAL LITERACY**	------
INCREASE DEI IN STEM	**Q 12**	**IMPLEMENTATING FED STRATEGIC PLAN**	------
ENGAGING WHERE DISCIPLINES CONVERGE	**Q 13**		

[redacted]

FUTURE OPPORTUNITIES IN STEM

Q8. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

[redacted] has traditionally offered three out-of-school-time programs: the [redacted] and our Summer Professional Development for teachers. These programs complement our [redacted] (translated into Russian and Japanese by the publishers and Spanish and Mandarin by our teachers) and [redacted] that have been adopted in most US states and dozens of countries around the world. When COVID forced schools to close in March, [redacted] rapidly re-imagined its curriculum. Our transition to online learning stays true to the best of what [redacted] teaches, namely

- a team-based approach to creative problem solving,
- legitimate biotechnology skill building,
- meaningful data analysis, and
- professional quality communication.

We plan to continually offer these online programs through COVID crisis and beyond. They sustain and expand our goal of providing life-changing science education for all. Truth be told, we had a longstanding skepticism about accomplishing all these goals remotely and through online platforms. But six-months in, two homeruns have been our use of [redacted] to bring a "thinking part and doing part" to each online meeting. **Next steps: scaling this approach**

DEVELOP STEM EDUCATION DIGITAL RESOURCES

Q10. Please describe your primary audience (e.g., I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.

One silver lining from the upending of everyone's school plan is the positive impact [redacted] can now have through our online content, including the Idea Accelerator, a Project Design Studio, Advanced Seminars and Virtual Bootcamps. A 90 second video about the work is [redacted] It illustrates our use of [redacted] to high school students and teachers.

With [redacted], an open-source tool for nonlinear storytelling, [redacted] is able to run a choose-your-own-lab-adventure experience. The experimental procedure is performed by a real person based on the decisions made by the online students. Students make real-time experimental decisions, for example should they remake a solution that gave a strange reading, measure it the same way again, or just ignore that data point? This unique offering puts online students "in the lab" and gives them first-hand experience with scientific ways of thinking and the adventure of doing real benchwork.

To teach computational thinking, meaningful data analysis, and effective communication, [redacted] has leveraged RStudio.cloud, an open-source collaborative platform. [redacted] provides students with "projects" that they open and copy to their personal RStudio accounts. Students then edit the code with no danger of overwriting the source material, applying the R programming language and project packages to their personal biodesign ideas and to the analysis of model data. Students become familiar with research-grade tools for statistical analysis and data management. Most gain proficiency with powerful research tools that will serve their future science and professional careers.

Next steps: scaling this approach

INCREASE DIVERSITY, EQUITY, and INCLUSION in STEM

Q12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

[redacted] draws on the framework proposed by the Boston Opportunity Agenda to help everyone, but minority and under-represented groups in particular, succeed in STEM college and careers.

- [redacted] provides technical curriculum that emphasizes design and problem-based challenges, improved teaching practices that are student-centric and that support active learning in middle and high school classrooms, and improved academic advising so the advantages of opportunities in STEM fields are known to all.
- [redacted] is exploring dual enrollment classes that provide community college credit for high school work. These are powerful drivers of Diversity, Equity and Inclusion when paired with articulation of agreements for transfer credits from community colleges to 4-year degrees, and with financial aid packages that make advanced STEM training possible.
- [redacted] sees an opportunity to more thoughtfully schedule community college classes like ours so students can meet family obligations. In addition [redacted] offers mentorship by STEM professionals at all educational stages, and is eager to partner for co-ops that help students learn and earn and provide a direct path to a STEM career.

Next steps: scaling this approach

ENGAGE STUDENTS WHERE DISCIPLINES CONVERGE

Q13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

[redacted] brings tomorrow's science to today's classrooms. By turning cutting-edge science and engineering into teachable modules, we open minds and doors into the world of STEM education for students and educators alike. Our curriculum is based on the undergraduate curriculum in synthetic biology that is taught in MIT's Department of Biological Engineering.

[redacted] applies biotechnology to the engineering of life science. Practitioners are DNA programmers who can design complex genetic circuits that operate inside living cells and solve real-world problems with biology. Current application spaces are materials science, fine-chemical production, fragrances, foods, and, to a lesser extent, fuel and medicine.

[redacted] is "cross training" for a student's brain, encouraging them to draw on multiple fields of study and apply their creative ideas to the design of novel solutions that meet grand challenges. Our future STEM innovators will be most ready if they:

- Have facility with core knowledge,
- Can apply critical and computational thinking to tough problems
- Work hard and with tenacity
- Stay optimistic as they learn by trial and error
- Exhibit social skills that enable individual and team-based exploration of innovations

[redacted] is also a practice in which attention to detail, careful planning and execution of multi-step procedures, facility with basic math, thoughtful data analysis, and clear communication are valued. These skills and capabilities, in addition to the ones listed above, are most relevant to those who hope to work in biomanufacturing jobs or who want to be responsible for the technical execution of future biotechnology. **Next steps: scaling this approach**

DEVELOP AND ENRICH STRATEGIC PARTNERSHIPS

Q18. What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

Most traditional EWD programs deploy one of three strategies for developing the future STEM workforce. Their deficiencies are underlined, and [redacted] responses to the needs follows.

STRATEGY 1: teach foundational STEM skills in PK-12 settings

In terms of teaching the necessary technical foundations in our primary and secondary school system, it's notable that US PISA scores for math and science are unchanged in the last 20 years, with the US performance looking more like that of New Zealand than that of our biotech competitors like China or Singapore. Similarly, US NAEP scores in math and reading are unchanged in a decade. Improved STEM resources for schools and new approaches to teaching them are clearly needed if we want to stay globally competitive and lead the future of STEM.

STRATEGY 2: raise STEM career awareness through site visits to companies, career-focused seminars, and NSF- and NIH-sponsored training programs (REUs, RETs, graduate exchange programs)

Career awareness through a daylong "visit a company" strategy is only anecdotally effective, with the impact of impersonal activities especially unclear for disadvantaged students. Sustained mentorship, however, that includes more personal interactions of students and teachers with STEM professionals, can powerfully influence the career trajectory of participants. As programs have shifted to online learning, there is a new and important opportunity to seamlessly integrate academic scientists and industry partners into the technical coursework students learn and teachers teach.

STRATEGY 3: expand learning opportunities that partner employers, schools and nonprofits.

Expanded learning opportunities, be they summer research opportunities for high school students, co-op programs for college students or graduate credit for teacher certification, seem to be especially meaningful for retaining and enriching the careers of participants at every stage in the STEM pipeline. The vertical integration of STEM education and professional opportunities across educational and industry partners is particularly effective for engaging and retaining minority and under-represented groups.

The [redacted] aligns our programs to each of the strongest approaches for work-based learning. Replication and scaling of these efforts is underway but is not currently funded at levels that support all interested and qualified individuals.

- Strategy 1: Our online and hands-on laboratory experiences, our biotech kits, and our teacher training programs have re-invigorated classrooms throughout the US, including in rural East Tennessee as described [redacted].
- Strategy 2: Our out-of-school programs like our [redacted] directly leverage STEM professionals as teachers, and let students work elbow-to-elbow with world class scientists.
- Strategy 3: Our Apprenticeship prepares students for summer jobs in the biotech sector.

Next steps: scaling these approaches

Q19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

From our vantage, STEM learning ecosystems is "stuck" in at least three ways and [redacted] addresses each.

First, STEM fields are presented to students as a series of techniques rather than a way to ask and investigate good questions. This shortcoming puts students at a tremendous disadvantage, given the speed with which the tools of STEM fields advance. The approach leaves students unfamiliar with the techniques that research labs and industry deploy, as well as mis-informed about the skills that make them attractive future employees. To get unstuck, [redacted] puts STEM in context.

Lessons are based on authentic challenges that exist for society today and that matter to the students. Sustainable food, fuel, medicine, environmental remediation, novel materials for agriculture or space -- all are ripe for invention by today's students. STEM education, when motivated by society's greatest needs, can inspire students to gain practical skill training, to think in critical and computational ways, and to choose careers for upward mobility and impact.

Second, early STEM instruction is – for the most part – delivered by secondary school teachers who have no direct research experience, limited time and material resources, and narrow views into the future careers that they are preparing students to enter. Among its many impacts, the COVID crisis has exposed the extent to which we depend on our educators. While teachers are trained and hired to develop every student's competency in school subjects, teachers are also asked to recognize and address food insecurity issues, mental health needs, and the impact of family trauma. If we are to attract the best and the brightest into teaching and then keep the most effective educators in the classroom, then we must do more to support them. In the context of [redacted] works in partnership with teachers to offer curriculum and training that re-ignites their own love of learning, as well as mentorship from practioners in higher ed and industry.

Third, access to STEM education is not evenly distributed. For example, two major biotechnology hubs are concentrated in the Boston- and San Francisco Bay-areas, and we see the positive consequences of density. Career opportunities in biotechnology arise from the established and startup companies in these areas while the large number of higher education institutions on each coast feeds the growing biotech industry and encourages local students to dream big and explore post-secondary education. Noteworthy, though, is how biotech companies in the costal hubs still have long lag times for hiring entry level employees, despite the deep pool of local talent.

Contrast this with the situation for rural or poor inner-city communities in which students who graduate from high school may have never met a STEM professional. If, by chance, such a student grows eager to work in the biotechnology industry, they must leave the community they are tightly connected to. When secondary school budgets are pinched, as they so often are, it makes little sense for administrators to invest in biotechnology resources like labs and equipment and training programs, when students will have to go elsewhere to pursue the field as a career. This exacerbates the draw-down of young professionals in rural communities and poor cities, perpetuating inequity by limiting access and opportunity in our growing bioeconomy.

[redacted] has been adopted in diverse communities across the country. A case study of [redacted] adoption in rural Tennessee notes: *"In addition to getting students excited about science,* [redacted] *also challenges them to a higher level of learning and thinking. [One teacher] describes it well: "When we do the lab, we ask the kids, 'If you were creating, what would you do? What problem would you solve? Where would you want to go with it?' The student becomes the scientist in that role. They are the problem solvers. It gets them to start thinking in scientific and engineering ways, and it has been really exciting to see. I think their whole approach and understanding are stronger because they have this experience that ties things together."*

Next steps: scaling this approach to reach every high school in America. [redacted] **teaches core competencies – as meaningful as reading, math, and computer coding. All students and teachers should have access to this curriculum.**

I am responding to this call for information as a post-secondary STEM educator, discipline-based education researcher, [redacted] I will indicate at the beginning of each answer, the specific perspective from which I am answering the question.

In this document, I will be responding to the following questions: “Future Opportunities in STEM Education questions 1-3, & 5”, “Increase Diversity, Equity and Inclusion in STEM question 12”.

1. (*My perspective for this question is as an educator and* [redacted] *and* [redacted] *related to challenges faced by post-secondary faculty and learners*). The two most prominent digital barriers based on my own experiences and those of colleagues with whom I work and communicate were: 1) lack of access for all students to high quality broadband in order to attend virtual classes and/or have access to online materials and 2) lack of familiarity of faculty with many platforms or programs to engage students effectively in a remote venue, synchronous or asynchronous. These issues have had partial resolutions. Some institutions and communities have had partial success in increasing broadband access, but this is definitely still a substantial barrier and one that disproportionately affects some populations which leads to increased gaps in access to education for students from low socioeconomic backgrounds and students traditionally underserved by STEM disciplines. One example of an institutional strategy that was related to me was an institution that provided hotspots for students without access to internet. Given increasing reductions of state and federal funding to institutions, it is hard to see how schools will be able to overcome this barrier on their own especially if students choose to matriculate remotely. Access to high quality broadband should be viewed as a national infrastructure priority like roads, etc.
2. (*My perspective for this question is as* [redacted]*, related to professional development opportunities for post-secondary faculty*). As the [redacted], I directed and am aware of the development of online versions of the professional develop programs offered by several national STEM education reform organizations – MoSI, SENCER, BioQUEST, POD, PULSE, and POGIL. These programs were able to offer professional development related to adoption of evidence-based teaching formats to faculty around the country with an emphasis on engagement in online settings, over the last several months. These groups shared strategies, successes and challenges through a recent [redacted] survey and virtual meeting. These programs were instrumental in helping prepare many faculty members for providing more effective remote instruction both synchronous and asynchronous this semester.
3. (*My perspective for this question is as* [redacted]*, related to professional development opportunities for post-secondary faculty*). Here are my top positive experiences using remote learning technologies:

a. Using digital platforms to engage students and faculty in remote synchronous environments has been very effective. I've used these platforms in four different venues since the beginning of the pandemic to train current and future faculty to use active, student-centered teaching strategies in remote settings. 1) During the spring semester, I taught the last half of my graduate class on how to teach using active, student-centered techniques (scientific teaching) using a combination of Zoom for synchronous classes and Google for collaborative work. 2) During the summer, I worked with several colleagues to develop an online version of the [redacted] We piloted this remote format for three [redacted]. We used Zoom (synchronous meetings), Google docs, forms, sheets and slides (for collaborative group work), and Libretext as an open resource online "course" management system for the [redacted]. We also introduced faculty to Padlet, Jamboard, Note.ly and Flipgrid as alternate platforms to support student engagement in remote settings. 3) Also, during the summer I used these platforms to lead a Learning Community for my department and ended the summer with an open session (advertised broadly through my [redacted] email lists) devoted entirely to engaging faculty with these various platforms and allowing them to test them and share experiences with one another. 4) Finally, I began the fall semester offering a similar professional development training for our graduate teaching assistants in the [redacted]. In all of these cases, the participants were overwhelmingly positive and grateful for the experiences. While I have been involved in professional development for many years, I believe the current lack of experience and comfort of most educators in remote teaching venues fueled the expressions of gratitude for this training. Due to enrollment issues caused by the pandemic, I believe that most schools will be reducing or eliminating money for professional development activities. I believe that one way that government could have an impact is to provide money for training current and future educators in the effective use of evidence-based teaching practices both in-person and remotely.
b. Using the platforms and approaches described above, my online class and my professional development programs became more equitable in two different ways. First, using Google docs or forms to allow students/participants to report out on individual or group learning activities allowed me to hear from my entire class/population in the same amount of time that it would have taken to hear from a single student in an in-person setting. This made for a much more equitable way to hear all voices which was a pleasant surprise and huge advantage of using these approaches. The second is that removing the financial and time burdens related to traveling to professional development events, meant that these offerings

were much more accessible to a broader audience. When we transition to a new, post-Covid normal, I hope that there will be more remote classes and professional development programs than before Covid to take advantage of the access and environmental benefits that have been a silver lining of the current situation. Grants by the federal government to continue to develop and assess the impact of innovations in remote teaching and professional development will help promote innovations and their diffusion throughout the community increasing the benefits mentioned previously.

5. (*My perspective for this question is as* [redacted]*, related to professional development opportunities for post-secondary faculty*). I think the two most beneficial areas of professional learning would be in facilitating small group collaboration in for synchronous and particularly asynchronous settings and creating assessments that work in a remote setting. A silver lining of the pandemic has been the unmasking of many of the ineffective teaching strategies that were being deployed in face-to-face classes. One hope is that this may be causing educators previously uninterested in change to contemplate teaching and assessing their students in more innovative, effective ways. Strategic partnerships between exemplars in uses of active, student-centered practices and STEM education reform organizations could provide effective tools, approaches, materials and assessments that could more easily be deployed by a broad audience in synchronous/asynchronous venues.

12. (*My perspective for this question is as an educator and* [redacted]*, related to post-secondary faculty and learners*).
    a. As an educator, my department has created a new Diversity, Equity, Inclusion committee for the department. The committee began meeting toward the end of the summer and has developed a strategic plan for the department that includes gathering data on departmental culture through two climate surveys followed by offering training, support, resources and policy changes related to areas of need. This initiative is intended to increase representation of people of color as faculty and increase persistence of students of color in the major. In addition to tracking changes in student persistence and success and diversity of faculty, climate surveys will be used to collect information on departmental climate on a regular basis to track changes in perceptions of these issues in the department.
    b. [redacted] these initiatives undertook work to increase diversity of participants (current and future faculty) and the diffusion of evidence-based practices to improve retention of students of color in STEM disciplines. The [redacted] diversified its training pool to include more people of color and representatives from minority serving schools. These voices were instrumental in developing the online version of the [redacted] which included an updated Inclusivity session that addresses

unconscious biases, microaggressions, cultural sensitivity and stereotype threat. In addition, [redacted] focus on evidence-based teaching practices which have been shown to reduce performance gaps for underrepresented students. Perceptions of value of the inclusivity session for the [redacted] is tracked regularly using an exit survey. [redacted] has a working group devoted to increasing representation of people of color at the professional development programs offered by the network partners. Unfortunately, the work of this group was put on hold as a result of the pandemic, but promises to yield important conversations and sharing of effective practices among organizations around this critical issue.

[redacted]

[redacted] STEM RFI Response

Feedback on America's Strategy for STEM Education from the [redacted]

Submitted by [redacted]
to CoSTEM@nsf.gov

in response to National Science Foundation's Request for Information (85 FR 55323)

October 19, 2020

As the [redacted] for each and every student, the [redacted] knows that teachers of mathematics are crucial to identifying and nurturing interest in STEM disciplines. They are among the first to see how learning mathematics--which is fundamental to every STEM field and discipline--creates the foundation for endeavors in science, engineering, technology and all of the fields that stem from them. [redacted] offer the following in response to the September 4, 2020, request for input related to implementation of the Federal STEM Education Strategic Plan, *Charting a Course For Success: America's Strategy for STEM Education.*

[redacted] is responding to the following questions:

- **Future Opportunities in STEM Education: Questions 1 and 5**
- **Increase Diversity, Equity and Inclusion in STEM: Question 12**
- **Engage Students Where Disciplines Converge: Question 16**
- **Develop and Enrich Strategic Partnerships: Question 19**

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1. **What COVID-19 related digital barriers (*e.g.,* access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?**

When educators assessed the barriers facing them as they grappled with a quick transition to virtual learning in the Spring of 2020, followed by adaptation to those circumstances and planning for the 2020-2021 school year, they found them to be many and sizable. Among the largest is the "Homework Gap"--a term that covers many issues related to access to technology and resources that support virtual teaching and learning. Too many students--particularly those from socioeconomic challenging backgrounds--have no access to broadband internet, devices that connect them to educators, or environments conducive to learning.

Among the pre-pandemic barriers was access to devices. This may have decreased with the transition to online learning as districts worked to ensure that all students had access to laptops (Chromebooks and Ipads), but other significant issues affect access to rigorous and engaging instruction. A coalition of 76 urban school districts reported that there were many lessons learned in an effort to provide internet access and adequate bandwidth to support students and parents in their homes. For example— many districts purchased and distributed mobile "hot spots" that were dependent on strong cellular signal availability. In some cases, students were required to be within 100 to 300 feet of a hot spot located on a school bus in outdoor areas, such as parking lots, and many other students lived in areas where there was no available cellular signal. While districts used these school buses to support access during the school day, buses were not available after school so that students could continue working on asynchronous lessons or for homework. Similarly, this was not just a problem for urban districts, but became especially pronounced in rural areas where cellular signals were non-existent.

Additionally, the lack of access to the Internet for parents and students at home was problematic. Many districts worked with Internet providers so students would have access, however that also became problematic. Some companies were willing to promote unlimited Internet access, but reduced data speeds after a certain amount of data was used, making connectivity slow and frustrating. Initially some service providers offered free or reduced connectivity for a limited fixed time, but recurring monthly fees for Internet devices was a requirement that could not be sustained by many families dealing with job loss, trauma, continued unemployment.

Additional challenges include continuous system and software updates and updated security to ensure student safety among them. These issues remain, especially for districts that allowed students to keep devices over the summer. Further, digital literacy overall is affecting equity in teaching and learning. Some families are more familiar with different learning platforms and submission options. For instance, not all families are familiar with annotating PDF documents and other files or uploading them for submission. Students who have difficulty with completing and submitting assignments online are at a disadvantage when they are a part of a larger system that has on-time and late assignment submissions guidelines.

The cancellation of virtual school, availability of devices, and professional development for teachers are among additional challenges. On this last point, providing support for teachers for professional development on using digital environments effectively for learning (implementing effective teaching practices for teaching mathematics) and providing them time in their school day to collaborate and plan with colleagues is needed.

[redacted] offered suggestions for addressing mathematics learning in the era of COVID 19 in their [redacted]. Recommendations include:

- Create vertical teams that design and implement tasks that incorporate relevant previous grade-level material with the on-grade level using the progression of the standard.
- Provide teachers with professional learning about relevant topics—for example, dealing with trauma or remote learning engagements—and then decide as a team how to implement new learning, adjust for students' needs, and monitor for successes.
- Establish clear, robust yet reasonable expectations for teachers and students for addressing learning needs.
- Encourage teams to take collective responsibility and implement a response to student learning after examining evidence of student thinking.

[redacted] has been supporting mathematics teachers via [redacted] to support the many challenges they face.

5. What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.,* utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

To maximize time focused on teaching and learning, teachers should be intentional about selecting and using formative assessments strategies that support teaching. The way in which teachers collect evidence and use it to make instructional decisions has a significant impact on student learning. Using the formative assessment strategies as well as designing quality formative assessments are needed to understand what students know and to build bridges to what they are learning. This is an opportunity to recognize students' strengths and to design and facilitate instruction that is strengths-based. Educators should be supported in their efforts to:

- Ensure a strong focus on high-quality mathematics instruction for each and every student, to prevent falling back to de-facto tracking or a focus on memorization of skills/facts.
- Use the [redacted] as well as the [redacted].
- Develop a culture of formative assessment and qualitative feedback and acknowledge the difficulty of doing so when in remote contexts.
    - Support teachers in implementing a culture of formative assessment and qualitative feedback.

    - Help teachers develop increased knowledge of the progressions of key concepts so that prerequisite skills are reviewed directly before building on them rather than teaching missed content in isolation. Acknowledge the challenge of doing so when in remote contexts, but provide needed supports to teachers.
- Consider alternatives such as virtual manipulatives (see list from [redacted]), objects available in most homes, easily made manipulatives, sketches of manipulatives.
- Learn to translate effective classroom teaching into online strategies—that is, how to do number talks, discourse, collaborative and cooperative group work.
- Learn to use technology to promote classroom discourse—that is, using breakout rooms, web-based applications, virtual manipulatives, strategies for asynchronous discussions.

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

[redacted] provides a structure for starting critical conversations across stakeholder groups as it relates to positioning mathematics as the foundation for all STEM learning endeavors, for each and every student. The [redacted] recognizes that "Disparities in learning opportunities based on race, class, language, gender, and perceived mathematical ability are far too prevalent in school mathematics" and that the "evidence is compelling that students who are identified as Black, Latinx, Indigenous, language learners, poor, with disabilities, and other marginalized learners do not have the same access to a high-quality mathematics program as their peers." [redacted] advocates for stakeholder groups to work intentionally and collaboratively to dismantle inequitable structures, policies, and practices and to reimagine and build a world where every student is empowered and inspired by mathematics, and understands the value of developing mathematical and more broadly STEM literacy for both their personal and professional future. Through [redacted] we can build more equitable, just, and inclusive mathematics programs that increase achievement, advancement, recruitment, and retention of students and teachers alike.

Within the organization, [redacted] deliberately recruits and invites diverse teaching professionals to take on [redacted] leadership roles to enrich their professional future, i.e., program committees, PDC, membership and affiliates. Headquarters also works with affiliate leadership to intentionally recruit a diverse group of leaders. Ultimately, these efforts offer opportunities for professional growth for members and aspiring leaders for the organization.

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way? What specific delivery mechanism works well for you (*e.g.,* online course, webinar, in-person workshop)? What technology tools would be helpful for you when using a transdisciplinary approach?

The idea that teachers need professional development specific to integrated instruction is not new. In 1996, the National Research Council stated that "[science teachers should] be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology, and other school subjects" . It is important to consider structuring such professional development to put mathematics at the forefront, rather than as playing a secondary or supporting role, such as when students create data displays, compute, or use measuring tools (Fitzallen, 2015). Instead, these missed mathematics learning opportunities should be rightfully leveraged in integrated or transdisciplinary learning experiences to address specific mathematics content and practice learning goals (Shaughnessy, 2013).

As described by the joint position statement from [redacted] entitled [redacted] advocates that "mathematics and science as disciplines, as well as integrative activities that cross the STEM fields, should be part of a comprehensive STEM program. An essential feature of integrative STEM activities should be that they support the individual disciplines addressed with integrity—using content from grade-appropriate standards that is taught in ways that support pedagogical recommendations from the disciplines" (p. 2). Integrated or transdisciplinary STEM learning experiences grounded in addressing the mathematics with integrity position students to understand and appreciate how mathematics can be used as a tool to make sense of and critique their world, including using mathematics to make sense of authentic STEM contexts and investigations - which all aligns to [redacted] advocates for professional development that provides research-informed and effective strategies for implementing integrated or transdisciplinary STEM instruction in the classroom in ways that prioritizes and capitalizes on all meaningful mathematics learning opportunities.

In addition, ethnomathematics is an emerging field which has the potential to provide a model for a transdisciplinary approach to teaching STEM. Ethnomathematics bridges the meaningful academic study of STEM disciplines with placed-based learning experiences, indigineous wisdom and the skills and perspectives students need to engage in and address the challenges of our continually changing world. Furthermore, ethnomathematics can ensure that, "teaching and learning is a humane, positive, and powerful experience for students" (Goffney & Gutiérrez, 2018, p. v).

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

The [redacted] series clearly articulates that "extensive, collective action from a wide range of stakeholders will be necessary to address the barriers that restrict access to a high-quality mathematics program" [redacted] For transformative change that uproots long-standing and deeply rooted inequitable policies, practices, and structures to occur, such collective action from "state and provincial education policymakers and leaders; regional support centers, school boards, building and district administrators; those making decisions about assessments; elementary, middle, and high school teachers; school counselors, curriculum developers and instructional leaders; universities and mathematics teacher educators; families and communities; student caregivers, paraprofessionals, and substitute teachers; school volunteers; and students" (p. 5) will be needed. Importantly, what the [redacted] framework is advocating for is for the field of mathematics education to function as a mathematics, and more broadly STEM, learning ecosystem, driven towards common goals of ensuring that each and every student has access to the highest quality mathematics program. With regards to the private sector and their role in a successful STEM learning ecosystem, [redacted] states that "a critical partner in education is the employment sector, including business and industry, which awaits our graduates. Community employers are well positioned to help assure that what is taught in class has meaning, con- text, and relevance outside of class." (p. 5).

A STEM learning ecosystem that is organized around ethnomathematics provides opportunities for meaningful partnerships with the community, including philanthropic, business and industry partners. In particular, community partnerships are critical for providing professional development opportunities for educators that allows them to experience local and global issues that can be understood and addressed through the application of STEM disciplines and problem-solving processes.

The current [redacted] came together to discuss the OSTP STEM Education RFI and determine common points of interest in this area. We provide the following answers to select RFI questions as a joint statement of our organizations, building on insights from our members across the country.

Sincerely,

[redacted]

Future Opportunities in STEM Education

1. <u>COVID-19 Related Digital Barriers</u>

Access to broadband continues to be a top digital barrier. Districts are providing hotspots, putting hotspots in community areas, and working with ISPs to provide internet access to families who cannot afford it, but the barriers are only partially overcome. Many families do not have access to sufficient cell service or broadband in their homes and do not have means for students to go to community spaces for access. Access to devices in general, and devices that can effectively manage online learning with multiple people in the household on the internet, is a concern for many families as well. Where schools have 1:1 devices, sustainably managing them is also a challenge. Finally, students with different abilities continue to struggle to find the accommodations they need.

Digital learning platforms could be better. They require ongoing training for families and educators to be able to use effectively, with some being more user-friendly than others. Educational resources designed for an online environment could also use further investment. There are still limited options that fully align to the research-based *A Framework for K–12 Science Education* (hereafter referred to as the *Framework;* National Research Council, 2012), which 44 states currently use as the foundation for their science standards.

2. <u>New or Existing Educational Programs</u>

There continues to be a significant need for instructional materials that are designed specifically to support the vision for science education that was described in the *Framework*. The commercial market remains dominated by instructional materials that focus on the acquisition of scientific knowledge and the development of isolated skills. This design is misaligned with the current approach to teaching and learning in K-12 schools. The current approach centers science investigations and engineering design. When investigations and design are at the core of science instruction, all students engage in the three-dimensional learning described in the *Framework for K-12 Science*. Centering investigation and design in instructional materials provides greater opportunities for historically marginalized students to learn rigorous science. Notably, high school science courses particularly lack materials aligned with this vision.

Much of the currently available instructional materials fail to leverage currently available technology. Virtual field trips, virtual interactive science investigations and design, interactions with community partners, and the opportunity to engage with out-of-school education partners are all important components of modern science instructional materials that are not widely available to students. More opportunities to co-design these experiences with out-of-school partners would be welcome.

There are a few examples of open-access, high quality science instructional materials available that exemplify science instructional materials being designed to meet the demands of the *Framework*. These include:

- inquiryHub: Research-based Curricula Supporting Next Generation Science,
- Next Generation Science Storylines, and
- OpenSciEd

3. Positive Experiences and Innovation

Many educators are creatively pushing science out of the classroom and lab to better involve students, families, and communities. Sometimes, when schools or community organizations provide students safe materials to explore relevant phenomena at home, it is easier for them to engage in their own sensemaking that is tied to their family and community, rather than look to the teacher or classmates for the answer.

Many educators have connected students to citizen science initiatives, which provide local and meaningful science opportunities for students. Federal agencies could do more to develop and share student opportunities to collect and analyze real scientific data.

Many organizations, from states' departments of education to national education groups to regional service agencies, have supported educators in the shift to virtual instruction. This proliferation of learning and learning networks has been a significant positive for educators and for building community. Our organizations, in partnership with several colleges and universities have been working tirelessly to create learning experiences that prioritize equitable access to high quality science learning opportunities. The Global Pandemic has created a demand for learning experiences that are equitable, accessible, and adaptable to multiple settings including remote learning, blended learning, and in face to face settings.

Federal efforts to support communities may be too distant to be as effective, but there may be ways to support these connections on a more local level. While a wide range of networks support teachers in this social media era, quality and coherence are sometimes lost amongst the sharing of what is quickly useful in the moment. There is a need to create a system that organizes and supports these distributed networks of educators.

4. Challenges with Online Learning

The greatest challenges include the aforementioned lack of access to broadband internet, variable access to teacher learning that is relevant for the current environment, and effective instructional materials for online learning. Education systems often do not have the capacity to support sufficient educator learning, particularly in each subject area, so educators are left to fend for themselves. Additional funding for ongoing professional learning is critical, particularly for educators serving higher needs populations.The federal government could also share examples of innovative, sustained professional learning systems that link to community partners and provide nimble resources based on evolving needs.

A new challenge being faced by educators and students is online learning fatigue. Not only is there the need for educator training on online materials, but also how to effectively and equitably engage students in meaningful asynchronous learning off the screen.

Many school districts across the country are limiting learning time in subjects beyond mathematics and English/Language Arts, particularly at the elementary level. Equitable time allotment becomes a major issue for science and STEM.

Teacher shortages, especially in rural and urban areas, are becoming even more of an issue as educators leave the field early due to COVID-19 concerns and burnout with implementing new modalities.

While take-home kits can provide increased access to lab-based science learning, educators worry about liability issues. This liability concern means some districts are unwilling to send home materials or allow teachers to encourage use of at-home materials. Federal monies could support the development of clearer safety and liability guidelines. Common safety guidelines from which curriculum developers are held to and from which legal counsel for school districts to make decisions for their use would alleviate some of the concerns that limit the use of instructional materials in home settings.

5. Areas for Professional Learning

Equitable instruction is a significant need for professional learning. Educators need support in meeting the needs of all learners and ensuring all students are meeting objectives. But, accomplishing that goal requires system-level shifts; administrators need further guidance and support on how to create equitable systems for learning for all students. Further, there are frameworks for effectively designing learning opportunities for youth, such as SAMR, but educators need learning on how to use these types of ideas to best harness technological tools. Additionally, research suggests that professional learning connected to effective instructional materials is particularly impactful -- developing materials that can be used flexibly online and in-person, along with the training to use them, is critical.

Teachers struggle the most with a blended classroom, where some students are in-person and some are online. Support for that maximizing that type of learning would be welcome. Further, educators need more than training on how to use particular technologies; they need to know how to use those technologies to support effective student dialogue, assess meaningful learning, and provide actionable feedback to students. The federal government could fund studies on the best methods of hybrid and online learning and instructional technologies to enable adaptation to emergency situations like COVID or natural disasters.

Teacher training programs particularly struggle right now with providing any field experiences for students, even with virtual classrooms. IHEs could use support exploring innovative solutions to this challenge. IHEs could also use funding to determine how teacher preparation on the use of technology in the classroom could be enhanced. Most teachers are not prepared well in this area. With many teachers being trained through alternate routes, assurances of effectiveness becomes even more important. IHEs must be part of a full ecosystem of coherent and ongoing learning.

6. Data and Information

Large-scale assessment, like high-stakes multiple choice tests, are a terrible idea during COVID and should be rethought in general beyond COVID. As seen through the last 20 years, they have little impact on educational systems. While they have importantly highlighted achievement gaps, real systems change has not been a result. Tracking achievement gaps is important moving forward, but that can be done through assessments with a more limited scale and scope. Local and actionable systems of meaningful student learning data should be supported (see National Academy's report, *Developing Assessments for the Next Generation Science Standards*).

It would be useful to know what is being taught across the country in terms of science and STEM throughout K-12 grades. These subjects are particularly important for developing student identities by the end of elementary school, but that is where they are most often scaled back. This has implications for student engagement and persistence in STEM pathways at the secondary level.

Beyond the COVID era, the Federal Government could provide better systems for tracking longitudinal outcomes of students. With students leaving states and regions, it is difficult to collect and use post-secondary outcome data.

Develop STEM Education Digital Resources

9. Types of Web-Based Resources Needed

There is an ongoing lack of instructional resources that meaningfully integrate grade-level, standards-based ideas across all STEM subjects. Effective engagement with science or mathematics concepts, or both, tends to be missing most often. Further, materials are put forward as truly "STEM" but are not -- vetting continues to be a major challenge.

While packaged curriculum materials can support effective and equitable instruction, there is an ongoing tension between widely applicable materials and adaptation to local needs and phenomena. That adaptation process is critical, as is supporting educators in seeing the connection between local,culturally-significant phenomena and a broad range of standards that relate to it. Culturally-affirming and sustaining practices, possibly because they can be locally dependent, are less likely to be part of available materials.

Additionally, elementary learning in particular often hyper-focuses on literacy and mathematics. There is a need for more quality science and STEM resources (as well as social studies resources) that clearly demonstrate gains in literacy and mathematics learning as well.

11. Resource Categories

Useful categorization includes subject, topic, and grade band. Links to elements of the National Academies Framework for K-12 Science would be useful, as 44 students use standards built from this document. It would also be helpful to have categories for local and regional phenomena.

Engage Students Where Disciplines Converge

24. Connections to the Federal STEM Education Strategic Plan

While our work clearly aligns with the goals and pathways of the Federal STEM Education Strategic Plan, the use of this document or changes because of it have been limited to date.

[redacted] response to the Federal STEM Education Strategic Plan

Submitted October 19, 2020

Contact: [redacted]

About the [redacted]

The [redacted] is a national network of more than [redacted] dedicated to advancing arts education. [redacted] has been supported by the National Endowment for the Arts and the U.S. Department of Education since 1995 and is administered by [redacted].

[redacted] is the nation's hub for arts and education leaders, building their leadership capacity to support students, educators and learning environments. Through research, reports, convenings and counsel, leaders gain knowledge and insights to ensure that all learners receive an excellent arts education.

In 2018, the Arts Endowment and Department of Education designated STEAM (science, technology, engineering, arts, and mathematics) education as a priority area for [redacted]. Since then, [redacted] researched, authored reports, convened experts across disciplines, offered technical assistance and presented nationally on how STEAM education can prepare students for life and work in the 21st century.

The following response reflects opportunities to leverage arts education to advance the priorities outlined in the White House STEM Strategic Plan, including increasing diversity, equity, and inclusion in STEM (**question 12**); engaging students where disciplines converge (**questions 13, 15**); developing and enriching strategic partnerships (**question 18**); and community use and implementation of the plan (**question 24**). For the purpose of this response, arts education includes dance, media arts, music, theatre, and visual arts, as well as folk and traditional arts taught in school and community spaces by certified arts teachers and teaching artists. STEAM education is defined as an approach to teaching in which students demonstrate critical thinking and creative problem-solving at the intersection of science, technology, engineering, arts and math, and includes instruction in arts education, arts integration, and STEM.

Increase Diversity, Equity, and Inclusion in STEM

Question 12: What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM?

- On page 10 of the Strategic Plan, arts and cultural education can be included in the description of a STEM environment as a strategy for fostering inclusive learning environments. Cultural relevancy should be considered as an element of quality in-person and distance learning opportunities to reach systemically underrepresented populations.

Including the arts and cultural education in STEM is one strategy to foster inclusive learning environments that increase diversity across race, gender, geography, and economic status in STEM education and the workforce. [redacted] offers additional access points for students to engage in STEM—especially those who identity with groups who are systemically underserved and underrepresented— and allows for students from diverse backgrounds to see themselves represented in fast growing STEAM careers. By engaging in arts education, learners have opportunities to represent themselves through their work, engage with work that represents others and make [redacted] The arts are offer unique opportunities for students to experience culturally relevant instruction that represents and celebrates diverse backgrounds, ultimately increasing student engagement, achievement, and cultural sensitivity.

Culturally responsive STEM and STEAM practices should be used by educators to effectively reach students across diverse identity markers. Geneva Gay defines culturally responsive teaching (CRT) as using the "cultural knowledge, prior experiences, and performance styles of diverse students to make learning more appropriate and effective for them; it teaches to and through the strengths of these students." Researcher, artist and STEAM educator Nettrice Gaskins suggests that CRT characteristics be included in maker, STEM and STEAM education, including:

- Acknowledging the legitimacy of cultural heritages of different ethnic groups
- Building bridges of meaningfulness between home and school experiences
- Using a wide variety of instructional strategies
- Incorporating multicultural information, resources and materials in all subjects.

Engage Students Where Disciplines Converge

Question 13. What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

- On page 16, arts integration and STEAM education can be included in the examples of educational opportunities that combine elements from traditionally separate approaches to learning.
- On page 20, an example of how STEAM education can be included under "Encourage Transdisciplinary Learning" to demonstrate the concept. The examples below may be included from the Wolf Trap Institute for Early Learning Through the Arts and the Wolf Trap Foundation for the Performing Arts.
- On page 21, STEAM education can be included in implementation of federal actions, including support of research, development and dissemination of effective

transdisciplinary practices, programs and policies, as well as expanded support for recruitment, preparation, retention and upskilling of educators.

[redacted] partner organizations use STEAM education and arts integration as strategies for transdisciplinary teaching and learning from early childhood through high school. In STEAM education, transdisciplinary thinking occurs when creative and analytical thought occur simultaneously; analytical thinking (most often associated with the STEM subjects) and creative expression (most often associated with the arts) combine to foster innovation.

STEAM education features many approaches to transdisciplinary learning, including arts integration as one approach. The Kennedy Center defines arts integration as "an approach to teaching in which students construct and demonstrate understanding through an art form. Students engage in a creative process which connects an art form and another subject area and meets evolving objectives in both." When done well, the outcome of arts integration is a deeper understanding in both the arts and at least one other subject area. STEAM education embraces this but also focuses on the processes of learning and problem-solving. While students develop deep understanding of content, they are simultaneously practicing skills that transfer across subject areas and investigating complex problems.

The State Education Agency Directors of Arts Education (SEADAE) notes that effective STEAM instruction is grounded in interdisciplinary and transdisciplinary engagement across STEM and the arts in a way that both draws connections across the disciplines and preserves their individual integrity. SEADAE further notes that STEAM education should be grounded in academic standards in all content areas, but standards across the disciplines do not need to share equal weight in all projects.

Authenticity is an important quality of transdisciplinary learning in the arts and STEM; for STEAM learning to be authentic, students must identify problems to explore with relevance to their own lives, and the exploration should occur at natural intersections across the disciplines. For example, the Nevada STEAM Subcommittee identifies spatial awareness as one example of an authentic intersection between the arts and sciences; spatial ability is both an arts-based skill (3D modeling) and a math and science skill (space imagination).

Integrating arts education with other subject areas has a [redacted] on improving student learning, developing social and civic skills, and enriching the learning environment. Enhancing the experience of the learner is central to STEAM education, which can improve student achievement and learning retention, while increasing enjoyment in learning.

Examples of STEAM education include the following:

Plant Life Cycle – *Science and Dance*

Consider the challenge preschoolers face in learning about the plant life cycle when they are only just beginning to understand the concept of living things at all. By incorporating dance into a plant life cycle lesson, for example, Wolf Trap artists and educators can help children visualize each phase of the cycle with their bodies and then create a sequence of unique movements to represent the cycle itself. First they become seeds, curling themselves into a small ball close to the ground. They slowly stand up, growing into a stem, and then extend and sway their arms as petals ad leaves blowing in the breeze. The dance sequence is repeated, not only to represent the continuous cycle of plant life, but also to strengthen the students' understanding through practice. The integration of dance and movement helps make the concept of the life cycle concrete, an understanding which gives students the foundation to learn more about the natural world and biology in the future. It also increases children's body awareness and continues their learning about how movement can communicate ideas.

Arts/STEM Learning in High School

Wolf Trap Grants for High School Performing Arts Teachers awards funding to help teachers complete dream projects with their students. Many of these projects integrate STEM topics. In one high school, students were introduced to composition software while recording original music tracks for short films. Students learned how to navigate various software systems and applied this knowledge to reach an artistic goal. This experience helped students understand the sequential and layered learning processes needed to grasp a new operating system. Students were able to take ownership of an artistic project, shepherding the musical piece through the planning stages to a final product. This valuable experience will aide students as they encounter novel programs in school or the workplace.

Question 15. What training have you/your organization received in any of these approaches for teaching STEM education: transdisciplinary, integrated, convergence, or engineering design, etc.? Please describe the training, if any (including university coursework or professional development), that helped you/your organization prepare to teach STEM using an integrated or transdisciplinary approach. Why was that specific training helpful, and if not, what could be done differently?

- On pg. 17 of the Strategic Plan, teaching artists and arts organizations can be included in professional development opportunities that support transdisciplinary learning.

Many higher education institutions include arts integration and STEAM education within teacher preparation programs. One example is the Lesley University Master of Education program in Integrated Teaching Through the Arts. This program prepares educators with strategies to integrate arts into the K-12 curriculum and examines both the theory and practice of arts integration in curriculum, instructional practices and assessment methods. Clemson University offers a STEAM Education Certificate as well as a Master of Education degree with a

STEAM specialization to train teachers in supporting students to solve relevant, real world problems across the STEM and arts disciplines.

Arts-based professional development opportunities also exist outside of the higher education field, and are offered by [redacted] partners including national and community arts organizations (such as Young Audiences Arts for Learning), professional arts education organizations (NAEA, NAfME, EdTA and NDEO), state education agencies and state arts agencies. Teaching artists—practicing, working artists who have dual careers as educators—are often an important part of professional development opportunities for classroom educators.

Develop and Enrich Strategic Partnerships

Question 18. How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities?

- On page 3 of the Strategic Plan, the National Endowment for the Arts can be recruited for the Subcommittee on Federal Coordination in STEM Education.
- On page 33, the Arts Endowment can be included in the federal implementation plan
- On page 9, community arts organizations can be included in list of institutions to align and include in implementation in addition to museums.
- On page 10, teaching artists can be included in the description of STEM ecosystems.
- On page 11, federal STEAM investments and arts education can be included in the implementation of federal actions, including building STEM ecosystems, searchable platform of STEM activities, increased funding opportunities, and research.

By 2030, Institute for the Future predicts that 85% of the jobs today's K-12 learners will be doing haven't been invented, demanding a workforce that is creative and prepared to respond innovatively to real-world problems. Including the arts in STEM learning can build upon existing approaches to STEM that encourage students to apply creativity to solving real-world problems.

The arts are included throughout the STEM Strategic Plan; however, the Arts Endowment is not represented on the Subcommittee on Federal Coordination in STEM Education. The National Endowment for the Arts has funded STEAM education activities for nearly two decades in both in school and out of school environments, as well as worked with community organizations across all 50 states, the District of Columbia and U.S. territories. Inclusion of the Arts Endowment in coordination of implementation of the plan would enable federal agencies to expand partnerships with the non-profit sector and educational institutes across the country. This would support the following statement from the five-year federal strategy: "[The strategy] emphasizes the importance of building connections across disciplines of study, across formal and informal education, and across communities."

Additionally, federal agencies can expand partnerships with community arts organizations across the country. Community arts organizations support in school and out of school STEAM learning and professional development, and further examples include the Innovation Collaborative, Engaging Creative Minds, Dramatic Results and the Salvadori Center. To further advance partnerships, the following additions can be made to the STEM Strategic Plan:

Community Use and Implementation of the Federal Stem Education Strategic Plan

Question 24. Please describe how your organization has used the Federal STEM Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?

The [redacted] can use the STEM Strategic Plan to develop and enrich strategic partnerships that ultimately increase diversity in STEM and engage students across disciplines, as described above. The arts are currently mentioned throughout the plan, specifically when describing an education system that requires students to ask and answer questions crossing traditional disciplinary boundary lines. This inclusion can have tremendous impact on expanding our partnerships beyond the arts community, and the [redacted] recommends that the arts continue to be consistently included in implementation of the plan. The recommendations above and examples provided above reflect the value and ongoing efforts of the arts education community to advance the priorities outlined in the Federal STEM Strategic Plan.

Organizational Overview

[redacted] is a consultant team committed to giving all students access to authentic, applied STEM education and the opportunities for a meaningful future that accompany it. We do this by connecting stakeholders—educators, funders, community organizations, businesses and government agencies—who, through collaborative partnerships, create meaningful STEM learning experiences for all learners, particularly those underrepresented or underserved. We are also the designer, operator and manager of the [redacted]

We have responded to the following questions:

Future Opportunities in STEM Education: Questions 5 and 8

Develop STEM Education Digital Resources: Question 11

Increase Diversity, Equity, and Inclusion in STEM: Question 12

Engage Students Where Disciplines Converge: Question 13

Develop and Enrich Strategic Partnerships: Questions 18 and 19

Build Computational Literacy: Question 20

Community Use and Implementation of the Federal Stem Education Strategic Plan: Question 24

Future Opportunities in STEM Education

5. What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.*, utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

Educators providing remote instruction especially need to collaborate and learn from each other during this time of remote learning. When stakeholders collaborate, they often discover means of sharing resources, filling gaps, solving problems, iterating solutions, and much more.

A Community of Practice for virtual or hybrid educators would be a valuable resource. Communities of Practice are groups of people who come together over a shared interest, subject area or goal, and together pursue collective learning on the topic. The community of practice model is already employed in the [redacted].

Likewise, LEAD STEM Practitioner Programs (LSPs) would provide a more structured but equally beneficial support for educators at this time. A Lead STEM Practitioner (LSP) Program is an extensive professional development opportunity focused on research-based practices, collaboration, and leadership. [redacted] hosts LSP training for teachers who demonstrate a commitment to STEM teaching practices and who are willing to explore leadership roles in their school and region.

Finally, a Professional Learning Community (PLC) devoted to educators who are teaching remotely would be valuable as well. Similar to a community of practice but specifically targeted toward teachers, PLCs are a group of educators who meet regularly with their colleagues to learn and to improve their teaching. PLCs can enhance both the knowledge of the teacher as well as the performance of the student and provide an excellent way for teachers to continue their own professional development after an external consultant or PD provider has left.

8. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

As manager of the [redacted], [redacted] regularly offers design services to existing (and prospective) STEM learning ecosystem communities as a way of enhancing or going beyond the regular technical assistance provided to [redacted] members. Below, we describe one example of how [redacted] has used its design services to support an ecosystem in response to COVID-19.

[redacted] is currently supporting middle school math efforts in Louisiana, including in the STEM NOLA and Northshore STEM Ecosystems. Before the COVID-19 pandemic struck, Louisiana was in the process of implementing new mathematics standards in its schools. A key component of this work was providing teachers with professional development opportunities. However, the work largely overlooked means of supporting parents, community members and others involved in a child's education. The need for this extra support was magnified by COVID-19, particularly through online learning. Students who are learning in remote settings especially need the support of more than their teachers in their math journeys. So, [redacted] proposed to design a support structure for students in selected school districts in Louisiana that will unearth community needs and design customized responses for remote learners. This approach will take the burden off of teachers while sharing it with families and community leaders who are now more equipped to take on that supportive role.

Our reach has gone beyond support of individual ecosystems. [redacted] offered emergency structural support to the entire [redacted] in the early days of the pandemic. We quickly assembled and launched [redacted]," a [redacted] initiative designed to get hands-on resources to learners and educators, quickly. We immediately collected and published an open database of STEM learning activities to keep learning going, and we launched a webinar series, [redacted]," discussions for teachers, school officials, community leaders and the many others impacted by school closures and virtual learning. Concurrently, we ran weekly "STEM Virtual Home Lab" workshops, designed to offer virtual experiments, practical tips and concrete tools for families and teachers to help engage students further. In all cases, the [redacted] is equipped with communications structures and resources to share these good practices through "Ecosystem to Ecosystem" (E2E) discussions and Community of Practice collaborations. This model has resulted in the transmutation of many programs between ecosystems in accordance with each community's needs.

Develop STEM Education Digital Resources

11. How would you like to see resources categorized (*e.g.*, subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.

We are currently collaborating across the [redacted] to create a directory tool that provides links to STEM opportunities to various user groups, including families, volunteers, STEM providers, students, and community leaders. There are several programs offering components of this tool, but we envision a platform where users can filter opportunities by demographic location, standards, education standards, delivery mode, badging, and more. More specifically, we envision the tool will offer insight into which opportunities and resources a community needs to prioritize (based on user-added data).

Increase Diversity, Equity, and Inclusion in STEM

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

One way that [redacted] and the [redacted] have recently enabled DEI across our work is to enable key partnerships between ecosystem members and diversity-focused organizations. More broadly, we have partnered with the National Equity Project to leverage their tools, resources and facilitated sessions for the design of a customized model that engages cross-sector teams in select ecosystems. The overall goal is to focus on dismantling systems of oppression for Black and Brown students by taking a lens to all layers of implicit bias and inequitable practices from pre-K–career. By engaging cross-sector teams, no single stakeholder group bears responsibility in isolation. Instead, there’s collective responsibility to take action. We are currently proposing that each participating ecosystem in the [redacted] defines a goal and works to implement actionable steps to result in observed changes to the system. This could mean a teacher recruitment campaign to identify, hire and train more teachers of color. It could be a policy change enabling different criteria for students of color to enroll in honors and AP STEM courses. The possibilities are endless and the urgency to act is clear.

Engage Students Where Disciplines Converge

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (*e.g.*, a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (*e.g.*, more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

In the [redacted], transdisciplinary learning is built upon cross-sector partnerships. Cross-sector partnerships between education, industry, families, community groups, higher education, etc. make it easier for teachers, out-of-school educators, and families to recognize, promote, and implement opportunities for transdisciplinary learning. Likewise, engineering design is at the heart of all [redacted] work--it is the process we use to collaboratively design solutions with our clients, and it is the process we encourage them to perpetually take, beyond our involvement as designers, to meet the needs of their community.

We encourage design thinking in the classroom through Design Challenges, STEM experiences, and Capstone experiences. Students who learn to use the Engineering Design Process in elementary school and continue to hone those skills through engineering design challenges in middle school and high school become life-long problem solvers.

STEM experiences and capstones also expose students to the crossovers between classroom and the real world—often in partnership with a local employer or industry partner. By using the Engineering Design Process, our design is iterative, responsive and adaptive to help any grade, classroom or district catalyze student engagement and achievement in STEM. Once broad goals and parameters are established, students mold and shape their individual capstone experience according to their interests and questions.

One way that we amplify transdisciplinary learning is through digital fabrication labs and makerspaces, where learners create engineering solutions to authentic real-world problems. Digital fabrication labs and makerspaces fit well into either formal or informal learning spaces. In the former, digital fabrication, making and tinkering can augment STEM classes or even the arts, like fine art, design and drama. Out-of-school digital fabrication spaces can offer students the opportunity to complete personal design projects, or even offer spaces for them to collaborate with a parent, peer mentor, or professional from the community on a project, bridging skills learned in school with real-world and community experiences.

<u>Develop and Enrich Strategic Partnerships</u>

18. What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

Strong cross-sector engagement is a crucial component for successful work-based learning programs. Communities who know and work with diverse cross-sector partners can work together to design programs that use available resources and creative approaches to meet the needs of students, schools, employers, and more. When designing work-based learning programs, a “Listening and Learning” approach is critical. Listening and Learning asks, “who are we missing at the table?” and takes immediate steps to involve those missing partners. To design effective work-based learning programs, ample consideration should be given to the needs of students, educators, and local employers and industry. In one instance, [redacted] partnered with the Gates Foundation to lead a "Learn and Earn" Convening, which brought together industry, government, and education partners together to design low-cost, practical ways for learners to earn credit and gain hands-on workforce training.

Designing learning pathways that connect regional STEM workforce opportunities to secondary and post-secondary coursework means that students will graduate work- and college-ready with an array of options to pursue STEM careers through credentials, certifications, job-based apprenticeships and/or access for pursuing advanced degrees.

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

[redacted] consist of multi-sector partners united by a collective vision of supporting participation in STEM through the creation of accessible, inclusive STEM learning opportunities spanning all education stages and career pathways. A STEM ecosystem continuously evaluates its activities and adapts as needed, plans for the long-term, and communicates its work to build broad support and advance best-practices.

The pillars of success of a thriving [redacted], as defined by [redacted], are:

1. Strong cross-sector partnerships
2. Systems that sustain the work
3. Aligned teaching and learning
4. Measurement of ecosystem progress
5. Workforce and career trajectories

The private sector has an important role in the success of a STEM ecosystem. Private companies can commit resources for community use, collaborate to design or offer hands-on learning or internship opportunities, and provide accurate updates on STEM workforce pipeline needs.

In response to the COVID-19 pandemic, [redacted] and [redacted] leadership hosted over 20 webinars as part of the [redacted]. Based on conversations with community leaders from across the nation, the [redacted] hosted Community Conversations to discuss the most pressing topics facing STEM ecosystems during this time. Topics included the schools and ecosystems leading food distribution, the digital divide, racial equity, re-building the education systems, and meeting social-emotional learning needs. Additional support was offered with hands-on Virtual STEM Labs for families and educators. These Virtual STEM Labs integrated the arts, literacy, math, science and engineering with fun and creative activities completed with materials around the house. Thousands attended the [redacted], with as many as 400 attendees at a time during the live taping. Recordings of the webinars can be found on the [redacted].

Since the launch of [redacted], local ecosystems across the nation have implemented their own regional versions to support their local communities. The conversations and learning supports have impacted hundreds of thousands of educators, families and students across the United States.

While the initial series of webinars concluded in June to give leaders and families a break after an emotionally taxing spring, the [redacted] has reignited webinar-based conversations this August, beginning with a conversation about racial equity in the college admissions process. Webinars conversations will occur throughout the Fall leading to the Virtual Fall 2020 Convening [redacted].

<u>Build Computational Literacy</u>

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

Computational thinking is a critical skill set for problem solving at all grade levels. However, siloed thinking on the topic—particularly the misconceptions that computational thinking means "computer science" and as such, must remain a standalone subject or must require prohibitive levels of technology—has limited the integration of computational thinking and digital learning in many schools. With the right tools and training, teachers can confidently incorporate computational thinking and digital learning into even seemingly unrelated subjects. In earlier grades, computational thinking can be taught through coding proficiencies, reinforced through literacy, and applied as a problem-solving toolkit for math, science, writing, and close reading. Older students reap the same benefits while also gaining exposure to high paying and in-demand jobs. Further, the concepts of computer science and computational thinking provide a fundamental understanding of the world that, in turn, allow students to have a better understanding of the technological forces that are in play in their lives.

<u>Community Use and Implementation of the Federal Stem Education Strategic Plan</u>

24. Please describe how your organization has used the Federal STEM Education Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?

Our work was pivotal to shaping the [redacted] language found in the Strategic Plan. We highlight this connection with both new and prospective community partners and ecosystem members. The Strategic Plan has helped communities see the value of properly designed and maintained [redacted], and it brings recognition and validity to our model to the general public.

CoSTEM Request for Information

Future Opportunities in STEM Education

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (e.g., virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (e.g., pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

[redacted] is working with several federal agencies (i.e. National Park Service, USDA Forest Service, Bureau of Land Management, and US Department of Education) in an ongoing effort to promote use of the environment as context for STEM education. The [redacted] STEM program model—which combines multiple instructional approaches (i.e. place-based, three-dimensional, project-based, and community-based)—seeks to seed development of STEM learning/environmental education ecosystems by funding demonstration projects involving collaborative partnerships between non-formal and formal educators, community stakeholders, and natural resource management agencies.

The goals of the [redacted] demonstration projects are to provide guidance, support, and resources for agencies and their partners to develop and implement [redacted] education programs that promote conservation, stewardship, and access to public lands and waters; equip educators with tools to enhance classroom learning and experiences that build educator capacity and confidence; and expose under-resourced and under-represented student populations to natural resource careers. The project teams identify locally relevant and accessible environmental challenges and natural resource issues, then develop projects where learners engage in a combination of classroom and field-based activities (e.g. citizen science/environmental monitoring projects, etc.).

In response to the COVID-19 pandemic some [redacted] grantees are substituting a combination of synchronous and asynchronous virtual activities for the in-person, first-hand experiences that are the historic foundation of hands-on, inquiry driven, place-based learning. The virtual engagements are being collaboratively developed by project teams; they take the form of pre-recorded and live video fieldtrips, interviews, and community events where project findings and recommendations are shared. A soon to launch demonstration project involving a large urban school district and a local science museum will develop a series of adaptable STEM learning activities that can be used remotely (i.e. at home), or in a combination of in-person and remote learning (i.e. hybrid), and for traditional in-person instruction—depending on current or future district policy.

[redacted]

[redacted] STEM RFI Response

The [redacted]

Responses are provided to the following questions:

- **Future Opportunities in STEM Education 3, 5, 6, 8**
- **Develop STEM Education Digital Resources 9-11**
- **Increase Diversity, Equity, and Inclusion in STEM 12**
- **Engage Students Where Disciplines Converge 13**
- **Build Computational Literacy 23**

Future Opportunities in STEM Education

3. *What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?*

The involuntary shift to a largely remote learning environment had a profound impact on the work of [redacted] We have had positive experiences in our professional development program, which is primarily geared towards college-level instructors. For example, our annual meeting, the [redacted] normally held in person for approximately 350 participants, moved online in summer 2020. Participants met for workshops, discussions, presentations, and keynote talks through Zoom, and collaborated with each other using technologies such as Google Suites. Likewise, our [redacted] has been partially converted from our usual in-person workshops into a virtual format. Further NSF funding could help with formalizing the conversion to digital platforms, allowing greater participation from around the world and different types of participation than are possible in person.

[redacted] also sponsored projects that brought communities of instructors together to address a need related to the COVID-19 pandemic, including [redacted] which was funded by NSF through a RAPID grant. The research team put together webinars over Spring-Summer 2020 to help field instructors use digital tools and develop virtual field trips. Digital tools included StraboSpot, GigaPans, Google Earth, SketchUp, Virtual Landscapes, Geologic Map Data Extractor, Tour Builder, Slack, Solocator, ThingLink, EazyZoom, Kuula, MetaShape, MeshLab, Could Compare, SketchFab, VisualSFM, GeoExplorer, and Flyover Country. Some of these are custom geoscience software developed with support from NSF.

5. *What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?*

College-level geoscience instructors could benefit from professional learning in all of the areas mentioned in this question (utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband). In addition, and more specific to the geoscience community, they would benefit from professional learning that supports field-based and lab-based instruction remotely. [redacted] has provided some of this support, particularly through the [redacted] and its webinar series, but could benefit from more resources to broaden access to these professional development opportunities.

6. *What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?*

[redacted] would benefit from access to data about post-secondary geoscience enrollment, changes in the nature of instruction across different institution types and geographic areas, impact on student learning, and changes in the geoscience workforce. The American Geosciences Institute (AGI) is currently collecting some of these data.

[redacted] is sponsoring a project, funded and conducted by SERC at Carleton College and the Research and Spatial Cognition lab at Temple University, that collected responses through a "daily diary" survey over two weeks in the spring (n = 262) and is collecting additional responses this fall that assess the level of disruption in respondents research, teaching, work/life balance, and communication. They also responded to two open-ended questions about the most important thing they have done that day and the most important insight from the previous day. Preliminary results show that participants are experience moderate disruption across all domains, and that the level of disruption varies by day (within individuals) and between individuals. The open-ended questions reveal that faculty are worried about all levels of the educational system, and have discovered new ways of doing things. That project is currently under review for NSF funding through the IUSE program, and would provide insight into the factors that support instructors' adaptive flexibility and their ability to provide equitable instruction.

8. *What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?*

[redacted] took several actions to support learning in its community of geoscience educators:

1) We moved the [redacted] online and added programming explicitly about learning online, including a three-day workshop [redacted] and a roundtable discussion "Transition to Teaching Online." Other programming incorporated components about virtual learning and teaching.
2) [redacted] and SERC's portal to resources for Earth educators, Teach the Earth [redacted], now includes a curated collection of resources for converting courses to an online format, including online teaching activities and courses, how-to guides for transitioning to online teaching and for teaching virtual

field exercises, a guide for best practices for teaching about Earth online, and a Teaching Geoscience Online community of educators.

3) [redacted] sponsored the virtual-teaching project [redacted] which was funded by NSF. [redacted] supported the development and implementation of webinars over Spring-Summer 2020 to help field instructors use digital tools and develop virtual field trips.

These three actions were helpful, and very positively received and appreciated by our community. However, as a non-profit organization with a limited budget determined in large part by member dues, [redacted] took a financial risk, in that each of these actions incurred greater expenses to [redacted] without corresponding increases in revenue. NSF funding for workshops, as well as robust NSF funding to collaborating organizations (e.g., the Geological Society of America and the American Geophysical Union), can help increase the resources available for the geoscience community. In fact, almost all [redacted] resources are available without a paywall, because we feel strongly that the entire community should benefit from our materials and events.

Develop STEM Education Digital Resources

9. *What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?*

An extensive, curated, and reviewed collection of web-based resources (https://serc.carleton.edu/teachearth/index.html) is one of the primary products that [redacted] provides to its community of geoscience educators through a collaboration with the Science Education Resource Center (SERC). There are several elements of this set of resources that we feel should be incorporated into any STEM education website:

- Resources that are designed using evidence-based practices in STEM education,
- Descriptions of and links to the research base,
- Support to help instructors implement the resources,
- Mechanisms for community members to contribute resources,
- Mechanisms for peer review of resources and elevation of the most comprehensive and complete resources in searches,
- Mechanisms for users of the resources to share their experiences implementing them and adapting them.

One of the biggest challenges we face with digital resources is keeping them current and updated. This is a very difficult problem to address when many of the resources are developed through grant funding, and once the grant funding ends, there is little or no support to update and maintain the resources. [redacted] has piloted the concept of volunteer editors within content areas of our resources, but the current situation has stretched many of our community members to their limits and their volunteer time is limited. All websites that host digital STEM education resources would benefit from a mechanism to ensure maintenance and updating of resources to keep them current, usable, and fresh.

10. *Please describe your primary audience (e.g., I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.*

[redacted] serves educators at all levels, in both formal and informal educational settings. The large majority of our members are college faculty, and thus the majority of resources that we provide online are geared towards college faculty. We also count K–12 educators in our membership, however, and have resources targeted for use in high schools and middle schools. The education resources mentioned above would help educators in the geosciences optimize their positive impacts on students and learners, including in the transition to online learning and teaching.

11. *How would you like to see resources categorized (e.g., subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.*

The Teach the Earth website (https://serc.carleton.edu/teachearth/index.html) has resources categorized in several ways to enable educators to quickly find appropriate resources for their needs. The materials are tagged by course topics, societal issues, grade level and setting (e.g., two-year versus four-year college), professional development needs, review status, and use of evidence-based pedagogical practices, allowing users to search and browse to find what they need. You can also navigate to resources that were developed as part of specific programs and events. The website also has highlighted parts of the collection, including peer-reviewed materials that have been rated "exemplary," and opportunities for educators to become part of the geoscience education community.

Increase Diversity, Equity, and Inclusion in STEM

12. *What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?*

[redacted] broad commitment to valuing all voices is stated in our mission which is "to support a diverse, inclusive, and thriving community of educators and education researchers to improve teaching and learning about the Earth." In late 2019, at the recommendation of an *ad hoc* task force, we established a high-level Diversity, Equity, and Inclusion (DEI) Committee. The DEI Committee's charge is "to facilitate [redacted] efforts to achieve its goals related to diversity of its membership, leadership, committees, award winners, and participants in all events." The DEI committee began its work in May. The charge includes a statement about the goals of the organization related to diversity. These goals do not yet exist; we are in the very beginning stages of a strategic planning process that will help us establish these goals, among others. We are currently working on a member survey that will include questions generated by the DEI committee that relate to our members' experiences and interests; the results will help inform our efforts and strategic planning process.

We have recently received funding from NSF to incorporate professional development in DEI for all of our workshop leaders (Early Career Workshop, Traveling Workshop Program, and others). This includes funding to bring in (virtually or in-person, as the times dictate) people with lived experiences very different from the majority-white leaders for leader development in early 2021. A second workshop proposal to NSF is currently under review that will support the implementation of DEI and anti-racist sessions into our Traveling Workshops Program during the 20-21 academic year.

In the last five years, we have moved all of our nominations for committees and leadership to an open nomination process from what was an informal process that limited nominations to people already known by the individuals in leadership roles. With open nominations, individuals may self-nominate or be nominated by others, and the process is intended not to be onerous. This has led to several successful nominations that have expanded the diversity of our leadership.

This year, a benefit of the move of many conferences to online allowed us to participate as exhibitors when otherwise the expense would be too high. We had a virtual booth at the National Association of Black Geoscientists (NABG) meeting, and are hosting a joint social with SACNAS as part of our GSA efforts.

Engage Students Where Disciplines Converge

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

[redacted] is keenly aware that geoscientists are critical for solving some of the most difficult societal problems, particularly related to mitigating and adapting to climate change, finding and using natural resources sustainably and equitably, and avoiding the severest impacts of natural disasters. All of these problems are transdisciplinary, and therefore require a systems approach that integrates social sciences and humanities with the geosciences and other STEM disciplines.

[redacted] recently co-sponsored InTeGrate: Interdisciplinary Teaching about Earth for a Sustainable Future (https://serc.carleton.edu/integrate/index.html), which received NSF funding. InTeGrate sought to improve Earth literacy and build a workforce prepared to tackle urgent environmental and resource issues facing humanity. To this end, the project supported interdisciplinary teaching about Earth and environmental issues across the undergraduate curriculum. The project collected and synthesized existing work into an extensive website; developed, tested and published 26 curriculum modules, 6 courses, and 16 program models; implemented large professional development programs involving more than 1500 educators; and created a national scale community which continues to work toward these goals. One goal of this project was to broaden participation in the geosciences.

Teach the Earth (https://serc.carleton.edu/teachearth/index.html) brings together InTeGrate and other multi-, inter-, and trans-disciplinary teaching resources for the geoscience education community. Some of these resources include opportunities for co-teaching, and all center student learning through meaningful formative and summative assessments that have been shown to improve learning for all students.

Build Computational Literacy

23. What technologies and resources do you currently use (e.g., apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

[redacted] contracts with the Science Education Resource Center (SERC) to support its operations; SERC hosts [redacted] website and we make use of all of the custom tools that SERC has developed (collectively called Serckit) to support collaborative web editing, hosting and sharing of resources, designating groups and providing tiers of access to internal web pages and workspaces, and handling membership. SERC recently received NSF funding through a RAISE proposal to improve resource discoverability, and [redacted] will benefit from the work done through this grant.

In addition to Serckit, we make use of Zoom, Google Drive, and Remo. One challenge of Zoom is that it does not adequately allow for spontaneous collaboration among small groups of people in meetings and workshops. Solutions to this challenge in any software package would be welcome.

[redacted]

[redacted]

October 19, 2020

BY ELECTRONIC SUBMISSION

Cindy Hasselbring
Senior Policy Advisor, Assistant Director, STEM Education
Office of Science and Technology Policy
1650 Pennsylvania Avenue, NW
Washington, DC 20504

CoSTEM@nsf.gov

Re: [redacted]: STEM RFI Response

The [redacted]

[redacted] mission is to advance the broader chemistry enterprise and its practitioners for the benefit of Earth and its people. As the lead voice for the chemistry enterprise, the [redacted] is dedicated to bringing members of the chemistry community together to collaborate and advance their science. Chemistry teachers and the K-12 education community are a vital component of [redacted] membership, and in 2014, [redacted] proudly launched the [redacted] to provide networking opportunities, teacher professional development and classroom teacher resources.

[redacted] welcomes the opportunity to respond to the National Science Foundation's request for input on CoSTEM's 5-year strategic plan and the current and future impacts the COVID-19 pandemic will have on the education system. [redacted] provided input at the start of the drafting process through stakeholder discussions, and is committed to ensuring the chemistry community is part of this ongoing dialogue. [redacted] and [redacted] have collaborated to compile feedback for this submission.

Future Opportunities in STEM Education, questions 1-6 and 8

1. Equitable access to technology for students is an existing challenge exacerbated by COVID-19. [redacted] recently observed this via [redacted], its program that offers chemistry research internships to students from economically disadvantaged backgrounds. Due to COVID-19, [redacted] students could not participate in on-site research, so staff organized an extended remote learning experience for students. To offer this experience, however, it was necessary for staff to provide computers and broadband access to many participating students. [redacted] also observes this challenge via its teacher association, [redacted]. More support is needed to ensure that all students have access to high-speed internet and the equipment necessary to engage in remote instruction.

2. [redacted] utilizes mentoring and mentoring networks to support teachers and students at all levels. One example is the [redacted] program, which pairs [redacted] teacher members with chemistry professionals to provide content knowledge expertise. These networks can be especially helpful during remote instruction, as best practices are still being established through research. These relationships can also help to offset any deficits in administrative support that are crucial to motivating and retaining teachers.

3. Despite the many challenges it presents, [redacted] has documented some positive experiences with remote learning at the K–12 and higher education level. Virtual or online labs, when used judiciously, allow students to make observations without distractions in a low-pressure setting and repeat procedures as necessary to develop confidence. Another advantage of remote instruction is a greater emphasis on data analysis, scientific writing, and literature review. These benefits may be leveraged to enhance in-person instruction in the future.

4. One challenge specific to the study of chemistry exacerbated by the shift to online learning is the need to provide equitable access to hands-on lab experiences. Due to safety and liability concerns, many students are unable to engage in this important practice during remote instruction and may fall behind in developing lab skills or learning from lab experiences. This has been mitigated to some degree by the use of virtual labs and simulations and leveraging simple experiments using only readily accessible household materials, but these solutions presuppose consistent access to technology and other resources. [redacted] regards these as temporary solutions and as supplements to hands-on activities but not a substitute for them.

5. [redacted] has seen significant interest from educators at all levels related to remote instruction. An [redacted] webinar on [redacted] attracted over 1,200 attendees and documented the need for follow up sessions exploring teaching methods and resources. [redacted] also convened over 150 chemistry department chairs to discuss their Fall 2020 challenges and successes in a discussion titled [redacted] Attendees noted a need for follow-up discussions focused on lessons learned as well as a desire for resources or a repository of strategies for effective virtual laboratory instruction.

[redacted] drew large numbers of K–12 teachers to a summer symposium on [redacted].” The most popular topics included virtual labs, engaging students equitably in a remote setting, and using technology platforms effectively.

6. To understand the disruption created by COVID-19 at the K–12 level, it would be especially important to research the impact on economically disadvantaged students, those without access to adequate technology, the impact on students’ college readiness, and peer interaction.

In higher education, to measure the effects of COVID-19 on STEM education collection of the following information is essential: 1) Data related to the development of hands-on laboratory skills, which may have been affected by the move to virtual laboratory instruction. These hands-on laboratory skills are essential in developing a strong STEM workforce. 2) STEM student attrition rates and graduation outcomes (placements in graduate or professional school, or the workforce) to determine the extent to which the pandemic has impacted the retention and development of a STEM-ready workforce. 3) To assess the impact of COVID-19 on institutional investments in STEM (faculty hiring, research funds, infrastructure upgrades), it is essential to collect data related to institutional funding and the effects of budgetary deficiencies on STEM and STEM-related departments. Collectively, these data would assess the short and long-term impacts of COVID-19 on STEM education in Higher Education. [redacted] currently collects data on undergraduate outcomes through the [redacted] Approval Program.

8. [redacted] moved quickly to support teachers during the transition to remote instruction. A significant portion of the classroom resources on the [redacted] website were made freely available for an extended period. [redacted] also provided teachers with a way to grant student access to multimedia on the [redacted] website, compiled collections of activities that could be done safely using household materials, promoted strategies from teachers, organized webinars on remote instruction, and more.

Develop STEM Education Digital Resources, questions 9-11

9. Through its teacher association, [redacted] addresses the importance of classroom resources and professional development to K-12 teachers. Classroom resources developed by teachers that show how to make connections across disciplines and differentiate the approach for learners at different levels would be especially valuable.

At the collegiate level and beyond, [redacted] has observed the need for curated, peer-reviewed or “approved” resources for laboratory instruction, particularly for upper-division/specialized courses. This resource would be particularly beneficial for resource-strapped institutions.

10. Through its Education Division, [redacted] supports teachers and learners at all levels of instruction, from K-12 through undergraduate education, to graduate education, and beyond. Through its teacher association, [redacted] focuses on K–12 teachers of chemistry, most of whom teach at the high school level. A curriculum that teaches computational literacy through chemistry and other traditional disciplines would ensure that students develop applied digital skills as they acquire the discipline specific knowledge that provides the foundation for them.

As computational literacy becomes increasingly necessary, the need to develop it without displacing traditional disciplines of science becomes an important consideration. A failure to integrate the foundational disciplines of STEM with digital literacy may narrow opportunities for students and slow scientific advances upon which technological advancement relies.

In higher education, the development of a centralized repository of curated or peer-reviewed resources for laboratory/classroom instruction, including examples of learning outcome and program assessment would provide students with an education consistent with the [redacted] guidelines for undergraduate education in chemistry. These resources would especially benefit resource-limited institutions where faculty may not receive the time needed to develop these materials.

11. [redacted] has found that teachers value resources categorized by topic (and sub-topic), grade band, resource type, connections to teaching standards or other relevant frameworks, time needed, and materials required.

Increase Diversity, Equity, and Inclusion in STEM, question 12

12. Diversity, Inclusion & Respect are core values of the [redacted]. Recent events in our country have motivated the Society to reaffirm our commitment to improving diversity through the chemistry enterprise. In 2020, the [redacted] committed an additional $1 million dollars toward advancing those goals. This funding will help strengthen the [redacted], an effort to increase the number of chemical science PhD degrees awarded to underrepresented minority (URM) students, and other successful programs listed below:

The [redacted] that annually provides approximately $900,000 in renewable scholarships to 350 underrepresented minority students majoring in undergraduate chemistry-related disciplines.

[redacted], a paid summer internship program for economically disadvantaged high school chemistry students to work in real laboratories, with real scientists serving as their mentors.

The [redacted] has been enhanced to include resources for [redacted] members and the general public, such as helpful readings, courses and multimedia resources related to this area. The webpage will be the central point for the Society to post its messages and actions related to Diversity, Inclusion & Respect.

Engage Students Where Disciplines Converge, question 13

13. [redacted] provides a suite of relevant customer-focused resources and professional training opportunities that enable learning and career development across all sectors in the chemical sciences. As stewards of the central science, [redacted] helps teachers and students make connections to other fields and to learning chemistry through real-world examples and chemistry professionals.

The [redacted] textbook, [redacted], is a first-year high school chemistry textbook that teaches chemistry concepts through the lens of societal issues. The seven units use real-world examples to teach students topics in chemistry such as materials science, environmental chemistry, organic chemistry, biochemistry, and industrial chemistry.

Through its teacher association, [redacted] provides a large collection of classroom resources, including lesson plans, labs, demos, and more many of which are aligned with the Next Generation Science Standards (NGSS) and incorporate engineering design where possible. Also through [redacted] has partnered with corporate partners such as Dow, Ford, and PPG to develop classroom materials with a real-world focus. The [redacted] program brings together [redacted] teacher members with chemistry professionals to help contextualize student learning. The [redacted] encourages students to make connections to chemistry outside the classroom. These approaches help to meet teacher needs around standards compliance, engage students, and develop future chemists and scientifically literate students.

Develop and Enrich Strategic Partnerships, questions 18 and 19

18. Through the [redacted], [redacted] observes the importance involving students in hands-on research, proving them with mentoring, and connecting them to the broader chemistry community. Due to COVID-19, [redacted] students could not participate in on-site research, so staff organized an extended remote learning experience for students. A clearinghouse of work-based learning programs would be useful in engaging more students in these opportunities.

19. [redacted] has worked with corporate partners, such as the Dow Chemical Company, to catalyze the formation of local STEM networks. Through these partnerships, [redacted] has found that investing in teachers amplifies impact, as each teacher works with many students over the course of their career. Another characteristic of success is leveraging local connections to make a national impact. In the case of the Dow partnership, [redacted] developed "teacher summits" which not only created professional learning communities among the attendees and Dow employees, but did so through resource development, which could be shared with teachers nationally to help meet the need for classroom resources that incorporate real-world connections. Such partnerships also help highlight STEM careers.

Build Computational Literacy, question 20

20. Integrating digital platforms into classrooms offers several benefits, including: more individualized feedback facilitated by effective real-time formative assessment, greater emphasis on individual questions, clarification, and application practice through "flipped learning", and the ability to use pre-labs or digital supplements to prepare students for a complementary hands-on lab. Challenges arise when there is a disparity in access to technology or when students' digital literacy skills have been cultivated inconsistently. Moving towards a more complete integration of traditional science with computational literacy will require developing curriculum to teach these disciplines through coding, data science, and modeling.

Community Use and Implementation of the Federal STEM Education Strategic Plan, question 24

24. The [redacted] was encouraged to see a strategic plan that emphasizes STEM literacy, a diverse and inclusive education system and workforce preparedness. [redacted] like many professional societies across the country, have looked internally at programs and policies to ensure that we are doing our best to support and encourage a diverse education system and workforce in the STEM fields. A key piece of this puzzle must also be to attract and retain a diverse teacher workforce. As Co-STEM looks to review and strengthen the federal agency commitment to STEM, the support of the STEM teacher workforce is of paramount importance. A core value of [redacted] is a focus on members, which includes educators at all levels of instruction. [redacted] sees these teachers, professors, tutors, and informal educators as integral to advancing each strategic pathway.

The [redacted] appreciates the opportunity to provide feedback on the STEM Strategic plan and to offer input from the stakeholder community on the education landscape in the wake of the COVID-19 pandemic and looks forward to continued collaboration to that end.

[redacted] would welcome the opportunity to further discuss with NSF the topics touched on in this submittal as well as to provide further information the Foundation might find useful as it finalizes its STEM Strategic Plan.

Sincerely

[redacted]

[redacted]

[redacted] **STEM RFI Response**

I am the [redacted] I have been teaching chemistry, physics, and mathematics for 23 years. I am a [redacted]. In [redacted], I was named a [redacted] I also serve as the [redacted] which provides instructional professional development to 6-12 science teachers.

Future Opportunities in STEM Education , questions 1-6

1. Our school is located in the [redacted]. We are part of a K-12 district that serves about 14,000 students through fourteen elementary schools, four middle schools, two high schools and a pre-K center. Our district is 30% low income. We were planning on going 1:1 with student chromebooks for 6-12 during the Fall of 2021. The pandemic accelerated this timeline. Luckily we were able to procure 6,000 chromebooks in June for August distribution. Our largest digital barrier has been access to fast, cost efficient broadband access for students as home. The digital divide- even in an upper middle class suburb- is causing major equity issues. We quickly ran out of internet hotspots to distribute to students and more were difficult to obtain. As far as school infrastructure, we are concerned about the wifi network in our building and whether or not it can handle so many devices streaming video at the same time. The nature of our hybrid plan could require students in the building to be on a video call with students from home. Finally, we need more technical support. Our district is short on network staff, IT staff, repair technicians, and education tech specialists. Money for new staff is in short supply. Our team is overwhelmed and needs support in the form of more staff. Adding positions is expensive in a time when the district is anticipating reduced funding. In summary, we have been mostly able to address hardware needs, we are about to find out if our network can handle the traffic, and we are in desperate need of more tech support staff.

2. Throughout the spring and now into the fall semester, what we continue to hear from students is that they prefer learning *from their own teacher*. They do not find learning from off the shelf, asynchronous, self-paced websites as beneficial as learning from their district supported classroom teacher. For example in chemistry class, I could easily post a video from the web about the definition of density and follow up with some pre-selected practice problems. What we have found is that students would rather hear the same content in our own voice. In

other words, students value the personal connection to their classroom teacher. While it takes more time for me, I also prefer to post chemistry videos made by me that are intended for my own students. The videos help build classroom community in a time when that is sorely missing. Teachers need access to video cameras, video editing software and websites (wevideo, etc.). Money to fund districts to purchase district site licenses would help ease the financial burden of this transition to remote learning.

3. The three core high school sciences courses; biology, chemistry, and physics, are lab sciences. In these classes students need hands-on experiences in a lab setting. This is not possible in the current situation. Even in the hybrid scenario that begins on October 19, it will be extremely difficult for students to gain lab experience. The six-foot social distancing requirements, along with the need to clean and sanitize large amounts of shared equipment, makes doing lab work extremely difficult. To that end, we have had success filming lab work so that students can use the videos to collect and analyze their own data. Of course, this eliminates the skill of laboratory techniques and becomes more of a video reading exercise, but video data collection is the best we can do. Several online platforms offer lab video collection suites (PIVOT Interactives, etc.) but these can run upwards of $10,000 dollars per school, per year. Teachers have had success again taking their own videos for students to analyze. Students have been able to gather data, graph data, make arguments from evidence - all without ever being in the lab. So we have had some success recreating the lab experience for students. In order to do so, however, teachers are spending countless additional hours to prepare new video lessons in addition to their normal responsibilities. We are not sure how long we will be able to last.

4. There are two great challenges we are currently facing with regards to inequities in STEM education. The first is a universal challenge and the second is unique to our hybrid schedule. As has been well documented, underrepresented populations in STEM have been populations that have been disproportionately affected by the COVID-19 crisis. In some cases, the students we need to see most in person are those we are most concerned about their safety and the safety of their families. One of the students I had last year in chemistry aspires to study medicine with the goal of becoming a doctor or a nurse. Her mother is a nurse and her father is a truck driver. In order to better protect their family, they have decided to keep her home. As a female student from an underrepresented background, this is exactly the type of student we need to encourage in STEM fields. I am afraid that we are not going to be able to provide her the STEM background that she needs to be successful at the next level. Her challenge is part and parcel of our second challenge. Because we are teaching three cohorts

simultaneously (A-K in person/at home, L-Z at home/in person, Fully remote students) we cannot provide an equitable classroom experience. Teachers had wanted to try doing labs for our in person students within our safety guidelines - one student per lab table, no shared materials, six foot spacing at all times, gloves and personal lab goggles. To do so would be to violate equity considerations for those students who have chosen to stay home. Why would some students be treated to hands-on lab experience, while those at home simply have to watch? Not only is this not fair (and not fun), but it also does not in any way provide an equitable STEM education. Once students return, we will be forced to adopt a "remote in-person" model by teaching to the lowest common denominator. Students will simply be engaging in the exact same video class but just doing so in person. There is no other way to provide an equitable lab experience.

5. This past July, I submitted a "Problem of Practice" grant application, which I co-wrote with another school district, to the [redacted] State Board of Education. The grant aimed to gain funding for teachers to problem solve teaching physical science in a remote environment. Part of the grant funded teachers working to convert lab experiences into a video platform that could be shared across districts. A significant portion of the grant sought to gain funding for the modeling instruction professional development workshops that we have run over the past nine summers here at [redacted]. All of the teachers in our department are trained in modeling instruction (www.modelinginstruction.org). With the exception of this past summer, we have welcomed over 100 science teachers each summer to our school for professional development workshops in how to teach science using the modeling method of instruction. We were seeking grant funding to provide ongoing professional development throughout the school year and into next summer where we would share with teachers what we have learned about teaching modeling in the remote environment. Two days before the grant review process ended, we were notified that the grant was cancelled and the funding was being reallocated for other purposes. Professional development in modeling instruction changed my life as a STEM teacher. We have used our experiences to welcome over 500 science teachers to our workshops. We need funding to continue. We need support to transition our experiences teaching science remotely into a workshop for other remote teachers. Professional development has allowed us to impact the STEM education of tens of thousands of students. We need to continue to provide modeling instruction professional development to teachers. Modeling instruction is grounded in the Science & Engineering Practices of the Next Generation Science Standards. We cannot have professional development grants cancelled.

6. The most important data to collect about STEM education during the time of COVID-19 is student attendance and participation. We need to know who has chosen to study fully remotely and why. We need to know who has chosen to return to a hybrid experience and why. Finally we need to know who has chosen to return to school in person, but then decides to return to full remote because the classroom experience is not much different than the classroom video call they have experienced since the beginning of the year. More importantly we need to know about the students who are neither coming to school nor dialing in to the video call from home. These are the students we are most concerned for. They are going to ultimately fall too far behind over the course of a semester.

Increase Diversity, Equity, and Inclusion in STEM, question 12

12. The COVID-19 crisis has exacerbated the current recruitment and retention problem with STEM educators. The anxiety, stress, and amount of work required by teachers to provide an outstanding STEM education to our students given the restrictions of the pandemic is causing teachers either to leave the profession or to consider leaving. Last month our sister high school posted a math teacher opening. We had *zero* applicants. This is a tenure track math position at a highly regarded high school, and either no one was qualified for the job - or worse - no one wanted it. Now the math department chair will be teaching 3 extra classes in addition to his administrative duties and his own two classes. I have no doubt that one of the after effects of the COVID-19 crisis will be to accelerate the STEM teacher shortage from moderate to severe levels. My number one goal for the remainder of my time in education is to increase the number of students pursuing STEM education as a career. In particular I want to increase the number of female physical science teachers, female math teachers, and teachers of color in all disciplines. Prior to the crisis we had begun to put together a program to identify high school students of color who possessed the traits we look for when we recruit new teachers. Our goal was to bring these students together throughout their high school career and then remain in touch to support them throughout the college career. We especially want to focus support on the difficulty of their content area courses (college level physics and chemistry courses can force students out of teaching) as well as their student teaching experience. Further, we want to help them secure a job in STEM teaching and selfishly guide a few of them back to working in our district. When I was in [redacted] we tried to make clear to the NSF representatives the dire nature of the STEM teacher shortage over the next decade. I am afraid we may be seeing the teacher shortage we anticipated in 2030 coming as soon as next Fall. Hiring teachers from underrepresented backgrounds will become exceedingly difficult. We need the

help of NSF, the Department of Education, and the rest of the Federal Government to promote careers in STEM education.

Engage Students Where Disciplines Converge, question 16

16. Last year we experimented with teaching computer coding within a traditional physics course. We felt that teaching coding in physics was a way to reach more of our student body. Over 90% of our students take physics as we have a three year science graduation requirement. If we offered a separate coding class through the department, we anticipated a gender imbalance in the class that would be similarly reflective of the gender imbalance in the coding profession. Coding in physics has the benefit of using computer programming as a tool to study another discipline. In using coding as a tool, we were hoping to expand the idea of coding as a profession and/or skill to more students. The pandemic disrupted our study. I continue to believe this is a good idea. We need funding for more study, curriculum design, and teacher training. Online learning seems to promote the idea of tech integration into traditional STEM disciplines.

Build Computational Literacy, questions 20-23

20. This question strand relates to the answer in question #16 above. Our plan over the next decade is to integrate computer programming into as many of our STEM disciplines as possible. We hesitate to offer coding as a separate course as we feel it will cause some students to self-select out of learning coding. We want to cast a wide net for students who may be interested in computational thinking thinking as a career and expose the remainder of students to this type of thinking for use as a general life skill. The largest challenge in incorporating coding into traditional science courses is time. Time to plan new material. Time to incorporate new material. Time to include all of this material into a two semester course. In other words, we will have to be creative as to what material can be cut, we must remain, and what can be integrated into the new curriculum. The big question is "what material considered vital to a traditional physics or chemistry course is no longer necessary in the information age?" Incorporating coding material into a standing STEM curriculum is a zero sum game. Something will need to be cut and we need to determine what that is while retaining the integrity of the discipline.

21. Computational literacy is vitally important at the K-5 level of STEM instruction. Students need to be able to read graphs and tables of data (and to create them!). Worksheets and memorizing in K-5 science are no longer needed. For example, it

is much more important to time a can of soup rolling down a ramp and make a graph in K-5 than it is to memorize the parts of a cell. When students reach us in high school, despite prior teachers' best efforts, our students cannot manage data and make claims based on that data. K-5 teachers are not STEM experts. We need support from outside sources to provide STEM specialists to K-5 teachers.

22. Modeling instruction was originally an NSF supported professional development instructional strategy. The American Modeling Teachers Association (AMTA) is now a self funded entity that provides professional development in a pedagogy that centers on computational thinking in all science disciplines. Workshops are expensive to run and, more importantly, expensive for teachers to attend. We need Federal support to provide teachers with funding to attend modeling workshops as well as to provide funding for workshop leaders. STEM education professional development is the key to improving STEM education. We have a model for professional development at [redacted]. We need support to continue our work.

23. Currently I am using the following for my advanced chemistry course: Google Classroom, Zoom, Google Jamboard, Kami, Pear Deck, A Web Whiteboard (awwapp), screencastify, WeVideo, and Vernier Graphical Analysis. I always use curriculum resources from the AMTA. I am looking at Classkick this week. We have tried PIVOT Interactives but it is too costly for the entire district.

[redacted]

STEM Education RFI Response

Prepared for:
National Science Foundation

This document contains responses to the following questions:

- Future Opportunities in STEM Education, question 3.
- Develop STEM Education Digital Resources, question 9.
- Develop STEM Education Digital Resources, question 11.

Executive summary

The future of the American workforce will depend on the ability to rapidly integrate the changing skill sets demanded by industry into locally curated curricula. This will require a marketplace of ideas that gives employers input into national curricula standards that shape content developed locally to address regional workforce needs. The goal of this approach is to infuse standards-based curricula with learning objectives that tie directly to the needs of employers, while preserving state and local agency, and enabling educators to best serve the needs of their communities.

[redacted] is a learning technology company focused on helping employees perform at the height of their potential. We do this by working with the federal government and private sector employers to build distributed training solutions that develop next-generation skills within their workforce. Our [redacted] platform gives subject matter experts the ability to author canonical training resources, standards organizations the ability to review and publish those resources to standard, and then equip distributed training teams to deliver standards-based training for job performance or certification.

Question responses:

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

[redacted] works with groups like Jackson Health System (JHS), New York Presbyterian (NYP), and the Defense Health Agency (DHA) to deliver standards-based training to a variety of audiences.

JHS uses [redacted] to equip behavioral therapists to administer standards-based Dialectical Behavioral Therapy to an adolescent patient population. The program transforms Dr. Alec Miller's DBT-A (for adolescents, specifically) from a paper-based process into a facilitated mindfulness curriculum that can be delivered remotely and asynchronously.

In the case of DHA, content is used for High School ROTCs as well as active-duty medics through a [redacted] app called [redacted]. The training content shares 80-85% of it's learning objectives with civilian credentials such as those provided by the National Registry of Emergency Medical Technicians (NREMT), and has also been included in high school microbiology classes. As such, we were selected as one of the primary outlets for COVID-19 information and protocols to a globally distributed audience. While content for [redacted] is centrally managed, the training programs are tailored by each military branch to their unique use case, and delivered locally by a globally distributed training workforce.

By analogy, industry leaders could work with instructional designers to curate learning resources that tie learning objectives to the workforce skills that drive economic growth, and make those resources available to school districts which can then incorporate the content into didactics, project-based learning, and mentorship activities.

Local industries could benefit as well by having a more knowledgeable pool of graduates to hire from who are already fluent in knowledge and skills specific to that role.

9. What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

STEM workforce development would be greatly advantaged by an online portal which targeted state and local curricular authorities, and combined the open curricular resources of a site like Teachengineering.org with the employment marketplace insights of a site like Army COOL (https://www.cool.osd.mil/army/index.htm). While TeachEngineering is an excellent resource for educators looking for curricula, lesson plans, and activities for STEM education, Army COOL helps users understand how their experiences map to professional certifications, easing veteran's transition into the workforce.

Using BLS data and industry input to define career paths could provide additional data-driven insights into what curriculum isn't just the most popular, but what is the most valuable in the workplace. Industry leaders with low content engagement, but valuable opportunities could begin to address that gap at a content level to help equip educators with more effective instructional resources.

This could also increase the value high school students place on educational objectives as they see their curriculum success translate directly into a stronger applicant profile for a preferred industry.

11. How would you like to see resources categorized (e.g., subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.

The Common Core's poor performance (as reported on the NAEP Assessment) may be attributed in part to the tendency of federal mandates to revoke local agency in the review and delivery of curriculum relevant to local industry.

This could be mitigated with a delivery mechanism that allowed for CoSTEM to curate standards-based content at a federal level, but provided states with a mechanism to retain autonomy in compiling and distributing that content based on skills and needs defined by industry in local collections that can be modified and/or supplemented based on local priorities.

[redacted] supports a delivery path that would match a federally curated asset library with local industry partners who could then build collections of content (including courses for certification) relevant to their industry. This would ensure local relevance to the content which K-12 educators could deliver on-demand in the classroom or directly to students through online self-directed courses.

This evergreen content resource would connect educators, industry leaders, and students to the same curriculum to provide greater learning support for student growth.

Employers could provide direct mentorship opportunities to K-12 students who demonstrate eligibility, or use the course benchmarks as entrance requirements to project workshops and competitions.

Teachengineering.com is a step in the right direction as a distribution point for approved content through Colorado University-Boulder, but the concept could be expanded with a state app that drew industry leaders as well. Students graduating and looking for work could fine-tune their knowledge based on skills and content defined by a specific hiring point.

[redacted]

[redacted]

Organization Type: STEM Education Non-Profit.
Organization Summary: The [redacted] provides PreK-12 solutions to expand access to challenging coursework and improve student achievement through proven programs that consistently produce systemic culture change and measurable results, with an explicit focus on attacking the disproportionality of access and achievement in college-level coursework across income, race/ethnicity, and language/learning differences.
Organization Audience: [redacted] provides programming for school district and school building leaders, educators, students, and their families.

Questions Addressed in [redacted] Response:

- Future Opportunities in STEM Education, questions 1, 2 and 4.
- Increase Diversity, Equity, and Inclusion in STEM, question 12.
- Build Computational Literacy, question 22.
- Community Use and Implementation of the Federal STEM Education Strategic Plan, question 24.

Future Opportunities in STEM Education, questions 1, 2 and 4.

Question 1: Access to Internet-enabled devices and reliable broadband connectivity is no longer nice-to-have, but a requirement for learning in and out of school. With the shift of student learning and educator professional development to fully online or hybrid models, the lack of consistent access prevents the most vulnerable students from engaging with learning opportunities. While many states and districts have worked to address these gaps, [redacted] has seen that many students continue to lack access to the connectivity that they need to access high-quality online instruction.

In addition to connectivity and devices, time is an essential resource for teachers. Many teachers are in fluid environments where they are in-person, hybrid or fully online, but due to the nature of COVID-19, their context might change at any moment. To ensure that high-quality instruction continues despite shifting contexts, teachers are craving high-quality materials that can be utilized flexibly across many learning contexts.

Lastly, the shift to fully or partially remote learning impacts students and the adults who are supporting their learning. Additional explicit support is necessary for learners and their families around digital literacy.

The primary barriers that remain are access to high-speed Internet connections at home and a digital device for each student and teacher in a household, flexible high-quality content and explicit digital literacy support.

Question 2: [redacted] has a track record of delivering evidence-based programs to support PreK-12 education and, in response to COVID-19, [redacted] accelerated its expansion of online delivery and has temporarily shifted all programming to online delivery. [redacted] has utilized experience from its previously online delivery and research-based best practices to deliver effective student learning and online teacher, school leader and district leader professional development.

[redacted] online **educator and leader supports** are comprised of the following services:

[redacted]

- [redacted] is a two-week online learning conference for teachers, academic counselors and administrators. Participants experience a variety of session types designed to prepare them for the upcoming school year. A key design element is providing teachers deep content support and insight into course pacing while also experiencing the types of pedagogical learning that fits their needs. As with all [redacted] professional development, these sessions are centered around the goal of helping teachers build capacity in content knowledge, assessment and data analysis, instructional strategies, students' understanding, and equity and inclusion.
- [redacted] are six-week online courses that occur during the school year. Participants experience a variety of session types designed to allow for just-in-time learning aligned with content and pedagogical skills needed in the coming weeks. A key design element is framing professional development in the context of what teachers are doing in the classroom at that time. As with all [redacted] professional development, these sessions are centered around the goal of helping teachers build capacity in content knowledge, assessment and data analysis, instructional strategies, students' understanding, and equity and inclusion.
- **On-Demand Teacher Supports** - No two teachers need the same supports. At [redacted] we support a broad range of teachers: From the physics teacher who primarily needs support in making learning engaging and relevant to high school students to the new teacher at the specialized school for travelling soccer players that is tasked with teaching all the AP courses to his players (true story). The beauty of online learning is that we can provide each teacher with unique support on the teacher's timeline. On-Demand Modules offer blocks of learning experiences from highly experienced and accomplished educators that teachers can engage in when they deem it necessary.

[redacted] online **student supports** offer 12 live sessions of Advanced Placement, topic-specific learning and review delivered by a [redacted] coach. Each session is also supported by an asynchronous, "work at your own pace" module that students can engage with on their own schedule.

In addition, [redacted] continues to support **school and district leaders** through leadership development training and program management, which consists of virtual visits, the development of a strategic action plan and regular coaching discussions using data to drive decision making.

Question 4: As mentioned above, digital access is one of the primary inequities [redacted] has faced when accelerating our work to a blended and online delivery model for teacher professional development and student learning. [redacted] identified local solutions in many cases where districts and states developed plans to support students with devices and Internet access at home, but [redacted] is still witnessing gaps in access. [redacted] has worked with Internet Service Providers to make connectivity at home available in cases where a local solution was not provided.

In addition, [redacted] has observed that due to increased logistical challenges and scheduling demands with online courses, hybrid models and retiring educators, some schools are no longer able to offer advanced STEM courses because those classes don't fit into the schedule or the teacher has left the teaching profession. Teacher shortages have long impacted STEM courses, but we are seeing that COVID-19 has exacerbated shortages and is also impacting teacher diversity. In the short-term, one solution is to support school systems to implement high-quality online course offerings to ensure that advanced STEM courses are still offered. In addition, it will be critical to support recruitment efforts into high-quality teacher preparation programs, like the UTeach STEM teacher preparation program. [redacted] have collaborated with leaders at 45 universities to create [redacted] across the country. Today, 11 Historically Black Colleges and Universities are

[redacted]

working with [redacted] and the [redacted] to create unique programs that will greatly increase the number of highly qualified Black STEM teachers in US schools.

In addition, in 2018, [redacted] was awarded an Education Innovation and Research (EIR) Early Phase grant to support students in rural communities to increase access and success in advanced STEM courses. [redacted] Rural ACCESS grant provides students, teachers and school leaders with an innovative blended delivery model of [redacted]. As a result of this grant, [redacted] began partnering with online AP course providers to offer online course options paired with [redacted] coaching and training. These efforts laid a firm foundation for [redacted] to be able to accelerate blended and fully online delivery of our programs, which have been incredibly impactful to support schools and districts with their response to COVID-19.

[redacted] measures our success utilizing a comprehensive evaluation framework that includes:

- impact on student learning as measured by validated reliable measures
- impact on student trajectories
- impact on student interest and identity
- impact on teacher mindset and confidence
- impact on teacher STEM identify, perception of value and retention
- impact on teacher practice
- impact on school leader and district leader mindset
- impact on systems and sustainability
- other community level outcomes as relevant to local context

Increase Diversity, Equity, and Inclusion in STEM, Question 12: From its inception, [redacted] work has focused on expanding access and achievement in rigorous education for all students. We intentionally engage, invite and support students furthest from opportunity – those who are part of communities that have been underserved and underrepresented because of race, ethnicity, socio-economic status or other traits and conditions. We strive toward a day when opportunity is not bound by income, race, gender, gender identity, sexual orientation, disability, zip code or national origin.

Our means of increasing representation, persistence and achievement are rooted in local partnerships. As one example, we work with school system leaders in our K12 programming to compare school and community populations with the population of students represented and striving in advanced education. We work with those leaders to develop and support local systems and goals that ensure equitable access and achievement.

As another example, we work with 45 college and university partners to introduce math and science undergraduates to STEM teacher career opportunities. We support programming in those institutions to prepare those students for teaching across diverse communities, helping them to graduate with STEM degrees and teaching certification within the same four years and without additional costs.

Our STEM teacher preparation program results in more teachers in Title 1 communities and we are working with nearly a dozen Historically Black Colleges and Universities to develop custom STEM teacher preparation programs to bring more highly qualified black teachers to K12 classrooms. This aligns with research that connects high school persistence and college engagement for Black students who experience learning from at least one Black teacher in early education grades.

[redacted]

Our interventions are measured by the level of enrollment, persistence and success in rigorous education systems, such as Advanced Placement, and by matriculation to and through college.

Based on recent evaluation, students who experience [redacted] flagship College Readiness Program are more likely to attend and persist in postsecondary institutions than the national average for all students and for Black, Latino and other demographic groups. Those students also are more likely to earn a postsecondary degree within four years than the national average and they earn STEM degrees at rates higher than the national average.

Build Computational Literacy, Question 22: There has been an incredible increase in interest in computer science and computing in K-12 education across the nation. In 2018, there were record increases in the number of female and minority students taking the AP exam, yet minority students still account for only 20% of those taking AP computer science and female students make up about 28%. Despite increases in participation in recent years there is still a long way to go to reach the vision of Computer Science for All. Students have too little early exposure to computer science, with current efforts usually relying on a single computer science champion (rather than making computer science part of the standard offerings in K- 12 schools) and there are many misconceptions about who should take computer science and why all students need it. Even when schools are able to offer computer science, the enrollment in the courses often does not match the demographics of the school, leaving many students out of this crucial discipline.

Support from the National Science Foundation is specifically focused on increasing equity in computer science and has led to the development of many evidence-based programs that serve students at different points in their educational careers. Yet, districts struggle to develop a comprehensive vision for computer science education across the grade levels. Since providers do not have a shared calendar or offer multi-program PD events, districts must effectively select solutions that best meet their needs, and then support the implementation of programs.

To see an increase in computer science programming across PreK-12 and the long-term sustainability of these programs, subsequent efforts should focus on full district models that include a few critical components:

- Build capacity for sustainment over a 3-year learning progression
- Utilize evidence-based programs
- Implement vertical teaming to allow for coherent student experience:
- Support for district leaders, school leaders and school counselors:

Because of the lack of district-level approaches for computer science education, [redacted] launched [redacted] in 2019, which represents a novel approach to PreK-12 computer science. A partnership between 10 organizations – the [redacted] Bootstrap, Exploring Computer Science, MIT App Inventor, Mobile CSP, NCWIT Counselors for Computing, Project GUTS, Cornell Tech's K-12 Initiative, CS for All's SCRIPT Program, National Center for Computer Science Education and UTeach Computer Science – [redacted] provides a three-year support model for school districts across the nation to implement a comprehensive, evidence-based Computer Science for All pathway in grades PreK-12 with an explicit focus on access, equity, and sustainability. To kick off the [redacted], [redacted] hosted a Summer Institute in July 2019 that brought together 23 school districts from across the nation to begin on their three-year journey to provide computer science to all students in their respective school districts. The school districts offered more than 200 educators to participate in research-backed and evidence-based computer science professional development with a focus on preparing teachers to integrate computer science in their classroom as well as providing the participants with the knowledge to make informed decisions when creating the district computer

[redacted]

science pathway for students in their school district. This event was a pivotal beginning for most of the school districts. [redacted] continues to support these school districts this year with content support, continued district planning, and vertical teams training and facilitation.

[redacted], alongside Mobile CSP, and NCWIT are recipients of a 2019 Education Innovation and Research (EIR) award from the US Department of Education to implement a three year consecutive teacher professional development and support model to reach AP CSP teachers in 50 high schools and 25,000 students across Texas utilizing core components of [redacted] evidence-based College Readiness Program.

Community Use and Implementation of the Federal STEM Education Strategic Plan, Question 24: In 2017, [redacted] embarked on a new strategic plan, [redacted], which is very closely mapped to the goals and pathways outlined in the Federal STEM Education Strategic plan.

Federal STEM Education Strategic Plan Goal or Strategy	[redacted] **Work**
Increase Diversity, Equity and Inclusion in STEM	• The focus of [redacted] mission is to increase diversity, equity and inclusion in STEM courses and experiences in PreK-12. • [redacted] focuses on systemic culture change with school systems across the nation and use a combination of data-driven coaching and professional learning for school and district leaders and educators to ensure that more students, especially students underrepresented in STEM courses have access and success in advanced STEM coursework.
Build Strong Foundations for STEM Literacy	• [redacted] works across the PreK-12 STEM education pathway to expand access and prepare students for postsecondary and workforce opportunities that so often require a firm foundation in STEM. • [redacted] efforts work explicitly to build STEM literacy for every student by having explicit supports for teachers in each grade band combined with vertical teaming to ensure students seamlessly progress throughout their PreK-12 careers.
Develop and Enrich Strategic Partnerships	• [redacted] also has a priority to build strategic partnerships to exponentially increase our STEM impact. [redacted] works with a diverse group of partners including school systems, community-based organizations, non-profit organizations, institutions of higher education, federal agencies and funders. • Since [redacted] formation in 2007, the organization has been a recipient of numerous public and private grants and contracts which the organization has utilized to expand our programs, maximizing our work and impact, and refine our offerings to best meet the needs of the diverse populations we serve resulting in stronger outcomes for students in communities across the country. • [redacted] has partnered with 1,400+ schools, 95 installations and 45 universities across 38 states to impact 65,000+ teachers and 2+ million students. [redacted] has deep experience managing large, multi-year projects

[redacted]

	and program evaluations and significant expertise in managing federal grant projects and their associated evaluations, including U.S. Department of Education i3, EIR, and SEED grants, along with grants from the U.S. Department of Defense and the National Science Foundation. • In 2020, [redacted] launched a Family and Community Engagement Initiative designed to support families and engage local community-based organizations more explicitly in [redacted] programming and in STEM education.
Build Computational Literacy	• Since our beginnings in 2007, [redacted] has explicitly supported AP Computer Science courses. • To double-down on [redacted] commitment to building computational literary, [redacted] launched [redacted] in 2019, which represents a novel approach to PreK-12 computer science. [redacted] program provides a three-year support model for school districts across the nation to implement a comprehensive, evidence-based Computer Science for All pathway in grades PreK-12 with an explicit focus on access, equity, and sustainability.
Operate with Transparency and Accountability	• Since [redacted] inception, [redacted] has had a focus on evidence-based programming and has remained committed to programmatic evaluation to build and use evidence in education both to increase **transparency and accountability** and contribute to the body of knowledge around effective STEM teaching and learning strategies for students underrepresented in STEM. • In 2018, [redacted] built out a dedicated Data, Analytics and Evaluation team has built an internal evaluation framework to expand [redacted] approach to measurement, analytics and evaluation of our programming. • In 2019, [redacted] along with 100Kin10, Barings, SRI International, AIR, and Genentech launched the [redacted] which pulls together publicly available data at the state, district and campus level in one easy to use tool to support public knowledge about STEM education. • [redacted] also receives a Platinum Seal of Transparency from Guidestar for accountability and 4 star rating from Charity Navigator.

[redacted]

Request for Information: Document Citation 85 FR 55323, page 55232-55326, Document number 2020-19681

Agency/Office: National Science and Technology Council's (NSTC's) Committee on STEM Education (CoSTEM)

Title: Federal STEM Education Strategic Plan, Charting a Course For Success: America's Strategy for STEM Education.

Information for RFI

1. Company: [redacted], national non-profit organization
2. Address: [redacted]
3. Points of Contact: [redacted]
4. Phone Number: [redacted]
5. E-mail Addresses: [redacted]
6. DUNS Number: [redacted]
7. EIN: [redacted]
8. Business Size and Classification: Non-Profit, Small Business

This RFI incorporates information in response to Future Opportunities in STEM Education questions 1-5, Develop and Enrich Strategic Partnerships questions 18 & 19, and Community Use and Implementation of the Federal STEM Education Strategic Plan question 24.

[redacted] is a nonprofit organization that brings life-changing STEM education resources and opportunities to under-resourced communities, providing equitable access to education and inspiring students to imagine their own success. Through innovative and experiential education programs for grades K-12, [redacted] programs are designed to spark interest in STEM careers, building the workforce of tomorrow that will drive the innovation economy, and bridging school, community, business and government.

1. What COVID-19 related digital barriers (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

COVID-19 has unearthed immense challenges and obstacles in nearly every aspect of life, and access to STEM education and opportunities has not been immune. In March, 2020, schools were forced to close as a result of the COVID-19 pandemic, forcing administration, teachers, and students to swiftly adapt to a new online learning environment with little time to adequately prepare. The most immediate barrier educators faced was a lack of quality lesson plans that could be implemented in a digital learning space.

To meet this immediate need, [redacted] quickly pivoted in order to provide the necessary resources during this unprecedented time, leveraging its rigorous laboratory investigation curriculum to deploy authentic STEM distance learning resources online. [redacted] Digital STEM Learning Program provides turnkey experiences for teachers to use in their own digital classrooms. Program components include real-time, mobile-friendly access to standards-aligned laboratory investigations, multimedia STEM resources, collaborative assignment tools, and interactive assessments, virtual professional development for educators, repositories of online learning resources and best practices with wide reach, and support for parents as educators at home (in multiple languages).

Although [redacted] Digital STEM Learning Program was extremely well received, gaps were quickly identified once deployed that centered around the loss of hands-on activities, too much on-screen time, and lack of equipment and supplies. Over the summer, [redacted] iterated on its distance learning program offerings to fill these gaps based on direct feedback that was provided by educators across multiple regions. Newly created as well as iterations of existing programs are outlined in the following question.

2. *What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (e.g., virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (e.g., pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.*

[redacted] has created new programs, and modified existing program mechanics in order to enhance remote (both synchronous and asynchronous) education, including deploying the following:

- Loaner kits - equipment and supplies for teachers to demonstrate laboratory investigations synchronously or asynchronously for their students, generate data for their students to analyze;
- At-home student kits - supplies for students to run their own laboratory investigations at home connected to digital STEM learning bundles;
- Guest speakers - connect with STEM industry professionals for synchronous or asynchronous discussions, virtual field trips, and laboratory investigations
- Standards-aligned digital STEM learning bundles for grades 6-12, designed for teachers to use in their own digital classrooms
- At-Home Science assignment ideas including dozens of hands-on experiments that students can do on their own with everyday materials
- STEM Career video profiles representing diverse backgrounds

With the use of digital technology, STEM professionals can step into virtual classrooms and expose students to STEM careers that would otherwise not be possible. Through virtual discussions, field trips, and lessons, students have the ability to connect with ind[redacted] that have chosen a STEM career path.

3 . *What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?*

While remote learning provides many challenges, it has also opened the door for many positive enhancements and expansions to [redacted] programming. With our mobile STEM laboratories parked, our team had the opportunity to not only revamp existing curriculum but also create brand new curriculum in a hybrid format to offer both online and in-person resources. By creating a digital platform, [redacted] is now able to serve any student, no matter where they are and regardless of medium.

The Federal Government has a unique opportunity to provide students of all ages an inside look at the various STEM careers that exist across the county. By utilizing the existing workforce of STEM professionals currently working in the Federal Government, and taking advantage of digital platforms, there is an opportunity to engage the current workforce in the education environment. Similarly to how [redacted] engages private industry partners, these engagement opportunities could include teaching and mentoring of students, curriculum and content development support in specific interest areas (and based on subject matter expertise), virtual field trips to federal research laboratories, speaking engagements around issues that affect our daily lives, and much more.

Additionally, the Federal Government could work with educational institutions at all levels to create virtual career exploration tracks. The tracks could be driven by researched curriculum that teach students skills needed for a variety of STEM careers and provide students an opportunity to take charge of their own learning while at the same time encouraging them to think about their career path.

4. *What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?*

The greatest challenges that have emerged related to inequities in STEM through the transition to online education centers around equity. Students that previously lived in a home with devices and access to reliable internet started off virtual learning leaps and bounds ahead of their peers who did not have the same access. Additionally, underfunded schools did not have the ability to provide their students, teachers, or parents with trainings and education around technology. Barriers are created when students and parents must troubleshoot at home, ultimately impacting teacher's ability to provide their students with quality, interactive education.

Through online professional development workshops and small collaborative work groups, [redacted] has been able to provide educators with training necessary to integrate online learning resources into their classrooms. Creating a hands-on STEM kit, [redacted]

[redacted] has also been able to aide teachers in fulfilling their classroom laboratory requirements, creating a kit that seamlessly enhances the free distance learning lesson bundles offered on our distance learning platform.

As these solutions are early in their deployment, [redacted] is measuring success of these resources through teacher surveys, student feedback forms, and focus groups. As the school year continues to operate in an online or hybrid format, searching for solutions that support meaningful and engaging learning remains the primary focus and concern of [redacted]

5. *What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?*

Through outreach to educators across the country, [redacted] has found that most teachers are eager to participate in focus groups, collaborative work groups, and online professional development centered around distance learning. One of the most challenging factors of this new normal is creating an equitable and fair way to measure success, both for educators and students.

18. *What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?*

The direct participation of private industry in work-based learning programs plays a significant role in not only encouraging and exciting students and schools to participate, but also supports the continual building of the STEM workforce pipeline. Since 2003, [redacted] has been sparking student interest in STEM careers and working to diversify the STEM pipeline by engaging more than 200,000 students in hands-on STEM curriculum across 18 states. [redacted] has a proven track record of success in improving students' STEM attitudes and content knowledge while increasing interest in STEM careers. After just one class with our educators:

- 48% showed an increase in confidence that they would be successful in pursuing a science career,
- 43% expressed greater interest in exploring science and engineering careers,
- 68% had an increased understanding of what engineers do,
- 62% of students reported an increased interest in finishing high school,
- 64% of students reported an increased interest in attending college.

Formative and summative evaluations are used to measure the impact of the program on teacher and student achievement, attitudes and confidence levels towards STEM topics, [redacted]ss of and interest in pursuing STEM careers. Outcomes are measured and evaluated using a variety of methods that may include classroom observation, focus groups, interviews, and pre/post surveys.

[redacted] success can be attributed to several factors core to its mission and values:

- Trusted relationships with schools, educators, students and community leaders;
- Leveraging strong partnerships with leading industry leaders, higher education institutions and governmental agencies (i.e. Verizon, Toyota, Northrop Grumman, Lockheed Martin, Johns Hopkins University, NIH, NASA, State of Maryland);
- Leading-edge STEM education programs that meet students where they are. Our mobile laboratory fleet and now are distance learning resources allows us to bring these resources right to the school parking lot or to their home;
- Successful track-record with proven results. Third-party evaluation data shows clear linkages for increases in student interest in STEM careers, knowledge and competence in science and technology and interest to complete degrees and pursue post graduate study.

[redacted] has spent more than 15 years developing, testing and honing its broad program offerings. In the past four years alone, [redacted] has successfully translated its program model to serve multiple geographic regions and a diverse set of schools and communities, raising more than $10M from corporate supporters, philanthropic organizations, and government. The organization has successfully diversified its funding stream, program offerings and geographic footprint. By bridging the gap between educators, government, and STEM professionals, [redacted] believes there is limitless possibility to continue to build, diversify, and strengthen the STEM ecosystem.

19. *If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?*

As the COVID-19 pandemic and resulting impact on our education system have shown, having a successful STEM learning ecosystem in place is critical to allow for continued engagement, interest and learning in STEM topics and careers. [redacted] has remained focused on finding new methods to reach students as a result of in-person learning being paused, and has remained committed to providing world-class STEM education opportunities to students in high-need communities despite the additional barriers that COVID-19 has presented. To expand access to digital learning materials for teachers and students [redacted] has been iterating on its programming and seeking out new partnerships to create a hybrid STEM education ecosystem that includes interactive digital lesson bundles, career snapshots, at-home learning, and STEM skills videos. These scalable, digital resources (which are free to students and teachers nationwide) are designed to increase engagement in STEM coursework and interest in high-opportunity careers. The library of hybrid learning resources includes dozens of standards-aligned lessons on topics ranging from biology to engineering to data-driven decision making to computational thinking.

This hybrid STEM education ecosystem expands both reach and equity in STEM education by offering resources and programs to engage students in authentic, collaborative l[redacted] experiences that balance and blend online and face-to-face learning environments. Components include multimedia STEM resources and enhanced content, game-based learning, tools for ongoing discussion, and hands-on laboratory investigation in robust digital lesson bundles. The resources support hybrid instruction allowing students to interact with content and engage in learning activities independently or asynchronously while collaborating and applying key concepts within the synchronous classroom.

The role of the private sector in supporting this hybrid STEM education ecosystem has been crucial to help boost our efforts. [redacted] corporate partners have not only supported this work from a financial perspective, but have also provided STEM professionals to engage directly with students, helping create an awareness of, and interest in, STEM careers, and providing them with role models in the field. Industry partners have also supported [redacted] curriculum development efforts, ensuring that relevant topics and experiences are incorporated so as to shed light on careers available and the type of work and training that is needed to fulfull these careers.

24. *Please describe how your organization has used the Federal STEM Education Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?*

[redacted] mission directly aligns with the goals of the Federal STEM Education Strategic Plan of building strong foundations fo STEM literacy, increasing diversity, equity and inclusion in STEM, and preparing the STEM Workforce for the future. [redacted] program objectives include:

- Increase equitable access to quality STEM education for underserved communities;
- Excite and engage student populations typically underrepresented in STEM careers through access to hands on experiences they cannot get in the classroom;
- Increase student efficacy and confidence with STEM concepts and techniques;
- Increase awareness of and understanding about well-paying, high-demand STEM careers;
- Provide professional development opportunities for teachers on advanced STEM topics;
- Increase teacher self-efficacy with advanced concepts, theories, and equipment used by STEM professionals;
- Increase teacher awareness of and understanding about well paying, high-demand STEM career opportunities for their students.

In alignment with the Federal STEM strategic plan, [redacted] operates and deploys multi-faceted programming that leverages and builds upon a successful and proven track record of running innovative and engaging STEM learning. The majority of students the [redacted] model serves come from under-resourced communities. These students gain access to critical STEM education resources and opportunities that ultimately help increase their awareness of, and interest in, STEM careers. Deploying unique and interactive STEM programming and resources, no matter the medium, benefits communities and taxpayers directly by strengthening students' science and technology skills and developing a diverse pipeline of talent into STEM careers.

[redacted] [redacted]

National Science Foundation
2415 Eisenhower Ave
Alexandria, VA 22314

October 19, 2020

[redacted] STEM RFI Response

The [redacted] is a nonprofit organization that works with the education community to accelerate the use of technology to solve tough problems and inspire innovation. In response to the National Science Foundation's (NSF) notice of request for information on implementing the Federal STEM Education Strategic Plan — *Charting a Course For Success: America's Strategy for STEM Education* — [redacted] is pleased to submit the following comments, which highlight current challenges in equitably delivering effective digital learning experiences to all students and strategies by which the federal agencies, including NSF, White House Office of Science and Technology Policy (OSTP), and the National Science and Technology Council's Committee on STEM Education (CoSTEM), may provide educators with necessary supports.

Future Opportunities in STEM Education (Questions 1-3, 5) and Develop STEM Education Digital Resources (Question 9)

What COVID-19 related digital barriers (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

Disruptions caused by the COVID-19 global pandemic illuminated and exacerbated existing gaps in the education system's current capacity to lead effective and equitable digital learning. Specifically, [redacted] has learned that there is a persistent and urgent need to support human aspects of digital equity — the capacity of educators to lead effective and equitable learning experiences empowered by technology. For example, 43 percent of district superintendents indicated this year that they do not have the instructional capacity for online learning, whereas according to principals, lack of instructional capacity was among the top barriers that hindered schools from providing effective online learning. Additionally, over [redacted] educators indicated that they require more support and resources around online learning.

Leaders of [redacted] also shared how the lack of preparedness for digital and online learning impacts educators on the ground. In a recent article, the Arizona Technology in Education Association (AzTEA) wrote, “Without continued, substantial investment to maintain...professional development opportunities, educators are essentially left to fend for themselves,” whereas the Alaska Society for Technology in Education (ASTE) noted difficulties with “provid[ing] training on high-demand topics like designing virtual learning spaces to promote collaboration, maintaining relationships, and engaging families.” Featured in another article authored by Senator Tammy Baldwin and Representative Ro Khanna, both the Wisconsin Educational Media and Technology Association (WEMTA) and CUE noted continued demand among educators for ongoing professional development in effective digital and online learning strategies.

Finally, Dr. Liz Kolb, Professor of Teacher Education and Education Technologies at University of Michigan, recently conducted national surveys that illustrate specific educator needs in digital and online learning. Her study shows that a majority of novice K-12 teachers do not feel well-prepared to:

- Use technologies to interact with parents and families
- Use technology integration frameworks
- Integrate digital citizenship into their teaching methods
- Use open educational resources in their teaching
- Effectively manage student data and privacy
- Use a Learning Management System in their teaching
- Manage technology tools
- Provide online learning experiences for their students

What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (e.g., virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (e.g., pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

Ensuring delivery of effective remote learning experiences at the K-12 level, including STEM learning experiences, must involve tackling educator capacity gaps at both the in-service and pre-service levels. At the in-service level, educators — including instructional technology coaches and library media specialists that frequently assist and mentor classroom educators — must be provided with flexible, ongoing professional development on how to implement and model effective pedagogy for remote learning. For example, [redacted] recently concluded the [redacted] program, which provided over 17,000 educators nationwide with a month-long opportunity to learn about how to create productive online communities, design effective online learning experiences, assess student learning, and ensure equity and inclusion. [redacted] is continuing to provide this type of professional development to states and districts through the [redacted] professional development platform.

Similarly at the pre-service level, educator preparation programs must be afforded opportunities to partner with experts in technology-empowered pedagogy with the goal of not only redesigning their programs, but also building the capacity of their own faculty to implement and model effective learning strategies. For example, Central Michigan University's (CMU) Master of Arts in Learning, Design, and Technology program recently achieved full alignment of their program to the [redacted], a research-based framework that empowers educators to support student learning and agency through technology-enhanced pedagogy across disciplines. Similar efforts have been led by the Connecticut Commission on Educational Technology and Fairfield University's Graduate School of Education.

What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

In partnership with CMU and the Michigan Department of Education, [redacted] recently hosted a statewide convening that allowed Michigan educators and district leaders to reflect on recent successes in implementing remote learning. Their responses included the following:

- Some district leaders and educators exemplified a commitment to equity. They engaged in cross-district collaboration to ensure that underserved districts had access to high-quality online learning resources.
- Districts that had been engaging in personalized learning (e.g. 1:1 initiatives, competency-based learning, project-based learning) fared better during the transition to online learning this spring.
- Districts' instructional technology coaches, library media specialists, and other certified teacher leaders were critical in helping educators get up to speed on a focused list of online learning tools and modeling instructional strategies.
- Extended, facilitated, and hands-on design sessions were especially helpful in building educators' confidence and skills.

- There was a renewed focus around social and emotional development and community building in digital spaces.
- Some educators took advantage of this opportunity to experiment with different instructional strategies. This included innovative clinical experiences led by educator preparation programs.

Federal agencies can scale such pockets of success by investing in capacity building partnerships between schools and remote learning experts. Federal agencies can also highlight innovative state or district systems that adopt a framework for effective teaching and learning with technology across disciplines (e.g. [redacted]) and strategically incentivize educators to undergo necessary training (e.g. through certifications, endorsements, and other credentialing models). In line with the Federal STEM Education Strategic Plan's goal to expand diversity, equity, and inclusion, such efforts must prioritize the needs of historically-marginalized communities.

What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

In partnership with education leaders in California, [redacted] recently surveyed educators on remote learning topics that would be the most helpful to have further guidance on effective practices. Their responses included the following topics:

- Lesson design that incorporates active learning opportunities
- Interdisciplinary activities
- Formative and diagnostic assessment practices
- Asynchronous vs. synchronous considerations
- Increasing student engagement in a distance learning modality
- Balancing instructional time and independent work
- Instructional models such as project-based learning, small group instruction, and multi-tier system of supports (MTSS)
- Accelerating learning for the most vulnerable students
- Relevant standards, including the National Standards for Quality Online Teaching Standards and [redacted] Standards for Students and Educators

What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

[redacted] has learned that educators benefit from multimedia resources that succinctly elaborate and illustrate effective pedagogy empowered through technology. For example, in response to numerous requests among [redacted] members for models of the [redacted] Standards for Students in practice, [redacted] recently developed a [redacted] showcasing real educators from around the country implementing specific standard strands in their classrooms. In just a few months he videos have already received nearly 100k views.

Also in response to COVID-19 and the rapid nationwide transition to online learning, [redacted] developed a model for multi-partner, web-based resource through learningkeepsgoing.org. Key content on this website include:

- Database of free digital tools searchable by grade-level, content area, accessibility, and other useful categories.
- Curated resources for students, educators, parents, and the higher education community.
- Expert webinars and podcasts on topics ranging from student engagement to trauma-informed practices.
- Digital help desk that offers educators free access to a professional learning community to share effective online learning practices.
- Other resources for educators and education leaders developed by the COVID-19 Education Coalition, a community of nonprofit organizations convened by [redacted] and EdSurge to support the education field as learning moves online.

[redacted] is pleased to find an emphasis on computational thinking (a key strand of the [redacted]), cross-disciplinary learning, and public-private partnerships in the Federal STEM Education Strategic Plan. [redacted] is also grateful for the opportunity to provide this input and look forward to working with NSF, OSTP, CoSTEM, and other relevant federal agencies on the successful implementation of the Federal STEM Education Strategic Plan. For any questions about [redacted] or our comments, please reach out to [redacted]

Sincerely,

[redacted]

Response to the Request for Information on STEM Education

Submitted by [redacted]

Relevant Questions (Category and Question Number)

- Future Opportunities in STEM Education, questions 1-3, 5-6
- Develop STEM Education Digital Resources, questions 9-10
- Build Computational Literacy, question 23

1. What COVID-19 related digital barriers (*e.g.,* access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

The [redacted] serves as [redacted] think tank and living laboratory for improving instruction and learning practices in higher education, with a focus on technology-driven education innovation. Through innovative transformational change, our work aims to enhance accessibility, affordability, and achievement in higher education. Our responses to the given questions are based on not only the institutional perspective but also findings from our recent research on remote teaching experience of faculty at [redacted]. [redacted] conducted both an online survey (n=266) and case study (n=7) between mid-April and May in 2020 in order to gain insight on faculty experiences and challenges during the emergency remote delivery of courses. All participants had in-person class meetings prior to the move to remote teaching during mid-March due to the COVID-19 pandemic.

We have found two salient COVID-19 related digital barriers: one is students' access to equipment, and another is connectivity. Some students did not have access to personal laptops or computers to connect to their classes and activity sessions or to take exams. This is a barrier that was resolved through the [redacted] library's coordination with departmental IT groups to provide a laptop borrowing program for students. The second COVID-19 digital barrier also impacts the first – we found that some students, faculty and staff members experienced internet connectivity issues due to weak or shared wi-fi. It is critical that this issue be resolved in conjunction with the lack of access to personal computers. To complicate things even more, [redacted] has students, staff and faculty located in more than 100 countries around the world and it is essential that our entire community have access to wi-fi to enable learning. Additionally, there are connectivity issues because of the time zone differences. For example, students based in Europe, Africa and most importantly in Asia (South Korea-China-India) had to adjust up to 11 to 14 hours of time difference with Atlanta.

There are a number of ways that [redacted] has worked to resolve connectivity issues and technical difficulties. One approach that faculty commonly reported was related to adjusting the format and logistics of lecture videos. Many instructors reported that they reduced the length of recorded lectures by dividing a continuous long lecture into a series of short videos (typically less than 15 minutes) and made them available in advance so that they can be downloaded and do not need to be streamed. Some instructors mentioned that they had a backup pre-recorded lecture in case of systems failure or inaccessible situations during a synchronous class session. Other instructors reported providing video captioning and speed tools. Another common approach was adding some degrees of flexibility to assignments and exams. For example, instructors often reported that they extended the assignment deadlines or divided long exams (i.e. 2hr-50min Final Exam) into smaller tests to minimize timeouts and connectivity issues. In particular, because of different time zones, the majority of instructors offered flexibility in test-taking by providing a wider time window to allow students to optimize their environment. Lastly, many instructors reported that they offered individual office hours almost anytime between 9am to 9pm to accommodate students in different time zones or those who were having technical difficulties.

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (*e.g.,* virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (*e.g.,* pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

Learning is a social process. However, the COVID-19 global pandemic has made communication between teachers and learners and among the learners more infrequent, inefficient, and difficult. Especially in higher education settings, we need digital tools that can foster more effective communication anyplace anytime. The pandemic has all made social interaction sparser and more limited. We need digital tools that help enhance social interaction among learners in a remote learning environment.

With this goal in mind, we suggest the following ideas collected from [redacted] faculty. First, educators can use technological platforms to increase the sense of connectedness among students. According to our faculty survey on emergency remote teaching, there are several instructional practices that can be used during synchronous virtual class sessions using web-conferencing tools such as BlueJeans and Microsoft Teams. This includes pausing often to give students a chance to make comments either verbally or through a chat tool, administering online polls and short quizzes, and utilizing virtual breakout rooms for small group discussions during the live session. Another type of approach was to use discussion forums to facilitate communication among students, teaching assistants and instructors. For example, several instructors used Piazza (an application in the Canvas learning management system) for students to ask questions and exchange ideas. Yet another approach was to make supplemental video clips to provide students with study tips, pep talks, and recommendations to help them better cope with issues related to the pandemic. A notable technology-driven case was an instructor who held classes and office hours in a 3D virtual setting. This approach required the instructor to provide students with VR devices beforehand, and thus it may not be suitable for large size classes. We note that most if not all of our current online web-conferencing teaching platforms were not designed with education foremost in mind. They were primarily built for business conferencing with education as an afterthought. There is a growing need for purpose-built synchronous online teaching platforms.

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

Based on the lessons learned from the recent emergency transition to remote delivery of courses, our research findings suggested that faculty generally looked at this situation as an opportunity for learning. The transition to remote teaching pushed instructors to experience and experiment with various technologies and modalities. We also observed that the transition process exemplified how agile and flexible instructors could be in adapting to the novel situation. As a case in point, instructors were able to record lectures on their own schedule and were able to utilize a variety of resources in their presentation such as supplemental videos and online articles. Moreover, using the online platform (e.g., web-conferencing tool), a range of virtual activities could be easily arranged with relatively minimal logistics coordination. Examples of these activities include inviting guest speakers, organizing workshops, and webinars. Additionally, instructors often noted some advantages that their students might have experienced in learning online. For example, students were granted the advantage of managing the learning pace by themselves which added flexibility to their schedule. To this point, learners also had the opportunity to view a lecture multiple times, and they could always revisit a lecture. This feature was useful particularly if they missed a specific portion of the lecture or if they lost their attention.

5. What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.,* utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

We find that some key areas of professional learning in which faculty in higher education might benefit from include engaging students in interactive learning activities as well as assessing students learning and progress with the same rigor and fairness that they would have had in an in-person class environment. According to our survey findings, the faculty respondents generally reported the lowest levels of satisfaction with the activity of assessment of student learning during the emergency remote teaching period. Also, they reported they had difficulties facilitating collaborative learning especially in discussions with online forums or chat rooms. Many instructors reported challenges in increasing interactivity between students and teacher, especially for large size classes in which students tend to be detached. These challenges were often associated with the fact that faculty were expected to handle students' increasing needs for accommodations. For example, students' participation in remote learning tended to decrease due to various technical obstacles (e.g., limited access to wi-fi) and personal challenges (e.g., lack of time management skills, living in different time zones). Moreover, it was not always feasible for instructors to continuously get spontaneous feedback from students in an online environment. Therefore, structured guidance about instructional tools and strategies to enhance interactivity and effectively assess student learning online might be beneficial.

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

Collecting some types of data is critical during COVID-19 to make further plans for the upcoming academic semesters and also to plan ahead for unforeseen potential situations. The data that could help in this regard include students' online clickstream activity (e.g., for the purpose of comparing the patterns of their activities before and after the disruption) and learning outcomes (to monitor the trends in the learning outcomes before and after the disruption and to find out the source of differences). Also, it would be beneficial to collect data on students' levels of satisfaction with learning through surveys at the beginning and the end of the course. Furthermore, surveys and interviews with instructors could also help identify challenges that instructors faced in switching to remote teaching, the level and types of adjustments they made, and the support they need to improve this experience.

9. What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

We perceive a need for more Curated Digital Libraries such as the Encyclopedia of Life which is led by the Smithsonian Institution's National Museum of Natural History (www.eol.org). The Encyclopedia of Life is an online collaborative platform which offers free access to both experts and non-experts around the world. It is intended to allow global users to document and contribute to compiling all of the living species known to science. Informed by this collaborative model, a future STEM education website could be developed in which educators and experts across the nation are invited to share their evidence-based knowledge and "field-specific" practices in higher education on a range of topics to enhance students' successful learning in a remote online teaching environment. These topics can include (1) how to modify course plans and syllabi, (2) how to adjust class activities and access alternative course materials, especially for courses that involve "hands-on" topics (e.g., studio-based, labs), (3) how to effectively engage students in online classes and foster a sense of connectedness, and (4) how to measure students' online learning outcomes and adjust grading schemes.

10. Please describe your primary audience (*e.g.,* I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.

[redacted] primarily works with various stakeholders in the higher education institution context, including students and instructors in formal undergraduate and graduate programs as well as informal lifelong education programs. In addition to serving residential students on [redacted] campus, we also work closely with [redacted] to support a wide range of adult learners who are currently taking online degree program courses at [redacted] or other professional certificate courses in various massive open online course (MOOC) platforms (e.g., edX, Coursera). We expect that the web-based STEM education resources that we suggested above will benefit our primary audience in numerous ways. Considering that the transition to remote course delivery requires a considerable amount of adjustments and efforts under time constraints, making the curated resources easily accessible through the STEM education will enable instructors to make adjustments to their course design and instructional activities in both effective and efficient manner. Subsequently, the increased ability for instructors to accommodate students' needs in online learning will help students stay on track and receive timely support for successful learning. For those existing online by design courses, such web resources are expected to provide instructors with structured guidance on the best practices in online course design. Online learners will also benefit from the information on various learning strategies to engage in online activities as well as to seek academic help from both their instructor and peer students.

23. What technologies and resources do you currently use (*e.g.,* apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

In response to the growing demands for support in remote and hybrid course delivery, [redacted] has developed a set of tools for faculty at [redacted], which can be easily integrated into and utilized in the Canvas learning management system. Among existing tools that we currently use are the [redacted] Roster in Canvas that allows for a quick overview of student activity in courses and the New Analytics tool (also in Canvas) that allows instructors to track average course grades for student submissions. Currently in the pilot experiment phase, we have also launched the Key Performance Indicator (KPI) tool in Canvas which provides a quick way to gauge student progress and collect feedback from students about their course experience on a weekly basis. This new tool can help overcome some of the limitations of existing evaluation methods by providing instructors with more fine-grained and immediate information on student progress.

[redacted]

Notice of Request for Information on STEM Education- Questions for Feedback:

Future Opportunities in STEM Education

1[redacted]ing to our [redacted] in a virtual platform, we encountered every barrier possible from limited access to broadband in our rural and urban counties, lagging broadband due to multiple devices being used during prime hours (parents and [redacted] contracts regarding behavior, learning platforms updating from adult use to kid-friendly and training for staff on the platforms. Most barriers have [redacted]nore familiar with the platforms [redacted]an [redacted] high even as schools are reopening, not all students are going in person.

3. B[redacted]o expand the reach of [redacted] has been a positive outcome from using remote learning technologies. Girls are interacting with other [redacted] not only from [redacted]ating in virtual camp events from Japan. It is opening their network beyond their troops. Another benefit is being able to put STEM experts in front of the girls in real time and giving them a chance to learn about careers and explore workspaces from the comfort of their home.

4 & 5. Our biggest challenge has been meeting the needs of exceptional children. Their neurodiversity is presenting challenges in the virtual landscape. A majority of the learning platforms are not conducive to meeting their needs if they are visually or physically impaired. Updates to technology is needed as well as training on the tool once enhanced. Another issue is getting "STEM" materials to students/girl scouts. Shipping costs along with inconsistent delivery are huge barriers. Most kids do not have what is needed to adequately participate in STEM challenges at home.

Develop STEM Education Digital Resources

9. Options for virtual field trips by grade level, NGSS standard, topic [redacted] (https://girlsleadstem.com/virtual-field-trip; The Connectory- ht[redacted]tps://theconnectory.org/ [redacted] speakers by topic (IF/THEN Ambassadors- https://www.ifthencollection.org/ [redacted]

10. We serve K-12 girls in STEM. We are always looking for ways to demonstrate how STEM is everywhere. We are up against parents who say they were bad in math and pass that on to their girls. Girls are also experience myths in real time about girls not being good in math or hearing the statistics about women in STEM and find it daunting to breakthrough the reality to find their place. See women with different backgrounds and exposing them to a variety of STEM or STEM adjacent careers would be a benefit to our organization.

[redacted]

11. https://ssec.si.edu/

Increase Diversity, Equity, and Inclusion in STEM

12. [redacted] are changi[redacted]kforce pipeline in STEM to meet the urgent need for female voices, engagement and leadership in the fastest growing sector of the U.S. economy.

[redacted]

https://ssec.si.edu/girls-and-women-in-stem

[redacted]

Build Computational Literacy

22. The [redacted] have begun to embed[redacted]ion literacy into STEM via entrepreneurship, physical science, biological science and invention/engineering ed[redacted]

https://www.iste.org/explore/Solutions/Computational-thinking-for-all

23. Apps & LMS: ZOOM, Teams, Google Meets, Facebook Live, Instagram Live
STEM websites:
https://tea.texas.gov/academics/college-career-and-military-prep/science-technology-engineering-and-mathematics-education-stem
https://www.onthefarmstem.com/
https://www.ngssphenomena.com/
https://ssec.si.edu/global-goals

Thank you for the opportunity to share my thoughts with you.

(b) (6)
[redacted]
(b) (6)

Increase Diversity, Equity, and Inclusion in STEM

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

[redacted] has two equity driven STEM properties, [redacted]. These programs have parallel goals, but serve distinct audiences. Each program's equity approach is described below.

[redacted]

<u>What the Research Shows</u>

Despite the number of women in science and engineering (S&E) occupations or with S&E degrees increasing steadily over the past two decades, a gender gap continues to persist in the United States. Women of all racial and ethnic groups, especially Hispanic and Asian women, are reflected in these increases; however, women from groups historically underrepresented in STEM continue to be significantly underrepresented in the STEM workforce[1].

Although they make up half of the U.S. college-educated workforce, women hold less than 30% of STEM jobs[1]. Women who are employed in S&E occupations are concentrated in different areas than men, with relatively low proportions in engineering, physical sciences, and computer and mathematical sciences[1]. Minority women comprise fewer than 1 in 10 employed scientists and engineers[2]. The graph below shows the comparison of women and men in STEM professions in 2015.

For the United States to remain competitive in STEM fields and to prepare our girls for the future workforce, we must close the gap. It is important to recognize that girls and boys do not display a significant difference in their abilities in mathematics and science; rather, the cause for the gender gap in STEM is social and environmental[3, 4, 5, 6, 7]. Research shows that girls start losing interest and confidence in STEM during middle school and this decline often continues as they get older[6, 8].

It is important to spark and strengthen girls' interest and confidence in STEM subjects before high school, when girls are deciding what kind of person they want to be[4, 9].

Since 2011, the [redacted] outreach program has worked with partner organizations in 35 states and the territory of Puerto Rico to build programs that inspire girls to pursue STEM studies and careers. During that time, [redacted] staff and Certified Trainers have trained over 3,600 informal and formal educators to incorporate the research-based SciGirls Strategies into their STEM programs. [redacted] videos, combined with our girl-centered, inquiry-based activities and a community-focused website, can foster girls' interest in STEM and shape their attitudes toward these fields. [redacted] welcomes girls from all experiences. We do not discriminate based on gender identity, gender expression, or sex assigned at birth. [redacted] resources, which are culturally relevant to all girls can advance gender sensitivity among educators. With this awareness, educators can recognize and avoid the unconscious behaviors that often contribute to climates unfavorable for youth in STEM classrooms or activities.

[redacted] airs nationally on PBS, the most trusted media brand for children. The backbone of each SciGirls episode is the science, technology, engineering, and math (STEM) that drive each project. Every experiment may not turn out perfectly, but each episode showcases important characteristics of a STEM project: teamwork, challenges, problem solving, freedom to express ideas, and support from a mentor. The [redacted] also model important practices like brainstorming, questioning, predicting, observing, measuring, classifying, investigating, recording, interpreting, graphing, and communicating. These practices are at the heart of the scientific and engineering design processes.

Research suggests that developing a STEM identity is an important factor in girls choosing to participate in STEM courses, activities, and potentially careers. STEM identity refers to a person's sense of who they are, want to be, and what they believe they are capable of in relation to STEM. Girls' STEM identity development is dependent upon factors like interest, knowledge, self-confidence, performance, and recognition[10, 11, 12, 13, 14, 32].

[redacted] are designed to instill confidence and persistence, and to motivate girls to develop a STEM identity during a crucial time in their academic and personal growth. The middle school years are when girls are deciding "what kind of girl to be" and figuring out desired versions of their future selves [4, 9]. This is when educators can help girls overcome barriers and push against stereotypical views to develop strong STEM identities. The identities girls develop are shaped by how they see themselves and how others see them in multiple spaces including in-school and out-of-school, social, and home/family [9, 15, 16, 17, 18, 19] across intersecting cultural characteristics including gender, race, ethnicity, and class[20], and in relationship to concepts of femininity that are congruent with ideas of warmth, sensitivity, cooperation, and the need for belonging[4, 5]. When a girl sees STEM as something that represents her interests, she has confidence in her abilities, and can embrace and celebrate the differences which make her competitive in STEM[8, 9, 21, 22].

Framework for the [redacted]

In addition to the [redacted] themselves, research and practice highlight the need for educators to consider the learning environment and to utilize culturally responsive practices to engage and effectively serve all girls in STEM, especially girls of color and girls from marginalized communities. Both the learning environment and culturally responsive practices are important in helping foster a STEM identity.

Create a STEM for ALL learning environment

For the [redacted] to be as effective as possible, it is critical to provide a supportive space and learning environment that fosters mutual respect, looks and feels inviting, and allows girls to feel that they belong23, 24. Research shows that a learning environment that is comfortable, personally meaningful, collegial, and supportive can positively impact girls' interest and motivation in STEM and positively influence girls' STEM identities[15, 22, 25]. The learning environment must also be culturally responsive, one that recognizes, reflects, and validates the history, cultures, and world-views of youth. In such an environment, diversity is valued as an asset, which leads to effective teaching and learning.

Tips to create a STEM for ALL learning environment

- Create a warm and welcoming space that is accessible to all and fosters cooperation and acceptance. Create an organized space where everyone can move easily and safely and work in a collaborative way.
- Learn about your youths' needs. The tools to make the environment accessible and welcoming vary depending on individuals' needs (vision or hearing impairments, sensitivity to light, etc).
- Practice and encourage active listening. Active listening includes orienting your body to the speaker, maintaining eye contact, nodding your head, using facial expressions (e.g., smile, frown) and verbal cues (e.g., "That is interesting").

- Create an atmosphere of mutual respect. Shared expectations help develop a sense of community and encourage positive interactions.
- Use icebreakers so youth can introduce themselves in a non-threatening manner. This activity allows your youth to relate to each other and share and appreciate differences among them.
- Provide opportunities for youth to voice their opinions and feel accepted. Encourage active participation by all youth and structure tasks that have multiple paths to a solution.
- Form meaningful connections with youth. Take some time to view everyone as an individual—encourage them to share their own lives and interests—and show them that you believe in their abilities.

Adopt Culturally Responsive Practices

Embrace diversity

The population of the United States is becoming increasingly diverse and this diversity is reflected in our K-12 schools. By 2044, half of all Americans are projected to belong to a minority group resulting in a significantly more ethnically and culturally diverse population. For example, one in four female students in public schools across the nation is Latina; by 2060 that number will increase to one in three[26]. Therefore, the youth you work with may differ from you and each other in ethnicity, race, language, and socio-economic background. To truly engage diverse youth in STEM, it is critical to reach out to them in ways that are culturally responsive and appropriate. Culturally responsive practices (CRP) support student achievement by providing effective teaching and learning in a culturally supported environment that is student-centered. In these environments, educators identify, nurture, and use the strengths that students bring to the learning space to facilitate and promote student achievement[27]. Geneva Gay, a professor in multicultural education, describes CRP as teaching to and through the strengths of students who are culturally, ethnically, and linguistically diverse. She defines culturally responsive teaching (CRT) as a process of using cultural knowledge, prior experiences, and performance styles of diverse students to make learning more appropriate and effective for students[28]. CRP empowers youth by respecting and incorporating their interests, identities, cultures, backgrounds, and experiences as central to the learning process[24, 29, 30]. Culturally responsive practices are particularly effective in motivating and engaging girls of color in STEM studies and careers as they recognize girls' culture as an important strength upon which to construct the STEM learning experience[31,32].

Getting started on your journey to cultural responsiveness

A culturally responsive educator is someone with the knowledge, attitudes, and skills to work effectively with and successfully engage youth from different cultures. Cultural responsiveness is a sensibility that we acquire throughout our life. Here are a few tips on how to become more culturally responsive.

- Understand your own culture and how it affects others. Engage in self-reflection regarding how your values, attitudes, experiences, and social context shapes your instruction and how it might be improved.
- Get to know your youth and build on their life experiences. Provide opportunities for youth to share their interests and personal experiences and connect them to STEM.
- Demonstrate caring. Develop meaningful relationships with youth by engaging them personally and getting to know what they like and value.
- Communicate high expectations for behavior and performance. Communicate clear and specific expectations, and let youth know that you believe in their capabilities. This can increase their confidence and their motivation to tackle challenging problems.

- Provide opportunities to belong. Foster a sense of belonging with youth by listening to their ideas and letting them make real-world connections to the activities they participate in.
- Embrace participants' home language. Validate youth's bilingual abilities to leverage learning and make youth feel welcome and accepted.

Go to the [redacted] website and watch the [redacted] for more information about culturally responsive teaching and becoming a culturally responsive educator.

The [redacted]: Proven Strategies for Engaging Girls in STEM
The [redacted] approach is rooted in research about how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and they have become the framework for [redacted]. The original set of strategies, created in 2010, were updated in 2019 to reflect current research.

1. Connect STEM experiences to girls' lives. (Boucher et al., 2017; Sammet et al., 2016; Bonner & Dornerich, 2016; Erete et al., 2016; Stewart-Gardiner et al., 2013; Civil, 2016; Verdin et al., 2016; Cervantes-Soon, 2016).
    - Make STEM real and meaningful by engaging girls in activities that draw on their interests, knowledge, skills, culture, and lived experiences. This helps girls develop a STEM identity and increases their sense of belonging in STEM.
2. Support girls as they investigate questions and solve problems using STEM practices. (Buckholz et al., 2014; Kim, 2016; Scott & White, 2013; Farland-Smith, 2016; Munley & Rossiter, 2013; Civil, 2016; Riedinger et al., 2016)
    - Engage girls in hands-on, inquiry-based STEM experiences that incorporate practices used by STEM professionals. Let girls take ownership of their own STEM learning and engage in meaningful STEM work to positively impact their identities and re-define how they see STEM.
3. Empower girls to embrace struggle, overcome challenges, and increase self-confidence in STEM. (Blackwell et al., 2007; Dweck, 2000; Halpern et al., 2007; Kim et al., 2007; Mueller & Dweck, 1998)
    - Help girls focus on and value the process of learning by supporting their strategies for problem solving and letting them know their skills can improve through practice. Support girls to develop a growth mindset—the belief that intelligence can develop with effort and learning.
4. Encourage girls to identify and challenge STEM stereotypes. (Allen et al., 2017; Carli et al., 2016; Cheryan et al, 2015; Robnett, 2016; Allen et al., 2017; Carlone et al., 2015; Sammet et al., 2016, Scott et al., 2014; Tan et al., 2013; Dasgupta et al., 2014; Verdin et al., 2016; Civil, 2016; Boucher et al., 2017)
    - Support girls in pushing against existing stereotypes and the need to conform to gender roles. Helping girls make connections between their unique cultural and social backgrounds and STEM disciplines will negate potential stereotype barriers.
5. Emphasize that STEM is collaborative, social, and community-oriented. (Capobianco et al., 2015; Diekman et al., 2015; Leaper, 2015; Riedinger et al., 2016; Robnett, 2013; Parker & Rennie, 2002; Scantlebury & Baker, 2007; Werner & Denner, 2009; Cakir et al., 2017; Sammet et al., 2016; Boucher et al., 2017; Clark et al., 2016; Leaper, 2015)

    - Highlight the social nature of STEM to increase interest and motivation and change the stereotypical perception that STEM jobs require people to work alone. Girls benefit from a supportive environment that offers opportunities to build relationships and form a collective identity.
6. Provide opportunities for girls to interact with and learn from diverse STEM role models. (Koch et al., 2015; Leaper, 2015; Adams et al., 2014; Jethwani et al., 2017; Kessels, 2014; O'Brien et al., 2016; Levine et al., 2015; Hughes et al., 2013; Cheryan et al., 2015; Weisgram & Diekman, 2017)
    - Introduce girls to diverse women role models from varied STEM career pathways to help girls see potential futures and develop resilient STEM identities. Positive role models can increase girls' interests in, positive attitudes toward, and identification with STEM

Footnotes

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[redacted]*: The Power of Science, Literacy, and Media For Young Learners*
[redacted] is an expansive educational media initiative focused on improving school readiness in science and literacy for children grades K-2 nationwide, with an emphasis on Latino communities, English Language Learners, youth with disabilities, and children from low-income households. [redacted] transmedia universe integrates science and literacy to ignite children's natural curiosity and broaden their understanding of how the world works and empower them to make a positive difference in their communities. All materials are aligned with the Next Generation Science Standards.

The [redacted] education program centers on an innovative learning platform featuring thematic "playlists" or collections of educational media assets with embedded learning analytics. Each playlist features: animated [redacted] television episode; digital or analog game; non-fiction e-books; hands-on science activities; [redacted] (where kids reflect and create their own content); educator support materials; and child enrichment resources for parents/caregivers.

The [redacted] follows Sparks' Crew, a team of super students with imperfect powers who are learning to harness the Superpowers of Science to solve problems, help people, and make the world a better place.

The [redacted] digital program transforms learning and helps all children succeed in school with more than 25 playlists organized by standards-based science themes. State-of-the-art embedded learning analytics measure student's progress.

All [redacted] Informal Education Partners have free access to video, online and print materials, combined with educator training, which aims to narrow the achievement gap between kids from low-income backgrounds and their peers. Our professional development workshops prepare out-of-school-time educators through in-person and digital training, encouraging them to tailor programming to suit the youth in their communities.

These educational materials were created using three frameworks to guide development of equity-centered media-rich experiences for all learners. These frameworks are shared below.

[redacted]: Effective Strategies for Engaging All Young Learners in Science

The goal of the [redacted] project is to achieve equity in science education and school readiness for children in grades K-2 across the nation. Our educational approach is based on research on effective teaching strategies to reach all learners in science. This work is based on research- and standards-based classroom strategies recommended in *NGSS For All Students*, published by NSTA Press, edited by Okhee Lee, Emily Miller, and Rita Januszyk, with featured case studies developed for the Next Generation Science Standards by Achieve.

1. Connect science to children's "sense of place"—the physical, historical and socio-cultural aspects of their local community.

Early science learning helps children understand the world around them. In the primary years, this is best accomplished when children engage in their immediate surroundings and investigate everyday natural phenomena. Providing opportunities for developmentally appropriate exploration of their surroundings helps children understand how things work and offers an important foundation for future science learning.

2. Empower children to be doers of science by connecting to the cultural knowledge and experiences of their families and communities.

Children come from different cultural and linguistic backgrounds and have a rich knowledge of their cultural and linguistic practices. When children are given opportunities to leverage these practices in developing scientific knowledge and practice, they engage in scientific reasoning. Provide opportunities to incorporate children's cultural and linguistic experiences into science learning.

3. Engage children's curiosity through real-world, hands-on experiences.

Science learning for young children need to be concrete and tangible. When engaging with scientific content, children learn better through physical interactions with the concepts. Providing hands-on experiences in realistic contexts supports children's understanding and expands their knowledge of a scientific idea by applying it in their lives. Real-world science is creative and fun!

4. Provide flexible learning experiences with multiple representations to engage all children.

All children learn differently from one another. Provide different means of interaction for students to understand the content. Include resources such as science related literature, hands-on activities, realia (real objects or events), Venn diagrams, and concept maps. Depending on children's background knowledge, provide resources to bridge their understanding of new ideas. For example, provide vocabulary support for English learners and adaptive materials for children with learning differences.

5. Facilitate discussion and reflection about science experiences.

Encourage children to develop science language and terms. Set high expectations for them about the importance and value of science knowledge. Offer opportunities for children to practice science language to describe, explain, and predict science phenomena.

6. Support science learning by connecting to home and community partnerships.

Partner with home and community resources in meaningful ways. Have families participate in classroom events. Include role models from students' communities, especially those who use STEM in everyday life. Engage community knowledge and resources to support children's science learning.

Fair Play: Creating Accessible Educational Media For All Learners

[redacted] educational designers created an inclusion framework to guide the production of all project digital and analog resources. Drawn from best practices specified in Universal Design for Learning (UDL) framework (CAST, 2011), computer assisted instruction (CAI), and research in science education, the framework features approaches for creating resources that are both welcoming and accessible to students with disabilities. The design features of [redacted] resources are specifically targeted to allow students with disabilities to access NGSS content on their own, and to allow teachers to adapt activities to provide students better access to the content.

1. Making project welcoming and accessible to individuals with disabilities.

Examples from the project include: creating a lead character on the Autism spectrum; representing kids with disabilities in live-action shorts; and hosting low-sensory events for children and helping other organizations do the same.

2. Designing products and resources that are accessible.

The Project accomplished this using: Universal Design for Learning; production checklists for team review; and expert review of products.

3. Developing collaborations with partners who are experts in the inclusion space.

Examples include: The Simon Technology Center at Pacer Center; Hope Haven; and the University of Central Florida's Department of Child, Family, and Community Sciences Exceptional Education and Florida Interactive Entertainment Academy programs.

4. Advancing accessibility in educational media through research and dissemination.

The project conducted research studies including a needs assessment and a case study and presenting at national conferences.

[redacted]

A final framework provides a set of guiding principles that integrate various understandings into one comprehensive framework that informs media and program development. The [redacted] was developed to apply theoretical and empirical understandings to creating multimedia programming, materials, professional development and outreach programs that promote early literacy and STEM learning, equity and diversity in STEM, and provide an integrated equity-centered approach to transmedia programming. The guiding principles that underlie this framework were derived from a synthesis of literature focused on identity development, equity and diversity in STEM education, culturally responsive teaching, science and engineering practices for early learners, early literacy and English language learning, and the Next Generation Science Standards (NGSS) for early STEM learners. This framework integrates various theoretical perspectives to inform transmedia content development, which includes digital, text-based, multimedia, and real-life spaces and experiences in ways that offers young STEM learners opportunities to engage, explore, play, investigate, collaborate, and make meanings that are personally, culturally, and communally meaningful (Herr-Stephenson et al., 2013). The principles of this framework support content developers in providing multimedia learning experiences that promote equity and early engagement in STEM for diverse learners. The framework is designed to be *transformative*, meaning that the approach to STEM transmedia learning fosters a shift in educators' perspectives from a deficit-based approach to an asset-based approach to STEM learning for diverse students. This shift is internal and lasting, which leads to the transformation of how educators perceive diverse children and subsequently how they approach their work. Further, this shift in perception leads to changes in how STEM education is conceptualized and approached, which will lead to positive learning outcomes for historically marginalized students (Ellington, 2019).

1. Addressing the intersectionality of racial, class, cultural, and STEM identities for young learners and dispelling negative stereotypes;

Numerous scholars who study Black and Latinx students in STEM have used the concept of identity to gain insight into its role in positive student outcomes (Kane, 2012; Martin, 2012; McGee, 2015; Cook, 2014; Wilson, 2016). Although there are many definitions and conceptions of identity (Abrams & Hogg, 1988; Jenkins, 1996; Oyserman, Elmore & Smith, 2012; Oyserman, 2007), identity is broadly conceptualized as one's answer to the statement "who am I?" or the ways in which individuals and groups define themselves, are defined by and relate to others (Abrams, 1994; Hogg & Abrams, 1988; Deng, 1995; Oyserman, 2007; 2008). As stated by Oyserman, Elmore & Smith (2012) "One's sense of self (his or her identity) influences what he or she is motivated to do, how one thinks and makes sense of oneself and others, the actions they take, and their feelings and ability to control or regulate themselves." (p 74). As a result, students possess different types of identities (e.g., social, racial, gender, religious, academic), and they negotiate these different identities within different contexts. Researchers suggest that learner's identities are enacted and shaped by their participation in socially situated practices such as STEM education (McGee, 2015). Hence, central to Latinx and Black students' persistence and success in STEM is an understanding of the types of socially situated STEM practices (community, school-based, classroom) that foster the kinds of identities that will promote their success and persistence and develop STEM programs that help Black and Latinx students identify as competent learners and doers of STEM.

Given that identity is critical to one's interest, engagement and academic choices, our framework is centered on the idea that our work will encourage young Black and Latinx children to develop positive STEM identities that are grounded in positive racial and cultural identities. This means that all the materials and programs created from this project will encourage and highlight how who they are, as Latinx and Black children, and align with what it means to be viable and productive STEM learners. All of the work that we do integrates these students' interests, values, beliefs and ways of knowing and how to see themselves as STEM innovators. The fundamental message that our STEM practices should reiterate to Latinx and Black students is "We are competent and confident lifelong STEM learners, doers and community members. We contribute to our communities through our STEM learning. It is who we are, and we belong here."

2. Grounding "real world" STEM experiences in the lived realities of diverse learners;

Research on STEM education illuminates the importance of grounding STEM learning in "real world" contexts (Hoachlander & Yanofsky, 2011). Scholars argue that to make STEM relevant to students, learning experiences must promote engagement and foster positive educational outcomes. STEM learning must be grounded in real-life experiences and be presented in ways that show how science can be used to solve real-world problems (Gay, 2002; Ladson-Billings, 1995; Torp & Sage, 2002; Villegas & Lucas, 2002). These real-life experiences connect to the NGSS Science and Engineering Practices of:

- developing and using models,
- asking questions and defining problems,
- planning and carrying out investigations, through the use of inquiry and discovery-based curricula and instructional practices, and
- collecting, organizing, representing and interpreting data (Gay, 2002; Kolb, 1984).

These practices, scholars argue, make science and related disciplines "authentic" and allow students to use their scientific knowledge and understandings in ways that reflect the actual work of scientists and engineers. One of the guiding principles of our framework is to ensure that STEM experiences, used in our programs and products, focus on making sure that STEM learners see how STEM is used in their daily lives and reflect authentic STEM learning. To this end, one of the critical principles shaping this framework is not only making sure that STEM experiences are informed by "real world" STEM, but also reflect the lived realities of diverse learners.

3. Recognizing and integrating social and cultural assets in STEM learning experiences;

A growing body of literature highlights the role of social-cultural capital in students' success and persistence in STEM-related fields (Cegile & Settlage, 2014). For the past five decades, the social and cultural capital literature has been used to understand students' ability to succeed and effectively navigate schooling (Thirutnurthy, Kirylo, & Ciabattari, 2010) specifically STEM education (Cegile & Settlage, 2014; Stolle-McAllister, 2011). Unfortunately, the discourse in this area has focused on the "lack" of social and cultural capital that Blacks and Latinxs have given the "negative plight" of these communities (Gándara & Contreras, 2009; Sattin-Bajaj, 2011). The social and cultural capital discourse is generally framed in ways that forward a deficit orientation of Latinx and Black students and their communities. However, there is a growing body of scholarship in STEM that is focusing on an asset-based view of Black students' community and social resources; this literature highlights ways to empower Black students in STEM by understanding the myriad of parental, community and personal resources that they bring to their STEM learning and illuminating how we can draw on these resources to improve educational outcomes for Black students (Ellington, 2016; Ellington & Fredrick, 2010; Harper, 2010; Stinson, 2006). Similarly, the deficit-view discourse of Latinx students can be counteracted by emphasizing the cultural, linguistic, cognitive, social and emotional assets Latinx students bring to the classroom (Garcia & Ozturk, 2018). This assets-based view of social capital asserts that children from all backgrounds are natural learners and doers of STEM; not only can their STEM learning be informed by their community's assets, but they can also give back to their communities through their STEM learning.

4. Integrating equity within Science and Engineering practices;

One of the central ideas embedded in the notion of "equity" is that all students have equitable opportunities to learn STEM, receive high-quality STEM instruction, and are expected to achieve and persist no matter what their race, gender or cultural background is (Gay, 2010). The practices required in science and engineering have been hailed as a key way to ensure that STEM learning is equitable. All learners can engage in these practices since science and engineering are not "culturally specific," and that all students use these practices in their daily lives and their various communities. By emphasizing the Science and Engineering Practices, [redacted] can support an expanded focus on the contributions of all cultures to the development of innovations and dismantle the idea that only Western cultures have contributed to STEM advances. Also, what counts as science can be expanded, hence shifting our content focus to be more inclusive of students who have traditionally been marginalized in the science classroom and who may not see science as being relevant to their lives or future. By solving problems through Science and Engineering Practices in local contexts, students gain knowledge of science content, view science as relevant to their lives and future, and engage in science in socially relevant and transformative ways (Rodriguez & Berryman, 2002; Torp & Sage, 2002; Lee, Miller, & Januszyk, 2015). Focusing on specific Science and Engineering Practices offers opportunities for “innovation” and “creativity,” and can be viewed as relevant to the lives of diverse learners.

Building on this idea, our framework is grounded on the principle that equity is not separate from science and engineering practices, in fact, they are integrated ideas. Traditional notions of equity have assumed that to achieve equity, Black and Latinx students needed some "special considerations" to address the historical inequities that have plagued these groups. By focusing on the practices of science and engineering through an equity lens, our project team looked for natural intersections of these practices to Latinx and Black students’ ways of knowing (Kelley & Knowles, 2016), norms and values, social and cultural experiences, and who they are. Further, this principle is guided by the questions: What does it mean to be a Latinx or Black student who engages in Science and Engineering Practices? What are the ways of doing science and engineering that are "natural" to the way I live my life and solving problems? The answers to these questions drive our work, sending the message that Black and Latinx children do not need to be "special" to engage in STEM nor do they have to disconnect from their communities and values to engage in STEM pursuits. The Science and Engineering Practices and STEM content are inherent in who they are and how they live their lives and are highlighted in all that we do. We thus ensure that this message is received by all young people who engage with [redacted], their families and their communities.

5. Understanding STEM as literacy;

The literature on early literacy and English Language Learning, and the *Ready to Learn* program, all espouse the notion that “school readiness” is essential to school success and that all students should be exposed to early learning and literacy experiences that will prepare them to be successful in formal school contexts (Zollman, 2012). Scholars in these areas have emphasized that literacy, English language proficiency, and overall success in formal education requires a focus on how literacy is embedded in the lives of young learners and supporting them in making the connection between their informal language experiences and more formal ways of expressing themselves. Besides, scholarship in these areas asserts that various forms of media content can be utilized to improve young children's cognitive, social, emotional, literacy and numeracy skills in ways that foster an early interest in learning and ensure that they are "ready to learn."

Recently, a focus on how STEM learning can be used to foster early literacy and English language proficiency has given rise to initiatives such as Science, Technology, Engineering, Arts and Mathematics

(STEAM), interdisciplinary education, reading across the curriculum, and whole language integration in STEM curricula and instruction (Zollman, 2012; Patrick, Mantzicopoulos & Samarapungavan, 2009; Mantzicopoulos, Patrick & Samarapungavan, 2013; Mantzicopoulos & Patrick, 2011). This expanded focus on STEM as a way to support young children in being ready to learn has provided an expanded view on the role of STEM as a context for literacy, English Language Learning, and helping all children be prepared for future learning. Hence, the teaching of STEM and the learning of English and literacy (reading, writing, and counting) are not separate endeavors but are innately interconnected.

One of the fundamental principles of this project is to promote the idea that to be an engaged STEM learner not only requires literacy, but is a form of literacy. This notion moves us from the idea that literacy must be "integrated" in STEM experiences to one that espouses that STEM is a form of literacy. To learn STEM is to be literate and Latinx and Black students are inherently doers of STEM; hence they are naturally competent literary agents. We believe that one cannot live life without STEM since life itself is STEM, and all students can naturally express themselves through their own lived realities, STEM can be viewed as a form of literacy that will support young children in being fully literate and ready to learn. We will focus on how young children naturally express themselves, how these expressions relate STEM learning and how they can express their emerging understandings of their world (STEM) in literary avenues such as speaking and writing. For English language learners, this is particularly important because their informal expressions are in another language and this language misalignment has sometimes been viewed as a cognitive issue (Martiniello, 2008; Nora, 2013); at the same time, evidence shows that supporting students' development in both their home language and English actually enhances and supports cognitive development (Martiniello, 2008; National Academies of Sciences, Engineering, and Medicine, 2017). We know that students who are learning English have ways of expression that may not be valued in traditional school settings; hence, this framework acknowledges how these students can and do express their lived experiences and do not view their language difference as a barrier. We aim to support learners in expanding their capacity to express their STEM experiences through enhanced language development.
The message that we wish to send is that STEM is a form of literacy and STEM is fundamental to every student's lived realities. Hence, all students are literate and ready to learn, and we provide ways for them to interpret their social, cultural and personal experiences in ways that reflect STEM understandings. STEM literacy is as natural as their expressions, and we support early learners in translating these expressions in various literary forms.

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This RFI is seeking input on strategic partnerships, transdisciplinary learning, digital STEM resources, computational literacy, use of the Federal STEM Education Strategic Plan, and more.

I know that you and your members offer incredible expertise in these areas and OSTP would welcome your perspective. The STEM RFI was created in coordination and alignment with the Federal STEM Education Strategic Plan, released December 2018. Respondents can provide comments for any questions they wish, but do not need to respond to all questions.

Future Opportunities in STEM Education

1. What COVID-19 related digital barriers (*e.g.,* access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?
    a. Lack of one-to-one devices for students, as well as internet connection. Currently these issues are partially-resolved. We dismantled all laptop/iPad carts in the school buildings to give to students learning remotely. This caused a new problem since that now that some students returned, we do not have the technology in the classrooms for them now.

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (e.g., virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (e.g., pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.
    a. We need to see more high quality, standards-aligned simulations to teach concepts that are normally taught hands-on, in a group environment (i.e., Gizmos for Science). This is needed for multiple courses.

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

a. Remote clubs can provide equity and access to students. Students who normally wouldn’t have transportation to stay after school (or that lived in an underserved area) could still participate virtually. The Federal Government could support with devices, materials, funding, incentives, credit for participation, etc.
b. Greater access to professionals in the field through Zoom calls since this method of communication is more widely accepted now.

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?
   a. Not all students have the support at home, same access to materials and resources, devices, etc. A significant gap is we cannot do the same types of learning experiences remotely as we can face-to-face.

5. What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?
   a. Classroom management skills, especially in a shared synchronous environment (teacher teaching remote and face-to-face students simultaneously).
   b. Assessment strategies, student collaboration strategies
   c. Models of success, promising practices

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

7. What experience does your school system have with interoperable learning records or precision learning systems? If used, please share any barriers, solutions, or other information relevant to their effectiveness particularly related to digital barriers and the impact or effectiveness related to distance education. How were these concepts used or modified in response to COVID?

8. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

   a. We created opportunities for teachers (job alikes) to network and share materials virtually.

b. We created model lessons and model resources.
c. We provided teachers a voice to address real time issues and concerns to try and troubleshoot.
d. We provided limited materials when needed (document cameras, tables for outdoor learning, etc.).
e. Barriers:
    a. Lack of funding to provide resource kits to all learners.
    b. Lack of supervision (at home, of students)

Develop STEM Education Digital Resources

9. What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

a. Interactive problem solving (give students a scenario, allow them to brainstorm/build solution virtually, then be able to test it)
b. College and career resources that are engaging for students (career spotlights, having a person talking about their job and how they got there).
c. Career pathways (how do you get to this job? What do you need to learn?)
d. Standards-based database of STEM infused learning opportunities for teachers to get ideas for a particular lesson.
e. Database to connect/network with STEM professionals (a lot of organizations have their own separate sites which is time consuming to search for).
f. Models of practice (what are successful STEM models that schools are using? Spotlight on schools, practices, etc.).
g. Database of quality, FREE resources that have been vetted for engagement and alignment to standards.
h. Grant opportunities
i. Calendar of events by geographic region of STEM opportunities (i.e., Atlanta Science Festival, Lockheed STEM Teacher Workshop, etc.)

10. Please describe your primary audience (e.g., I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience

a. We support K-12 schools and campuses, all levels and courses. We primarily work with admin and teachers to support STEM learning. All of the resources listed above would support the teachers in providing high quality STEM infused learning to their students. It would help support them by removing barriers (time, lack of resources, etc.) that sometimes prevent them from providing these opportunities to their students.

11. How would you like to see resources categorized (e.g., subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.

a. The NGSS website is set up well. https://www.nextgenscience.org/

Increase Diversity, Equity, and Inclusion in STEM

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

b. We have a focus on underrepresented populations in STEM, to provide awareness and access. We focus specifically on Women in STEM.
c. We collect a large number of metrics to determine how our programs are impacting the young women we are supporting, such as: career awareness, number served, satisfaction, likelihood to continue in a STEM pathway, longitudinal data.
d. Provide infrastructure to support and encourage young women to consider STEM.

Engage Students Where Disciplines Converge

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

Please see our [redacted] for our certification practices. These have been modeled after the Georgia DOE STEM Certification and Cognia STEM Certification. Transdisciplinary learning is the gold standard with which we are trying to get schools to offer STEM infused learning for students.

14. How has your ability to teach transdisciplinary concepts to your students changed in recent months because of the shift to remote teaching and learning? What teaching modalities have you employed to deliver transdisciplinary instruction virtually?

15. What training have you/your organization received in any of these approaches for teaching STEM education: transdisciplinary, integrated, convergence, or engineering design, etc.? Please describe the training, if any (including university coursework or professional development), that helped you/your organization prepare to teach STEM using an integrated or transdisciplinary approach. Why was that specific training helpful, and if not, what could be done differently?

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way? What specific delivery mechanism work well for you (e.g., online course, webinar, in-person workshop)? What technology tools would be helpful for you when using a transdisciplinary approach?

17. If you are a student, what specific delivery mechanism works well for you (e.g., online course, webinar, in-person workshop)? What technology tools would be helpful for you to enhance your learning and engagement to deliver transdisciplinary education to your students?

Develop and Enrich Strategic Partnerships

18. What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

a. The private sector can provide relevancy to what the students are learning: a problem for them to solve, a career connection, etc. They also help us identify tools and resources that students can start using that prepare them for real-world work. They can provide teacher professional development through teacher externships. They can improve communication to stakeholders.

b. We’re promoting opportunities to connect with STEM professionals and encouraging students to maintain/expand their partnerships with STEM professionals to close gaps in access to resources/materials.

Build Computational Literacy

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.

22. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.

23. What technologies and resources do you currently use (e.g., apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

Community Use and Implementation of the Federal Stem Education Strategic Plan

24. Please describe how your organization has used the Federal STEM Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?

[redacted]

STEM RFI Response

Notice of Request for Information on STEM Education

A Notice by the National Science Foundation on 09/04/2020

Based in [redacted], [redacted] that is the recipient of a US Department of Homeland Security grant to develop and freely distribute STEM, Cyber, and Cybersecurity curriculum to teachers across the country. [redacted] empowers educators to teach cyber confidently, resulting in students with the skills and passion needed to succeed in the cyber workforce.

This response includes information on the following four questions:

- Future Opportunities in STEM Education, question 5
- Increase Diversity, Equity, and Inclusion in STEM, question 12
- Develop and Enrich Strategic Partnerships, question 19
- Build Computational Literacy, question 22

Organizational Information:

[redacted]

[redacted]

Future Opportunities in STEM Education

5. What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

[redacted] provides curriculum and professional development to US and DOD teachers of grades K-12. Our in-person professional development model has a proven record, with previous external evaluations demonstrating its strong effectiveness at raising teacher confidence in STEM pedagogical practices. However, in response to the COVID-19 pandemic, [redacted] converted its workshops to a virtual format for the summer, training 1202 teachers from 42 different states. Evaluation of the summer virtual workshops showed that they were just as effective as previous in-person workshops at raising teacher confidence. In part, this success was due to [redacted] intentionality around using online learning platforms effectively and showcasing their versatility. As teachers planned for the upcoming school year, their major takeaways from the online PD included a variety of remote learning strategies, in addition to the content knowledge that they gained. Some of these strategies and tools included:

- Instructor demonstrations of technical skills through the use of screen sharing and document cameras
- Hands-on engagement within the virtual setting, e.g., including using Zoom breakout rooms for troubleshooting individual issues
- Collaboration tools like Google Docs and Jamboard (https://jamboard.google.com/)
- Recorded sessions so that teachers could go back and watch the workshops at their own pace
- Careful planning of PD schedules, with multiple short sessions and adequate break time, to ensure that teachers do not become burned out by their time online

We believe these represent emerging best practices for teacher engagement in online professional development. Previous studies have shown that teacher professional learning is most effective when it is tailored to teachers' specific subject areas. Therefore, we aim to demonstrate specific pedagogical practices (e.g., small-group collaboration, authentic assessment, project-based learning) through our content-specific PD workshops so that teachers can then implement these strategies in both physical and virtual classrooms.

Since the school year began, we have consulted with teachers nationwide to adapt their courses for virtual instruction. We have specifically provided guidance about adapting hands-on science, engineering, and robotics courses for a remote or asynchronous format. Where possible, these adaptations have included the following: using virtual simulations of robotics, coding, and cybersecurity platforms; rotating supplies among different students to ensure maximum use; reorganizing the scope and sequence to help students meet course objectives while allowing for maximum flexibility about learning platforms.

[redacted]

Increase Diversity, Equity, and Inclusion in STEM

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

To ensure equitable access for all learners, we must focus on how STEM resources are being integrated into the classroom. If a high school STEM course is only available as an elective, that narrows the pool of students who can take that course. In this scenario, only students who have open slots on their schedules can take advantage of this elective. We see that students who are more advanced being the ones who can test-out of certain courses, thus providing an open class schedule. This ideology begs the question, should STEM electives be available to only academically advanced students?

STEM, though a combination of Science, Technology, Engineering, and Mathematics, is really about introducing students to a way of thinking. As a model, STEM education is designed to engage students in hands-on, application-based learning where he/she can walk through an iterative process to apply the concepts learned within a classroom. By focusing on the integration of a hands-on, application-based learning environment into the science, math, and English classroom, we have an opportunity to impact and influence all students within a school. We encourage educators to think about it in this way – Should 21st-century jobs, 21st-century degrees, or even 21st-century skills be available to students as just an elective course? When phrased like that, the answer is an emphatic "no." Our responsibility as educators – no matter which subject area, is to ensure students have the foundation skills to be productive citizens within our country's society and economy.

We must ensure that STEM classrooms are utilizing curricula resources that are purposefully designed with relevant, real-world applications of content. These connections will allow students to retain the knowledge being presented to them. Unfortunately, our research has shown that this happens best when the communities that support the schools are cyber "literate." The absence of these regional cyber resources leads to areas that have been coined , "cybersecurity deserts," of which there are many across the county. This term refers to a region's lack of cybersecurity knowledge, jobs, or academic programs. In areas that might qualify as cybersecurity deserts, curricula resources with purposeful STEM applications become even more important as teachers typically do not have the ability to bring resources such as visiting speakers or practical technological applications into the classroom.

Develop and Enrich Strategic Partnerships

[redacted]

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

[redacted] engages in a variety of STEM ecosystem models with several partners from around the country. This section will discuss current ecosystem models that can be observed in northwest Louisiana and North Dakota.

In 2008, the [redacted], through funding from NASA and NSF and in partnership with Louisiana Tech University, began to develop a program that would support K-12 education in the region of north Louisiana across the I-20 corridor. Since that time, the public-private partnership that has evolved out of that project has become the national model for cyber education and has impacted more than 22,000 teachers and 3 million students across the country.

The key component to the I-20 partnership has been the opportunity for K-12 educators to collaborate shoulder-to-shoulder with college and university faculty. These relationships helped to develop a number of projects including STEM and cyber-focused student camp models, elementary, middle school, and high school curriculum resources, and a teacher professional development model that employs a flipped environment. Since 2011, [redacted] has been delivering professional development to teachers across the country in this flipped environment. This opportunity allows teachers to view new curriculum from their students' perspective, allowing them to experience the same first-time mistakes that their students may make in the classroom. It also allows the instructional leaders to model some of the classroom management tools that have worked for them in the classroom.

In 2016, a partnership that included [redacted], NDIT-EduTECH, and Palo Alto Networks formed to begin transforming the model of K-12 education across the state of North Dakota. This partnership had the vision to not only align educational models in primary and secondary education across the state but would also align those priorities with their post-secondary and industry partners. This vertical alignment from kindergarten through career would eventually become the first K-20W pathway in the country.

In addition to developing this kindergarten through college and workforce pathway (K-20W), the partnership collaborated on the development of the North Dakota Computer Science and Cybersecurity Standards for kindergarten through 12th grade (https://www.nd.gov/dpi/sites/www/files/documents/Academic%20Support/CSCS2019.pdf). With the support of the State Superintendent and the Department of Public Instruction, this project brought together K-12 educators with college and university faculty to identify a series of cross-cutting standards that would allow any teacher to impact a students' day with computer science and cybersecurity content information.

[redacted]

Emerging research shows that students, teachers, and schools benefit from a robust community cyber ecosystem with government, industry, and educational partners working synergistically. A 2020 research report from the EdWeek Research Center [redacted] shows that levels of cybersecurity education knowledge are higher among educators in communities that have cybersecurity resources, such as cybersecurity companies, organizations that employ cybersecurity specialists, and universities that offer cybersecurity programs and/or conduct cybersecurity research. By contrast, "cybersecurity deserts" (communities that lack these resources) have lower levels of access to and knowledge of cybersecurity education. These cybersecurity deserts are disproportionately rural and poor.

In order to begin turning these cybersecurity deserts into sanctuaries of activity, local leadership must be prepared to work with their regional economic development agencies and state and federal representation to create opportunities for STEM, cyber, and cybersecurity partnerships to flourish. We have found that regional economic development agencies are very willing to work with their educational partners because it is the educators that are responsible for developing the workforce that will benefit the region and eventually supply the STEM and cyber partnerships with an able and literate workforce.

Build Computational Literacy

22. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.

Through funding from CETAP (Cybersecurity Education and Training Assistance Program, from the US Department of Homeland Security), [redacted] has created a library of content and curricula that all teachers in the United States can access for free. Courses such as Computational Thinking, Cybersecurity, Cyber Literacy, and Cyber Society, to name a few, can provide elementary, middle, and high school students with an integrated approach to STEM, cyber, and computer science content in a core subject classroom, an elective space, or an extracurricular setting.

- Computational Thinking (CT) is designed to introduce students to computational thinking skills and processes (decomposition, pattern recognition, abstraction, and algorithm design) through discipline-specific projects from computer science, math, science, and the humanities. Lessons are available for elementary and middle school teachers of science, math and English-language arts to immediately bring CT design into their core lessons. For the high school teacher, a full-year CT course is available that explores 9-weeks' worth of CT in each of a science, math, and English-language arts setting as well as a 9-week independent study where students can apply what they have learned in the previous three quarters.

- Cybersecurity lays a foundation for understanding cyber law and policy, Linux, networking technology basics, risk assessment, cryptography, and a variety of cybersecurity tools. As a high school level course, the content also prepares students for the Security+ credential from CompTIA. Any opportunity where a student can graduate from high school with an industry-accepted credential is a plus, and as one of the building blocks for the DOD's baseline 8570 certification, this content can be a critical building block for students considering employment right out of high school.
- Cyber Literacy guides 8th and 9th grade students on a variety of deep dives into relevant real-world topics such as text-based programming, electricity and circuits, sensors and autonomy, current events, and what it means to be a cyber citizen in today's evolving digital world. As an entry-level opportunity to study cyber engineering, this course can be very useful to help students identify whether or not they want to pursue additional studies in the area of STEM and cyber.
- Cyber Society is a set of liberal arts units designed to introduce students to how the world of cyber affects their lives every day. The skills they learn from these modules will help them be more confident in interacting with the ever-growing and connected world around them. The modules throughout this course will better prepare students to become educated members of the future cyber workforce.

[redacted]: STEM RFI Response

About the Responding Organization

Author of Response: [redacted]

Agency-Representing Official: [redacted]

Program Summary: The [redacted] of the [redacted], was awarded the [redacted]. The [redacted] at [redacted] is the first Federal entity as a recognized mentoring organization in the twenty five-year history of the [redacted]. The [redacted] trains and mentors 12th-grade high school students in hands-on in biomedical research. This [redacted] program has been instrumental in training the most junior members of next generation of biomedical researchers for over thirty years. For further inquiry, please contact [redacted].

RFI Sections and Questions

Future Opportunities in STEM Education

1. **What COVID–19 related digital barriers have you found most prominent, impactful, or difficult to overcome?**

- The [redacted] operates in the preK-12 arena.
- Barriers to online education for the [redacted] include internet access in more rural settings, the lack of directly applicable curricula, the lack of staff resources for developing suitable courses, and the reality of laboratory research training, which requires hands-on experience in a physical setting.
- Internet access for instructors conducting online classes could be solved with suitable Government-furnished equipment.
- It was challenging to develop training materials within a short timeline for implementation. We are building and continuing to phase in new materials and activities for online training.
- While the need for direct hands-on training cannot be conveyed online, the nature of biomedical research shifting towards data science is allowing about 30% of [redacted] mentors to continue training [redacted] interns online.

2. **What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education?**

- The [redacted] operates in the preK-12 arena.
- While remote education for laboratory research outside the physical laboratory setting is difficult, such training could in part be accomplished by virtual laboratory experience. Examples of this kind are referenced in the answer to Question 9.
- Prerecorded resources of the [redacted] of the [redacted] are also very helpful [redacted].

3. **What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new**

opportunities in STEM education?

- The [redacted] is conducted by the [redacted] a Federal agency.
- Students welcome the [redacted] specific and science-oriented subject matter. They also prefer instructor-led courses with questions/answer sessions and relevant homework assignments, i.e. direct instructor involvement rather than prerecorded, non-interactive videos.
- The [redacted] also expects to conduct small group feedback session with students online to reinforce personal interaction of interns with the program coordinator/scientific advisor.

4. **What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training?**

- Underrepresented minority students in STEM benefit more by direct classroom interaction with a mentor/role model, where individual attention can be given to a student with others listening and observing.
- In order to draw in students early enough for acquiring sufficient, science-based course credentials by grade 11, the [redacted] has been engaging 9th-grade students through small, direct classroom sessions (12 students maximum) as part of [redacted] program.
- The [redacted] also expects to participate in such [redacted] classes for the 2020/21 school year, using a virtual setting as needed.
- The [redacted] program conducts surveys on how students enjoyed and benefitted from the interaction with a STEM professional/role model. Feedback on [redacted]-led sessions has been very positive over the past several years.

5. **What areas of professional learning would be most beneficial to educators providing remote instruction?**

- Educators in our program could benefit from professional learning about online teaching approaches, conferencing/teaching tools, and online curriculum development. Adaptation of traditional lecture materials and approaches is difficult as junior-level learners are less versed in any particular area of science, needing more individual interaction for staying focused and encouragement for small achievements.

6. **What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID–19?**

- For [redacted], it is most important to expand the number of online-capable mentors in order to reach more students. Mentorship and research instruction typically involve one or at most two interns per mentor and laboratory. It is the larger laboratory/research office environment which provides the best support for a learning intern.

7. **What experience does your school system have with interoperable learning records or precision learning systems?**

- No such records/systems are in place at our agency. Mentoring/teaching is just one facet of scientific activity in our scientists' responsibilities. Many mentors do not have a formal background as educational professional.

8. **What actions did your STEM Learning Ecosystem take to support learning in response to COVID–19?**

- The [redacted] has converted a full day Science Skill Bootcamp to a virtual version. The bootcamp provides (i) a lecture-style orientation to the agency's infrastructure, research environment, and scientific skills such as research documentation and presentation. The bootcamp also contains (ii) hands-on exercises using teaching microscopes, and micropipetters. (iii) Lab math, aseptic technique, and scientific data interpretation are conveyed in team exercises. Areas (ii) and (iii) were also converted to online demonstrations, but lack true hands-on authenticity.
- Further, scientific research activities will be converted to virtual during this school year: a

scientific journal club and scientific poster presentations. Both of these skills can be acquired reasonably well by interactive online instruction and discussion.

- With respect to barriers: Overall, [redacted] staff have taken on many new research efforts related to COVID-19 in addition to their normal duties while, at the same time, developing remote learning content for the [redacted] and other training programs. The limitation is staff numbers and limited hours in the day to build online content, and that remote learning cannot substitute for on-site lab experience.

Develop STEM Education Digital Resources

9. What type of web-based resources and opportunities would you hope to find on a STEM education website?

- Online resources pertaining to biomedical laboratory skills are very helpful in complementing instructor-led classes of the [redacted] at [redacted]. [redacted] resources for high school interns typically are not interactive.
- Examples of useful laboratory skill videos and virtual laboratories that are available for free:
    - Introduction to Practical Microbiology Laboratory https://www.youtube.com/watch?v=bj6Vgc3LcLE
    - The Virtual Immunology Laboratory https://media.hhmi.org/biointeractive/vlabs/immunology/index.html
    - The Virtual Bacterial ID Lab https://media.hhmi.org/biointeractive/vlabs/bacterial_id/index.html
    - The Virtual Transgenic Fly Lab https://media.hhmi.org/biointeractive/vlabs/transgenic_fly/index.html
    - Cell Culture Basics https://www.thermofisher.com/us/en/home/references/gibco-cell-culture-basics.html
    - Biosafety video series https://www.who.int/ihr/publications/biosafety-video-series/en/
    - Using a Micropipette https://www.youtube.com/watch?v=uEy_NGDfo_8

10. Please describe your primary audience and how the STEM education resources you identified above would help you serve your audience.

- The [redacted] primary audience are 12th-grade high school students. Nevertheless, our office also reaches out to younger high school students as well as elementary students. For the latter, we teach [redacted] interns to become mentors and encourage science-fair participation by underrepresented minorities.
- Our mentoring in the "wet lab" setting: Hands-on training in biomedical research techniques, including molecular biology, cell culture, immunology, small animal model research.
- Our mentoring in the "dry labs" setting: Hands-on training in biomedical informatics, imaging and analysis, molecular modeling, scientific/technical writing, biomedical technology transfer, and outreach/mentoring for STEM for elementary students.
- Our online training approach is more successful in the "dry lab" setting, as this project area can be conveyed more realistically. While the virtual "wet lab" experience is not quite as tangible, we are able to at least provide a sense of what the research job is like, using live demonstrations with laboratory tools/instruments by the instructor.

11. How would you like to see resources categorized?

- Resource topics should be in line with laboratory/experimental activities and their development could be guided by the existing offerings of [redacted]. Nonetheless, effective and realistic resources would benefit from public-private partnerships, where developers would directly interact with our mentoring scientists.
- Federal procurements of resources would be preferred as they could be made available

without licensing fees and thus permit broader access by underrepresented minorities.

Increase Diversity, Equity, and Inclusion in STEM

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM?

- Our program focuses on local area high school seniors and draws from the diversity that exists in the local community.
- We are actively engaging the local school system's (county government) help for increasing the level of underrepresented minorities in science. This effort is not trivial as our community is suburban/rural without a strong public transportation network. The bussing system for high schools in the county may be able to alleviate the need for personal transportation of interns, since it coordinates instruction at one centralized/common school with other, outlying schools in the county.
- Access to personal transportation is a requirement for our interns in order to manage adjacent class schedules at school with their internship activities in the laboratory.

Engage Students Where Disciplines Converge

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design?

- Biomedical research interns need to develop a variety of skills with respect to scientific competence, ability to work independently, and interpersonal skills. In addition to mentor-conferred skills which contribute to all of the above, common classes are conducted in the areas of research ethics, scientific skills, and research communication.
- Many laboratories acquire scientific data through experimentation while, at the same time, engaging in data analytics, scientific modeling, and informatics. As such, interns are exposed to the broadest activities and skill requirements of a research scientist, whether they eventually seek employment as an entry level laboratory technician or as a seasoned postdoctoral fellow with graduate experience from a regional/national research university.

14. How has your ability to teach transdisciplinary concepts to your students changed in recent months because of the shift to remote teaching and learning?

- The [redacted] saw a 70% reduction in mentorship capacity since the majority of mentors are not able to convey needed "wet lab" (see Question 10) experience through online instruction.
- Virtual-capable mentors primarily work in "dry lab" settings, such as scientific imaging, informatics, research partnering, and scientific communication and STEM-focused outreach.

15. What training have you/your organization received in any of these approaches for teaching STEM education: transdisciplinary, integrated, convergence, or engineering design, etc.?

- Our mentors typically are research scientists with a Ph.D. level background in various biomedical disciplines. Senior mentors also have postdoctoral experience, which may include some aspects of classroom teaching and often hands-on training of junior staff.
- As productive scientists, our mentors continually adapt to the evolving interdisciplinary nature of biomedical research.
- Data science and IT-based analytics/informatics play an increasing role in the biomedical research laboratory. Adaptation of such novel approaches in a laboratory is also driven by the regular influx of postdoctoral research fellows.

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way?

- See responses to previous questions.

17. If you are a student, what specific delivery mechanism works well for you?

- Not applicable.

Develop and Enrich Strategic Partnerships

18. What factors drive successful work-based learning programs?

- Student interns really take to becoming junior scientists. Personal interaction with caring mentors, competent preceptors, and a supportive laboratory community all contribute to the personal and professional growth, which our interns proudly speak about when moving forward in their chosen careers. Even interns, who do not seek research-related careers speak well of the personal maturity they gained on their way to becoming a successful professional.
- The success of [redacted] is evident from these metrics: (i) [redacted] interns frequently sweep the county's science fair awards and go on to state and national competitions. (ii) A majority of mentors invite [redacted] graduates back to their laboratory for summer and winter internships throughout the college years and beyond. [redacted] interns are a trained, reliable, and thus valuable workforce. (iii) On average the [redacted] has mentored 60% female interns over the course of its thirty years of operation. (iv) The great majority of [redacted] graduates go on to study at major research universities, Ivy League schools, and prestigious colleges in STEM and health-related disciplines. (v) An estimated 80% of [redacted] graduates remain employed in these fields.
- COVID-19-specific adjustments: We encourage our mentors to increasingly develop online learning activities that are suitable and relevant for biomedical research scientists.

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success?

- For success metrics, our internship graduates speak highly about their training experience, their mentoring support, their success in gaining university/college access in a field of their choice, their ability to obtain scholarships, and that a great majority of our interns become successful professionals in STEM fields.
- Public-private partnering is essential in our case as high school-class and laboratory training schedules need coordination. To achieve greater diversity within our Federal WHK SIP training environment, the [redacted] has to work with non-Federal community partners for increased flexibility.
- Our first success is that the [redacted] training initiative for STEM has continued during the pandemic, albeit at a smaller footprint.
- Adaptation of training measures to the virtual domain is expected to benefit our mission. Coursework can be repurposed for further outreach (see [redacted] in Question 4) to a larger and more diverse population of prospective interns, overcoming current socio-economic, science-related cultural, or [redacted] policy-based age barriers for laboratory workers.

Build Computational Literacy

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources?

- Biomedical research has evolved rapidly over the past two decades. The main effort of a biomedical research laboratory used to be time for and emphasis on data acquisition. However, as many aspects of experimentation have become standardized and better supported through modern technology (automation) or experimental kits/services (commoditization), a laboratory's effort could shift to pre-experimental planning and post-experimental analytics/meta-analysis. All of the latter require extensive computational skills in areas of statistics, data science/informatics, and digital modeling. The transition from purely wet-lab experience to hybrid wet/dry lab or entirely dry lab (see Question 10) is benefitting the [redacted], allowing it to achieve an online-capable mentoring pool and thus broaden the internship base. In addition, dry lab areas for training were expanded in recent years to also include technology transfer, scientific/technical writing/communication, and scientific project management.

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels?

- Historically, research in the natural sciences has shifted towards data science, as we first observed with physics and chemistry and, more recently, with molecular biology. Systems biology seeks to integrate these traditional fields and gain knowledge and inference power for aiding human medicine.
- Interdisciplinary approaches to training the new generation of scientists are critical because mentors are highly specialized in existing, well-defined fields. Sustained progress in any area of scientific endeavor, however, requires ongoing innovation. The very junior workforce likely is more comfortable with unconventional approaches, evolving technology and, most importantly, would exhibit an appetite for experimenting and risk-taking.

22. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education?

- The [redacted] of the [redacted] at [redacted] provides a mentoring environment which increases the computational literacy of interns. This development is primarily driven by the evolution of life sciences, biomedical research, and the supporting technological context. The shift towards data science and scientific communication in cancer research enables almost fully virtual internships.

23. What technologies and resources do you currently use?

- Our training curricula for high-school interns are highly individual, tailored to the needs of our mentors and their laboratories/research offices.
- While [redacted] (see Question 2) does provide a number of online resources already, more need to be created to convey greater authenticity for online learning of laboratory skills, and also to achieve better learning effectiveness than common lecture-style instruction.
- The development of virtual research laboratories that permit self-discovery and trial/error-capable experimentation is a step in the right direction.
- Perhaps instructional videos which utilize on-demand, augmented reality for lab demonstrations could also help to increase the authenticity of the biomedical research experience.

Community Use and Implementation of the Federal Stem Education Strategic Plan

24. Please describe how your organization has used the Federal STEM Education Strategic Plan.

- In its thirty-year history, the [redacted] at [redacted] has trained over 1100 junior biomedical researchers, 60% female on average. The training of this next generation of scientists is governed by the Public Health Service Act, in the section where responsibilities and privileges of the [redacted] Director are enumerated. The [redacted] is unique in that it focuses on high school seniors to receive authentic training in cancer research laboratories and research offices of the [redacted] at [redacted] In order to enhance participation of underrepresented minorities in the STEM fields by grade 12, [redacted] administrators and interns actively participate in our outreach initiatives to engage disadvantaged elementary, middle, as well as younger high school students within the area.
- The programmatic goals of the [redacted] are very well aligned with the Federal STEM Education Strategic Plan as it pertains to strategic partnering, interdisciplinary teaching approaches, computational literacy, as well as transparent and accountable operations.

Response to RFI on STEM Education

Questions Answered:

Future Opportunities in STEM Education #4 and #5
Increase Diversity, Equity, and Inclusion in STEM #12
Develop and Enrich Strategic Partnerships #18 and #19

Answers are being provided by (b) (6) [redacted] I have been a high school science teacher in [redacted] for 17 years and am currently serving as a [redacted]. Opinions presented are my own and do not reflect either my school district or the [redacted].

Future Opportunities in STEM Education

4. In March, when our school suspended in-person classes due to COVID-19, our rural school district recognized that there was a significant percentage of families that did not have reliable access to broadband internet. This access limitation was not always related to socioeconomic status, but often due to many of our families living in rural areas (often on farms) that are remote from the school and community technology resources. Many of those who had access may not have had internet quality to stream content or support multiple students and remote-working adults on their connections. Access to computing devices was an additional problem for some families, however, the school district had an adequate supply of Chromebooks to loan out to families that requested them.

The consensus among our administrator and teacher-leader team was that we could not provide equitable opportunities for all our students if we required on-line access for remote learning. Therefore, our school-wide expectation was that paper packets would be sent home to all students for all classes. On-line resources could be suggested, but would be for enrichment, not required coursework. Additionally, teachers were instructed to present mostly "review level" work for students, since it would be more difficult to provide new content instruction, via packets, in equitable fashion. These guidelines were developed and implemented for what we sincerely believed would be a short term – 2 or 3 week – disruption in in-person learning.

When we received notice that our students would not return in-person for any of the remainder of the school year, our lack of technology access took a much harder toll. Lack of synchronous meetings with our students eroded even the strongest teacher-student relationships and limited teachers' abilities to provide deep, engaging instruction on new content that would require more teacher support. Teachers were also extremely concerned about the safety and welfare of students who would no longer have access to school physical and human support structures. We also felt it necessary to adjust grading policies in our district so that student grades were not at risk due inequitable resources at home. Unfortunately, as soon as students realized that their grades were "safe", many stopped participating completely. This highlighted the underlying focus on "earning a grade" vs. authentic learning that many of us have suspected.

Lack of technology resources does exist, and with some time and funding, these physical resource gaps can theoretically be closed, however, I fear that these resources alone will not be enough to close the equity gaps for all our students. The non-technical resources in our students' homes vary so greatly that we can not even pretend that teaching and learning remotely provides a level playing field. Families differ broadly in the time, money, patience, knowledge, and attitudes that they have available for schooling. Some students have parents who believe in the value of education and are excited to teach them at home; they've set up a dedicated desk with special school supplies and the parents are on-hand and engaged in encouraging their students' participation. Other parents, often through no fault of their own, simply do not have the resources (material and/or human) that allow this level of engagement and encouragement. No two students EVER show up at school equally prepared and able to learn, but at least being in person gives teachers a chance to really see each student and apply our professional knowledge and skill to push them individually to grow and succeed. Remote learning has set up a new system of inequities, and even complete closure of the digital divide won't erase many of the non-technological differences among our students' experiences that are currently mitigated by thoughtful instructors.

5. Successful remote teaching cannot look like a repackaged version of traditional teaching. Teachers are being provided platforms (Zoom, Google Classroom, etc.) that are supposed to allow them to convert their classrooms to virtual formats. However, the human to human interaction is nearly non-existent and the amount of screen time is wearing out parents and students alike. This isn't a sustainable model for long-term engagement and inspiration for even our very best students. The PD that teachers need right now isn't another "how to " lesson on using yet another technology platform. Teachers need out of the box solutions for getting students to interact in discussions and small groups remotely, for incorporating hands-on activities, and encouraging self-motivated off-camera work continuity. Teachers need strategies for encouraging students' intrinsic motivations to learn, vs. emphasis on compliance and traditional grades. School on-line cannot just be a repackaged version of school on-site.

Increase Diversity, Equity, and Inclusion in STEM

12. Within our rural midwestern school, the traditional groups that society labels as "diverse" are often represented by individual students, not wide swaths of our school population. With roughly 40 students in a graduating class, each student represents 2.5% in any demographic profile. In any given year, we may or may not have a single student of color, a student with a

noticeable disability, or a student with open LGBTQ status among our graduates. Most of our students come from working class families, and a variety of non-traditional family structures are common. Our female students, based on anecdotal observations, seem to be out performing their male counterparts even in our STEM classes where females traditionally fall behind. All of these standard categories of underrepresentation, at first glance, seem to be non-issues in rural schools like ours where levels of "diversity" seem to be limited. However, I would argue that our rural status, in and of itself, is its own category for underrepresentation.

Our rural geography leads to many of our students being underrepresented and underserved in STEM education. Our community is largely agriculture-centered, with no other major business, academic, medical, or industrial employers in the local area. Our lack of physical proximity to employers means that many of our students lack exposure and access to knowledge about careers, STEM and otherwise. Many of our students have never met an engineer, architect, scientist, or computer programmer. They know our one local doctor, pharmacist, and veterinarian by name, and may know a few nurses and a physical therapist (if they've had a sports injury). They see teachers at school and farm service providers at home, but may not know many other people who have even gone to college. When asked what they want to do after high school, many of our students don't have good answers, simply because they haven't seen examples of very many careers demonstrated within their families or community. They don't have background knowledge about the types of education and skills that are required and don't have opportunities for internships or part time jobs that might spark an interest that could drive them into a STEM career field. As a high school teacher, I see where students without solid goals for their future careers can struggle with motivation. They have not found the "hook" that connects them to the purpose of school and often get through high school on the path of least resistance and poorly prepared for their next steps.

Our school district has recognized the need to provide more rigorous STEM learning opportunities for all of our students and has taken actions to innovate. Our improvement efforts started over 3 years ago when a team of science teachers from our school attended a workshop and was introduced to the Carnegie STEM Excellence Pathways model. With our administrators, we used the Carnegie Self-Assessment tool to identify our district's strengths and areas of need specific to STEM education. With evidence from this process as justification, we allocated personnel and budgetary resources to begin developing a comprehensive, multi-faceted k-12 STEM program. This allowed us opportunities to offer an after-school elementary STEM program and to build STEM elective courses for our junior high and high school students. We have put more emphasis on structured career exploration in classes and through student field trips to regional manufacturing facilities and college and career expos. We have started conversations with local business partners, provided PD for our teachers, and have paired elementary and high school students for STEM events. Although we have far to go, we have seen success in the enthusiastic participation of our students and the willingness of our staff to adapt and innovate. And because we are a rural school, all the efforts we do to provide extra

STEM exposure and access to our students reduces the likelihood that our population will remain underrepresented.

Develop and Enrich Strategic Partnerships

18. My rural school has only limited opportunities for work-based learning programs due in large part to our distant proximity to employer sites. To gain exposure to or experience in many STEM related career fields, our students would need to travel at least 30-60 minutes from school, making school-day internships impractical on a traditional school schedule.

We do offer our students a traditional Vocational-Technical learning opportunity, but because students must be bussed to a larger school district each day, Vo-Tech students face time limits that preclude them from taking other college-preparatory or dual credit classes. Students who choose Vo-Tech education are usually stereotyped as "non-college material", which carries a stigma of its own.

Our school's strong FFA/agriculture program does provide opportunities for students to participate in supervised agricultural experience (SAE) projects where they develop their agriculture production and agri-business skills. This program probably does not receive the attention that it should within our school community, given that it is our best effort at authentic work-based learning. It should be noted that our students' SAE projects are worked outside of normal school hours, not as part of our school day structure.

19. My rural school is not currently part of an established STEM Ecosystem since these efforts have so far been concentrated in the 2 major metropolitan areas in my state. However, I am actively looking for ways to establish more Ecosystem-type connections among schools, businesses and industry, and community partners within my region. I sincerely believe that the best way to serve ALL our rural students is to eliminate the competition BETWEEN schools and start working better together so that all our students can compete in the broader career landscape. It should not matter than my school's math state-test scores are better than the district 20 miles away; we have a responsibility to all of these students as future citizens of our state and region.

There are hundreds of rural schools just in [redacted] where a 2-person science or math department struggles to meet all the curriculum and instruction needs for their entire secondary student population. Rural schools struggle to recruit fully qualified STEM teachers and the loss of a single motivated teacher may eliminate an entire successful STEM initiative. Rural schools need systems in place that allow STEM teachers to collaborate and learn together, leveraging knowledge, energy, and physical resources across schools vs. expecting each individual teacher in each of 100 schools to become an expert on all things STEM. Rural schools do not have enough resources to have a dedicated Science Specialist or even a general Curriculum Director. We rely too much on individual teachers to establish rigor and to innovate, producing widely varied results across our region. Establishing a new system of STEM Learning Ecosystems – focused on rural schools and their unique challenges and opportunities – could leverage the resources we do have and lift our teachers out of isolation and into more fulfilling teacher-leader roles.

[redacted]

October 19, 2020

[redacted]: STEM RFI Response

The following is feedback on America's Strategy for STEM Education submitted by [redacted]. The feedback is submitted via email to CoSTEM@nsf.gov in response to the National Science Foundation's Request for Information (85 FR 55323).

The [redacted] brings together more than 70 industry, nonprofit and advocacy organizations and [redacted] to make Computer Science a fundamental part of K-12 education. The [redacted] offers the following in response to the September 4, 2020, request for information related to implementation of the Federal STEM Education Strategic Plan, *Charting a Course For Success: America's Strategy for STEM Education.* The [redacted] is responding to the following questions:

- **Future Opportunities in STEM Education: Questions 1 and 6**
- **Increase Diversity, Equity and Inclusion in STEM: Question 12**
- **Build Computational Literacy: Questions 20 and 21**

Future Opportunities in STEM Education, questions 1 & 6

1. What COVID-19 related digital barriers (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

- The "digital divide" between families with adequate access to broadband or high-speed internet and devices sufficient to access the internet and those without is not a new problem. The disparity has been highlighted by current circumstances and become more urgent as states transition to distance learning models in response to the COVID-19 pandemic. Over 55 million students began learning from home in 2020. Yet, an estimated 16 million children lack home internet access. That means 30% of K–12 public school students lack access, including 37% of students in rural areas and 35% of Native American students. Each day a student is disconnected from the internet during this pandemic is equivalent to missing a full school day. The FCC defines baseline speed (25 megabits per second (MBPS) upload and 3 MBPS download) for adequate capacity. This speed is not sufficient in a household with multiple simultaneous users.

- At [redacted], we have this issue of access first-hand by analyzing usage of [redacted] and its resources and the impact of school closures on underserved student populations. Based on March 2020 usage data, there is:
    - A 14% widened gap between usage for students from **rural** communities vs. urban or suburban;
    - A 10% widened gap between students attending **economically disadvantaged schools** vs. those attending better resourced schools; and,
    - An 8% widened gap between students from schools with larger populations of students from **underrepresented racial/ethnic groups** (i.e., >50%) vs. schools with smaller numbers of these groups.
- These barriers persist; resolution would be buoyed by federal investments in the E-rate and other programs that support expanded access to broadband service and devices.

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

- It's critical to collect data on which students have access to and participate in classes in the STEM subjects. Considering the high levels of inequity in participation in STEM subjects - particularly in computer science - by students from marginalized racial and ethnic groups, students in rural areas, students with disabilities, English language learners, and economically disadvantaged students, understanding the barriers and challenges they face during remote and hybrid learning, is critical in providing equitable access to a high-quality education.
- [redacted] has collected information and data from various partners and stakeholders, including teachers, schools, and professional learning providers. We've conducted formal surveys and hosted informal listening sessions

throughout our national networks as we work collaboratively to adjust our programs and resources.
- The types of information that have been most valuable (and continue to be valuable for decisions making), particularly in light of COVID, include, but is not limited to:
    - Data about school opening plans (both dates/schedules as well as models of learning (in-person, hybrid, etc.).
    - Changes to school budgets and how funds and resources are being redirected in light of COVID.

Increase Diversity, Equity, and Inclusion in STEM, question 12

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

- We believe that computing is fundamental to understanding and participating in today's society and that it is valuable for *every* student to learn as part of a modern education. We also believe that acknowledging and shining a light on the historical inequities within the field of computer science is critical to reaching our goal of bringing computer science to all K-12 students. Across the U.S., Black/African American students, Hispanic/Latino/Latina students, and Native American/Alaskan students are less likely to attend a school that teaches a foundational computer science course. Students in rural areas, students with disabilities, English language learners, Native Hawaiian/Pacific Islander students, and economically disadvantaged students are also underrepresented in computer science courses. We provide tools and strategies to help teachers understand and address well-known equity gaps within the field. We recognize that some students and classrooms need more support than others, so those with the greatest needs should be prioritized. All students can succeed in computer science when given the right support and opportunities, regardless of prior knowledge or privilege. We actively seek to eliminate and discredit stereotypes that plague computer science and lead to attrition of the very students we aim to reach and promote teachers and administrators to recruit diverse groups of students to their courses.
- [redacted] was the recipient of an EIR grant in 2019 to develop and implement 1) an outreach and recruitment program for school administrators to adopt - and for school counselors to enroll students in - AP Computer Science; and 2) a blended professional learning program for AP CSP teachers that builds on [redacted]

open-source curriculum, associated in-person Professional Learning Program, and robust network of Regional Partners.

- The EIR-funded work focuses on students who are historically underrepresented in computer science, including women, underrepresented *racial and ethnic groups*, and rural populations across five states—Alaska, Idaho, Kentucky, Texas, and West Virginia. The program goals include training new AP CS teachers, increasing the number of schools adding AP CS into their master school schedules through work with school administrators and counselors, and increasing the number of underrepresented students participating and earning qualifying scores on the AP CSP exam, thereby demonstrating increased college readiness. [redacted] is able to reach these underrepresented communities as a direct result of the Department of Education's EIR grant; federal grant competitions, with specific funding priorities for computer science-focused projects, such as the EIR competition, will continue to be essential for advancing this type of work.

Build Computational Literacy, questions 20-21

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

- Computing is a fundamental part of daily life, commerce, and just about every occupation in our modern economy. Computer science is foundational in transforming the way a student thinks about the world. It's about more than technology; it's about learning to think differently about any problem - helping students far beyond the direct benefits of digital literacy or careers in technology. Computer science puts students on the path toward some of the highest paying, fastest-growing jobs in America. Studies show students learning computer science in primary school perform better in reading, math, and science; in secondary school have better scores on standardized AP exams; are 17% higher likelihood of enrolling in university; and perform better at problem-solving, from primary school to university. It's about teaching students new ways to think, solve problems that we don't know exist, and foster a new sense of creativity and learning for every student.
- Integrating computational literacy into any STEM curriculum fosters increased access and equity, since it would be used in every class. By integrating computer science into the course schedule in K-12 schools — where gender is usually evenly split, and students of all ethnic and economic backgrounds are

represented — we see an increase in diversity of students learning computer science who may never try it otherwise. In addition, learning computer science in a classroom can help students progress faster and further than learning on their own.

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.

- Problem-solving and computing - Through problem-solving and computing, students are introduced to a problem-solving process and learn how computers input, output, store, and process information to help humans solve problems within the context of apps. Students should be able to identify the defined characteristics of a computer and how it is used to solve information problems. They should be able to use a structured problem-solving process to address problems and design solutions that use computing technology.
- Design Process - The design process transitions students from thinking about computer science as a tool to solve their own problems towards considering the broader social impacts of computing. Students are asked to consider and understand the needs of others while developing a solution to a problem. Students should see the design process as a form of problem-solving that prioritizes the needs of a user. They should be able to identify user needs and assess how well different designs address them. In particular, they know how to develop paper and digital prototypes, gather and respond to feedback about a prototype, and consider how different user interfaces do or do not affect their apps' usability. Students should leave the unit with a basic understanding of other software development roles, such as product management, marketing, design, and testing, and how to use what they have learned about computer science as a tool for social impact.
- Data Science - Data science highlights the importance of using data to solve problems, how computers can help in this process, how different systems are used to represent information in a computer, and the challenges and trade-offs posed by using them. Students learn how collections of data are used to solve problems and how computers help automate this process's steps. Students should have a broad understanding of the role of data and data representation in solving information problems. They should be able to explain the necessary components of any data representation scheme, as well as the particulars of binary and the common ways that various types of simple and complex data are represented in binary code. Students should also be able to design and

implement a data-based solution to a given problem and determine how the different aspects of this problem-solving process could be automated.

- Physical computing - Students look towards modern “smart” devices to understand how non-traditional computing platforms take input and provide output in ways that couldn't be done with the traditional keyboard, mouse, and monitor. Using [redacted] and Adafruit’s Circuit Playground, students develop programs that utilize the same hardware inputs and outputs that we see in many modern smart devices, and see how a simple rough prototype can lead to a finished product.
- Algorithms - Students learn to design and analyze algorithms to understand how they work and why some algorithms are considered more efficient than others, including mathematical concepts that enrich students' understanding of how algorithms are analyzed.

This response is submitted on behalf of the principal investigators of the [redacted]. The [redacted] whose mission is to advance theories of learning in diverse settings through the design, development, and research of innovative and transformative learning environments. The Institute's current portfolio includes multiple federally funded research projects in K-16 settings. Our comments below reflect the perspectives and experiences of researchers working in elementary, secondary, and postsecondary public school systems. Specifically, we have collated responses to two areas: Future Opportunities in STEM Education, questions 1, 4, 5, Develop STEM Educational Digital Resources, question 9.

The COVID-19 pandemic has created an extremely difficulty context for successful teaching and learning across these settings. Instructors at all levels report that they have the required technology to implement remote and hybrid instruction, but students do not have similar access. Instructors have reported issues persist with respect to minimum requirements for hardware and network activity. Equally problematic, concerns around privacy have limited the amount of interaction instructors can foster with many students calling into class or leaving cameras muted. Instructors are often unsure whether students are actively participating even in synchronous settings. Instructors require additional support with professional development experiences that help them increase and maintain engagement in online environments as well as develop their skill with educational software that supports remote learning.

With respect to STEM instruction specifically, our partner stakeholders have reported that laboratory-related instruction has been significantly compromised. While several online tools have emerged rapidly that allow students to explore virtual laboratory experiences, the constraints on in-person instruction in the laboratory continue to be worrisome for most instructors. This issue is particularly salient in university settings where students no longer have opportunities to interact directly with scientific apparatus or data collection.

To support instructors at all levels, STEM education website might serve as a resource hub that exposes instructors to various tools to support teaching in an online context. Most importantly, these should include apps that allow for collaboration opportunities among teachers and also among students. The website should avoid decontextualized links to tools and include video-based tutorials that demonstrate how the integration of each app into instruction. Each app should be tagged with meta-data that captures the appropriate age range, technology requirements, and subject matter.

Responses to NSTC regarding STEM Education

[redacted] [redacted]

I am a recently retired science teacher, still involved in professional development and non-profit STEM education organizations. In addition to over 40 years of public school teaching, I have been a leader in several STEM education organization - leading workshops, field trips, and organizing conferences for educators.

The category and questions addressed in this response are:
Future Opportunities in STEM Education, question #2
Develop STEM Education Digital Resources, questions #9, 10, 11
Engage Students Where Disciplines Converge, question #13
Develop and Enrich Stategic Partnerships, question #18
Build Computational Literacy, questions #20, 21, 22

Future Opportunities in STEM Education
#2. (for students and teachers) An outstanding set of online, data-driven classroom investigations for students in advanced middle school through college are being developed by the Rubin Observatory in conjunction with Legacy Survey of Space and Time (LSST) Survey. I was part of a group of educators involved in reviewing the scope, content, and method of the activities. Currently they are in Beta testing and receiving rave reviews. They perfectly address standards in STEM developed by a team led by a master science teacher who herself has many years experience in a classroom. For more information, go to:
https://www.lsst.org/content/education-public-outreach

(for teachers, students, informal educators) Other resources that are too often overlooked are various professional science education organizations, at both the state and national level. These groups collected and created extensive lists of online activities and links with the onset of the Covid19 pandemic.

(for teachers) The American Meteorological Society has three outstanding online courses and two summer programs for teachers in STEM fields. The courses address basic science in meteorology, oceanography, and climate science. Teachers acquire college credit free, but must pay a modest course fee. More information can be obtained at:
https://www.ametsoc.org/ams/index.cfm/education-careers/education-program/k-12-teachers/

Develop STEM Education Digital Resources
#9. (for students and teachers) PhET Interactive Simulations project at the University of Colorado Boulder created free interactive math and science simulations. They are

based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery. I used the frequently with students and always found them to be very effective. They are an excellent model of what would be good for others to develop. To view their simulations, go to: https://phet.colorado.edu/

(for teachers, students, and informal educators) The Michigan Department of Natural Resources (and undoubtedly similar agencies in other states) developed a variety of digital educational resources. Each pre-lesson includes a Kahoot!, online resources and activities that introduce the lesson, as well as topic background information for teachers. Each post-lesson offers a wrap-up, more resources and student activities to further explore the content covered during the interactive 30-minute lesson. Teachers choose the distance learning platform they are familiar with, and invite our staff to join into a virtual class. View their site at: https://www.michigan.gov/dnr/0,4570,7-350-79135_101864---,00.html

(for teachers, students, informal educators) Other resources that are too often overlooked are various professional science education organizations, at both the state and national level. These groups collected and created extensive lists of online activities and links with the onset of the Covid19 pandemic.

#10. (for teachers, students, and non-formal educators) I have worked with both formal high school students and in informal education programs. The activities/resources described above provide access real world data and/or visual representations of complex relationships. Such qualities not only help students better understand processes in science, but also are effective at motivating students. In the case of the simulations, they provide opportunity for students to change variables as if conducting experiments.

#11. I would like to see resources categorized by topics and subject. Age suggestions might be helpful. But I have found that varies by situation (e.g., a ʻʻhigh school activityʼʼ might work well for advanced 8th graders in one school, but more appropriate for an 11th grade remedial classes in another). I also have taken activities created for one grade level can be altered to work very well for another grade level.

<u>Engage Students Where Disciplines Converge</u>
#13. In my own science teaching I often brought in history of science, applications and impacts of science and technology on society, and connections to other disciplines. I was able to do that because of (a) a solid general education (rather then highly specialized) an (b) a unique college program connecting the natural sciences with the humanities and social sciences (Lyman Briggs College within Michigan State University). During a unit on sound, I had students investigate the acoustics of our school auditorium. In a unit on nuclear reactions, we looked at pros and cons of nuclear power.

In addressing the NGSS and state standards on climate science, I broadened it to include the technology standards related to technology and science processes. The unit included student investigation of climate data, evaluation of several alternative ideas about what might cause global changes (including variations in Earth orbit and solar output), student research on impacts of climate change, and alternative technological ways to minimize and mitigate climate change. In the process, multiple standards were addressed while also making real world connections to multiple disciplines - from astronomy to electricity to economics and life style issues.

Develop and Enrich Strategic Partnerships

#18. For a time I taught a class helping students with work-based learning. The particular element I was most hopeful about involved work shadowing. But there were several major problems which discourage schools and student from utilizing such opportunities. First of all attendance policies in most schools and the principle of *in loco parentis* often cause school to prohibit such programs. They raise important liability questions for administrators. Secondly there is a perception among some students and parents that such programs take away from what they think of as *real learning* and/or are only for students who aren't particularly smart. There are a lot of reasons that is wrong. But the perception needs to be addressed. Thirdly work-based learning programs (with students learning by working with someone away from school) needs good supervision and guidance. This is important both to protect students and to make sure the experience is a positive one helping the student prepare for actual work after they complete the program. Many non-school people who are willing to work with a student in this setting are thoughtful and effective in what they do. But there can be individuals who just seek cheap labor or motivated in other ways not beneficial to the students.

Build Computational Literacy

#20. Challenges to integrating computational literacy into STEM education include tight curriculum expectations imposed by mandated testing, lack of training in such integration, and few ready to use activities that do this. On the other hand science and technology uses computation as a fundamental tool, so such integration should be natural. Utilization of real world data analysis is one way to both achieve this integration and address basic science process and technology standards.

#21. A major topic which would integrate computational literacy into STEM curriculum is numerical or computer based modeling. At some level students creating actual numerical models would be appropriate. But I am suggesting here is an important need to teach about what numerical modeling is, part of which would be to have students perform some very simple numerical modeling so they understand both their power and limitations. Such modeling are significant parts of our society today. They are used in fields as diverse as crime fighting, military operations, manufacturing, space travel, and climate science. But many people (students and adults) do not understand them or even trust them.

#22. An existing example that shows numerical modeling (and computational literacy) embedded into STEM education unit is from BSCS (Biological Science Curriculum

Study) materials. In one of their integrated science textbooks they engaged students in an investigation of the Milankovitch cycles. In investigation students took science based but simplified data, graphed it and looked for patterns. At the end of investigating the three cycles, the directions led students to add together the values from all three to see what the combined effect of the three cycles would be. The math was very simple. But students could see how computation allowed them to view the effect of multiple variables in a complex system. Seeing that pattern is not possible without computation and numerical modeling.

Response to RFI on STEM Education

Our Perspective:
The [redacted] focused on increasing diversity and inclusion in computing and technology fields, based at the [redacted], with over [redacted] across the US. [redacted]

Bringing together nearly [redacted], [redacted] serves multiple stakeholders, including girls (and an increasing number of boys), adult influencers such as counselors, formal and informal educators, families, universities, and workplaces. [redacted] promotes and engages in research and evidence-based practices through a dedicated team of 15 research scientists, as well as program and communications staff.

Future Opportunities in STEM Education - Q5:

Q.5. What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

Researchers and activists focused on equity and inclusion are discussing the various ways in which remote instruction could be either positive or negative for groups underrepresented in STEM. Virtual classrooms are unlikely to be neutral; it is likely they will either reinforce exclusionary practices in the classroom or provide new opportunities for equity-minded classrooms. It is critical that educators providing remote instruction think not only about curricula, assessments, and scheduling--as they are bound to do by the nature of their jobs--but also attend to pedagogical practices that ensure all students feel welcome, included and important in virtual learning settings. While there is little current research on these practices and their impacts during the COVID-19 era, there is literature about best practices concerning online pedagogy and best practices concerning inclusive classrooms, which could be drawn upon for educator professional development. We house a repository of such information on our website, which is discussed in further detail below.

Develop STEM Education Digital Resources - Q9-11:

Q.9 What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?
Q.10 Please describe your primary audience (e.g., I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.
Q.11 How would you like to see resources categorized (e.g., subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.

STEM Education Digital Resources should help educators navigate the challenges mentioned above, those they face when considering curricula, assessments, and scheduling, while simultaneously attending to pedagogical practices that ensure all students feel welcome, included and important in virtual learning settings. These resources should cover multiple educational settings, from early childhood education through postsecondary, and should be applicable to educational institutions, regardless of their history with technology or inclusion practices.

Since 2004, [redacted] has been creating resources that draw from the best social science research available and help educators assess and improve the inclusivity of their classrooms and curricula. These are available through [redacted]

[redacted] online repository of educational and outreach resources are research-based, with a focus on increasing gender diversity in the fields of computing and technology through recruiting and retaining girls and women via inclusive cultures. The resources draw from extensive social science research and provide practical solutions aimed at increasing influencers' and practitioners' awareness of the issues, knowledge about how to solve the issues, and specific techniques to change the status quo. Our resources focus on the entire computing ecosystem, from K-12 teachers through postsecondary faculty through industry employees and management.

Through our programs and resources, we help change leaders implement reforms, raise awareness, and reach out to historically marginalized populations. [redacted] resources focus on inclusion, and promote systemic change rather than adopting a deficit-based approach in which women and other underrepresented groups are "trained" to fit into existing educational or disciplinary contexts. The resources found on the [redacted] website have been instrumental to the creation and execution of computing education across the U.S., as they are widely used by educators in formal and informal instructional settings, as well as influencers in industry. Our free, online research-based resources for reform are frequently cited by national media outlets and widely distributed through outreach events and our member organizations' networks.

During the COVID-19 pandemic, we've collected new and existing [redacted] resources to support educators as they strive to create inclusive virtual classrooms [redacted] All of these resources would be relevant for a Federal STEM education website, whether as a group or individually. Items in the collection include:

- [redacted]

[redacted]

Another relevant online resource is [redacted] that addresses pedagogical practices applicable to all STEM fields. This engagement practices framework was developed for the [redacted] a repository of introductory computer science assignments peer-reviewed by social scientists and computer science educators. This repository could serve as a model for a Federal website that would allow educators to reference and download peer-reviewed lesson materials that follow research-based engagement practices. Ideally such a database would include practices and assignments specific to virtual classrooms as well.

Based on data collected by our evaluation teams, we know our resources are enormously useful to people; we also know our existing structure for online delivery has room for improvement. We are in the midst of restructuring our repository for better user access based on recommendations from information architects who conducted usability and user studies with our constituents. We expect to have an updated user interface, organizational and metadata system online in the first half of 2021. See [redacted]

Increase Diversity, Equity, and Inclusion in STEM - Q12

Q.12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

Background:
Historically, interventions for increasing diversity in STEM contribute to the greater participation of women seen in many STEM disciplines today. Percentages of bachelor's degrees awarded to women in the decade 2008 to 2018 increased in several major STEM disciplines. Biology, chemistry, and biomedical engineering continue to see high participation by women, partly because women become familiar with biology and chemistry content and jobs in high school and gain confidence that they can be successful in these fields. Most college students majoring in STEM make that choice during high school. Unfortunately, despite the national demand for computing professionals and the increasing threats to our nation from malicious cyber activity, the majority of American high school students, particularly girls and students of color, do not study computer science in high school and therefore do not gain familiarity nor confidence. Furthermore, girls and students of color continue to be less likely than white or Asian boys to actually take a high school computer science class. Women and people of color who do pursue computing majors in college take computing courses under different conditions than their male peers from majority backgrounds, resulting in higher attrition even when they have higher grades than the men who stay.

The [redacted] Approach:
[redacted] aims to increase the recruitment, retention, and advancement of underrepresented individuals in STEM through the resources described in Questions 9-11 as well as through two well-established programs with strong records of success in computing fields. [redacted] recruitment interventions take into account gender-based socialization regarding computing professions and leverage effective messaging and sense of belonging to unseat these influences.

The [redacted] program supports college and university clients in creating and implementing a multi-component strategic recruitment and retention plan that is responsive to local conditions. [redacted] consultants and research staff work with faculty committees to identify and locate potential students that can be successful in their computing majors; align departmental messaging with the present values and goals of these students and their influencers; use credible messengers and media that have a strong chance of being heard; leverage existing assets on campus and in the community; and provide capacity-building so the departments themselves can learn to evaluate what works and what does not.

The [redacted] supports the recruitment and retention of women into undergraduate computing by providing encouragement, awards, near-peer role models, and a sense of community. The primary function of the [redacted] is to build identity in computing for women and nonbinary students and cement their interest and confidence in computing; interest and confidence are important predictors of career choice in computing. Recognizing students in high school with an award for their early efforts increases their likelihood of continuing on to postsecondary studies in computing and STEM.

To support women's retention throughout undergraduate computing programs, [redacted] suggests interventions that improve the experience of all students, not just women or others who might feel marginalized in STEM. [redacted] guides departments to focus on classroom and curricular experiences that can support development of identity in the field and a sense of belonging in the local computing community.

The [redacted] supports the retention of undergraduate women through the [redacted] a private community open to [redacted] winners and to women pursuing postsecondary degrees in computing fields. Participating in the [redacted] shows women that they are not alone in their passion for computing/engineering, and mitigates the isolation and lack of belonging technical women can feel in their classrooms and workplaces. In addition to the online platforms utilized by the community, [redacted] has local programs led by [redacted] Campus Representatives who organize events, share opportunities, make connections, and serve as mentors for younger peers.

<u>Evaluation:</u>
Both [redacted] and [redacted] have proven track records of success based on professional evaluation. Since its 2006 launch, [redacted] has successfully worked with 131 undergraduate computing departments in public and not-for-profit private U.S. institutions. The 32 earliest [redacted] participants steadily increased the percentage of awards to women from 10% in 2008 to 21% in 2018. In contrast, the rest of the nation

remained relatively flat, gaining only 2% in the same time period. The mean percentage of women awarded computing bachelor's degrees among the 28 served from 2013-2015 increased from 14% to 20%, a 6% increase in five years. [redacted] participants in the rest of the nation increased by 2% during that time.

[redacted] data show that [redacted] clients steadily increased the retention rate of women declared computing majors from 79% in 2008 to 91% in 2017. In addition, [redacted] departments dramatically narrowed the attrition gap between women and men declared majors from 7% in 2008 to 2% in 2017. This strongly suggests that the effort to change the conditions under which all students experience the major is effective. This also suggests that as [redacted] institutions embed [redacted] evidence-based practices at their home institutions, the practices become sustainable.

The [redacted] program has awarded over 17,000 high school women, of whom 35% are women of color. Tracking data indicate that 9 out of 10 of these women declared STEM majors in college and most of these (82%) majored in a computing field. Award recipients consistently report positive impacts from winning the award. In 2019, these impacts included: increases in confidence in ability to pursue a technology career (85%); feeling the identity of a "computing person" (79%); and increased interest in and commitment to pursuing a computing career (78% and 72%). These metrics serve as stark contrast to the 4% of all US undergraduate women who earn engineering or computing degrees.

These comments are all from the [redacted] of the [redacted], including input from the [redacted] at the [redacted]

Future Opportunities in STEM Education

1. The COVID-19 pandemic has illuminated the digital divide that exists in Michigan. A survey of computer and broadband access in PK-12 districts was conducted in mid-April, 2020 by a division of the [redacted] The results of the survey indicated that about ⅓ or 500,000 students in Michigan were without computers in their homes and/or without access or with limited access to high-speed internet. While many school districts have provided devices to students and staff using federal CARES Act stimulus money in which Michigan received $390 million under the Elementary and Secondary School Emergency Relief Fund to support local school districts with the impact COVID-19 has had on our elementary and secondary schools, more federal funding from Congress is needed to purchase devices.

The transition to remote or distance learning has only increased the need for residents and students in Michigan to have easy access to broadband services. Rural areas, communities with persistent poverty and tribal communities are most impacted by the lack of high-speed internet or affordable broadband internet service. Home connectivity is essential during a time when education and work are relying more and more on online platforms. Home is now a more obvious extension of school and work. Now more than ever, we need federal funding to narrow and ultimately eliminate the digital divide that exists in our state.

The [redacted] fits in this space in terms of assessing and improving broadband access along with a citizen science approach to data collection within the work. This project has helped us to move beyond discussing only access to broadband services and devices and has helped us to think about a community approach to finding solutions as this is not an isolated education issue. In addition, the citizen science approach of this work helps us to solve the issue while at the same time educating individuals about the career opportunities available by learning to use the technology tools that help collect and map this data. Even if we “solve the digital divide,” understanding the appropriate implementation and usage of these tools once available and in hand is a completely different issue. This issue of quality technology implementation is in some cases a much larger issue that must be solved so that the use of digital or hybrid learning doesn’t cause an increase in inequities. Therefore we need to have greater understanding and professional learning about how best to engage learners in virtual spaces and design of curricular resources.

Finally, the survey that was completed by [redacted] in the spring needs to be redone now that efforts have been in place to close the divide. We need to continue conversations around this topic--schools that were already utilizing and had infrastructure in place to switch to hybrid and remote learning scenarios are now even farther ahead in terms of the quality of educational opportunities available to their students. For those communities that did not have the infrastructure in place or the staff familiar with interacting in this way, those communities feel the stress of this shift even more. We need to concentrate our efforts in the spaces where the need is greatest. We also need to be cognizant about and focused in our communications about the future. The solutions that we are putting in place now are actually really great possible solutions for the future of learning and work (post pandemic). The implications for solving the digital divide at a minimum allow for more flexible schedules and a lack of interruptions in schooling such as when weather related events make it impossible to meet in person. We must help everyone shift to having conversations about what we are learning during this time for the engagement of students, families, and staff and the opportunities that it opens for us in the future.

2. These suggestions are for both synchronous and asynchronous education systems and were alluded to in the previous question. Many teachers were caught by surprise when the transition to remote learning occurred in spring 2020. Those who were already familiar with the tools and technologies that make remote learning work were best prepared--this made the digital divide and inequities between communities even more stark. Remote learning instruction preparation, including pedagogies, is needed for all teachers (and faculty) going forward. Field experiences for preparation need to include virtual, hybrid, and in-person scenarios--including leading events such as virtual field trips, working with citizen science opportunities, and recognition of home/community phenomena and problems to study that link directly to education standards. At top of mind are understanding differing cultural needs, historical family relationships, and the flexibility that everyone needs to do this work well. A one-size fits all model does not work in a face-to-face setting and virtual/hybrid learning scenarios only exacerbate these inequities.

Other potential topics that we wish the formal system would embrace:

- Cohorting of students--why force different relationships to be built from what was already established in person last year? Building new relationships online--between classmates and the educator is much harder than in person.
- Treat the relationship with the educator as a primary concern--in a virtual or hybrid space, use educator teams to co-design the learning/curriculum (flexibility here) for delivery instead of responsible for one subject or classroom/on their own...we could even network across the state/nation in building OER, etc. We need to leverage in a better way curricular design experts and have local educators focused on relationships and personalizing the experiences for learners.

An example of a professional learning community where educators are able to lean on each other and the curricular development teams to co-design and share solutions with others as a necessary support in our systems is found through [redacted]. The [redacted] professional learning series is an example of this type of support for middle school teachers transitioning to remote learning formats. Teachers who have come up with good solutions share their strategies with others and teachers get a chance to work with others to reflect on the new ideas via Zoom breakouts. Example here: [redacted]

3. In addition to items we have suggested earlier, a survey of students at [redacted] administered at the end of spring semester 2020 indicated that students appreciate having the opportunity to access recordings, with captions of lectures so that they can review those materials repeatedly. Students like having the opportunity to interact, for example, in small group breakout sessions on Zoom, or in virtual study groups. They also like having one-on-one connections with their teachers via virtual office hours. The take-aways are that they like and need human connections and they want to actively participate in the learning process, we see these practices getting pushed out in exchange for mass delivery models--relationships and interactions should be the focus. At [redacted] information about the things that students liked are now being shared via a virtual learning series that includes presentations and discussions.

All of the items listed above could not be possible without access to a reliable internet connection and equipment/devices. The federal government is instrumental in focusing efforts on eliminating the digital divide across our nation.

4. In addition to what was mentioned in earlier questions, STEM education continues to be an afterthought. When we are not in pandemic times, STEM education takes a backseat to ELA and siloed mathematics instruction. This comes from a focus of teaching to what is going to be on the state assessments which comes as a priority from the federal government. We see this focus overly exacerbated in pandemic times--where schools are telling their teachers to stop teaching science and other STEM courses completely at the elementary level in order to make sure that students focus on their ELA and math courses.

For enduring sustainable changes to occur and live beyond a pandemic solution, we need an overall cultural shift that has to be prioritized in a coherent message from the federal level to individual communities about the importance of high quality mathematics, science, technology and engineering education and how these areas work together in authentic, real-world applications for the future success of our learners and communities. A coherent message that STEM education is an extremely important and useful way to engage students in their learning and that quality education in STEM actually increases literacy development is paramount. We need sustained efforts and funding to build the expertise of all educators as STEM educators by living the vision of the federal strategic plan in moving towards transdisciplinary instructional models. We also need to prioritize the benefits gained from STEM education that are not assessment driven. The continued focus on performance on state assessments needs to be diminished as a harmful practice and greater priority given to producing competencies that promote discipline convergence, problem-solving attributes, and team-driven aptitudes.

An important addition to the above statement is that schools view STEM education as expensive, that you need to have lab equipment and manipulatives to be able to teach these subject areas. This mindset then also leads to liability concerns and questions about how to provide enough equipment and get it to all of the students. We propose professional learning that helps to connect education standards with the everyday world--all of our educators should have the ability to recognize the STEM phenomena that present themselves in daily activities. We have also seen an increase in citizen science types of activities in our communities--these are a lot of times driven or supported by federal research programs and are possible for anyone to connect with. This sort of learning connects STEM to our lives and therefore makes it relevant and meaningful.

5. In general collaboration, formative assessment, and academic discourse are all good professional learning needs. Encouraging the use of more formative assessments and fewer high-stakes (e.g., finals) assessments so that students with challenging learning environments have more opportunities to demonstrate competency in multiple ways is extremely productive. The use of multiple choice tests, while easy to score, is problematic because it is easy for students with limited technology options to select the wrong choices and for students to have others take the assessment for them.

Overall, some of the greatest successes that we have seen in pandemic learning is the reconnecting of students and their families, including connecting with their communities. We recognize that there are many assumptions included in this statement, for example that families aren’t homeless, they are together, they may not be essential workers, etc. In all of these lived situations though we need to help educators be fluent in connecting individual family interests and cultural practices to the standards-focused instruction they are providing (equity learning). There needs to be solid professional learning on how to support families and educators in taking everyday activities and connecting them with the educational development of the child and recognizing these learning experiences in the formal system. In other words, we need to have greater professional learning support for place-based, culturally sustaining learning models and a shift in our values that recognizes all of the spaces where learning occurs. These approaches work whether you have access to technology or not.

6. Data/information that would be helpful to collect:

- Student and parent preference regarding remote or face to face instruction
- Students' perceptions of what works and what doesn't work
- Digital and capability divide
- What "courses" or standards are being taught
- Learn from those that have had success in this space & experts in the field, don't ask educators/schools to determine this on their own--we have possibilities for data and information gathering that are scalable and would take this burden off of local districts

Information we have collected, but would be good to learn about on a larger scale:

- Schools are offering hybrid, virtual, and face-to-face offerings at the same time and sometimes the same faculty/teachers are "teaching" all of these at the same time. This has more than doubled the workload for many and is not sustainable over a long term. Some of our institutions are monitoring how staff are modifying the modality of their courses through time and also tracking the costs associated with the equipment/training/time needed to offer multiple options.

8. Here is a summary of the programming that we supported with state funds to help leverage the expertise in curriculum related programming on behalf of the entire state (and in some cases national reach). The following programs are ones that we have supported with former MSP funds and state funds over a number of years. By leveraging the curriculum development experts for these programs and some of our teacher leaders that could describe the constraints and needs for shifting these primarily face-to-face curricula, we were able to impact the largest number of educators using a similar program across the state. Instead of educators having to adapt these programs by themselves, we organized the adaptation for hybrid and virtual learning environments and then are organizing embedded PD throughout the year to support the ongoing usage and modifications needed. As these have just been released, we don't have data collected or formal feedback on these efforts yet, but initial responses have been positive.

Program	**Response**
Cereal City Science	•New online curriculum created, and training offered to Teachers at no cost •Curriculum, materials, teacher guides to Region 9, 12, 14 •Teacher Guides 2nd edition for 3rd & 4th grade Physical Science curriculum to existing districts statewide
Code.org	•Development of curated resources for

	educators to deliver lessons remotely or virtually •Professional learning seminar to guide in use of resources
Great Lakes Stewardship Initiative	•Creation of (3) new pandemic-proof project-based challenges for existing hubs •OER resources on place-based stewardship education and case studies •Video – teaching how to use the outdoors, safety and norms
Math Recovery	•Early Number Bundle-set of 3-Slide Decks •Up to additional 3-slide decks for virtual instruction •Math Recovery certified educators receive Annual Membership Renewal
Mi-STAR	•Share two remote learning lessons linked to OER and create professional learning videos to accompany the lessons •Support teachers through a virtual Mi-STAR Learning Series of instructional videos explaining a variety of technology-enabled pedagogies and tools (Jamboard, etc.)
NGSX	•Creation of professional learning materials to support implementation of NGSX •Guidance for teachers and families on how to use materials in student home •Virtual facilitators training for pilot initiative
Phenomenal Science	•Develop example remote learning resources and curation of online units •Conduct professional learning sessions and create a teacher network

As we continue our efforts and thinking, we are exploring other opportunities for STEM learning where we can leverage the power of a connected ecosystem now that geographical boundaries are removed since most people and activities have transitioned to a virtual space. Initial conversations have been around connecting out of school programming with the formal school “classroom” learning, virtual field trips and career fairs, virtual mentoring opportunities and expanded professional learning communities for educators that reach across the state. The pandemic has accelerated the conversations that we were trying to have to connect the in school and out of school spaces and to bring opportunities and experts only available in certain parts of the state (or world) to all students, families, and educators. We haven’t done more than this because we didn’t want to overwhelm schools with resources--there needs to be better coordination across the state for support.

Develop STEM Education Digital Resources

9. Vetting websites continues to be a challenge as lots of organizations create websites and web-based resources. It would be great to have some sort of vetted/quality standard.
We would love to see the federal citizen science supported website built out further--how to connect actual STEM research and work that is happening where members of the general public and schools can participate is extremely useful. It would be great if this was expanded to help educate on how everyday phenomena can be successfully adapted into a packaged curriculum that a school may be using. This is a critical adaptation skill that the pandemic has highlighted as a missing skill for many educators (and family supports). Educators (and families) sometimes don’t see the connections between phenomena and a broad range of standards that relate to it. Culturally-affirming and sustaining practices are important to consider as part of this set of resources. We need tools to help us understand the community we work with well enough to make these relevant connections.

Federal support / websites and resources also help to make links beyond the local public education system. For example, is there programming that could use the radio and television stations as broadcast/learning tools that may be more readily accessible to all (i.e. help with the digital divide)? This would include support for broader family engagement in the learning. While curriculum and professional learning resources are both needed, a federal website would be most effective if it linked to resources that are specific to individual states since states also have their own unique needs.

10. We represent STEM leadership voices from the State of Michigan and work across many different perspectives and sectors. Therefore, we are looking for aligning efforts across the home learning space, out of school formal and informal spaces, and the formal classroom. There must be a coherent, equitable vision for STEM education across all of these spaces and support for this common vision in each space in order to make the transformative changes we need to see in education.

11. We would prefer grand bands and subjects as a categorical option, but we also need a way to show the intentional disciplinary convergence (as called for in the federal plan). If we

continue to silo learning by space, age, and subjects, then we won't see the transformation that our needs/goals call for. We caution against creating a tool that further encourages the disconnect between lived and school experiences. We need tools that show the way you connect equity with transdisciplinary learning and the application to life/careers in an intentional way.

The citizen science website is a good start https://www.citizenscience.gov/#.

Increase Diversity, Equity, and Inclusion in STEM

12. We applaud this section and question and it greatly needs to be answered. We are too early in our processes and strategies to effectively report, but we are focusing on transformative strategies versus mitigating strategies in order to address these issues. We believe that there is real opportunity to learn from business and industry how they market, recruit, retain, and develop talent. We believe that there is promise in switching to competency based models for educator continued learning and micro-credentialing systems for continued certification. We also believe that utilizing state approved CTE programming that allows for dual enrollment and pre-college credit earning opportunities are important ways to make the education preparation process more affordable. We also are trying to be strategic in the way that we engage older students as "mentors and educators" for younger learners...they may find that they enjoy "teaching" and decide to follow that career path, plus it helps to have representative populations in front of our students. We also need to target our state and federal funds to populations that are most needed--this includes serving rural populations as well.

Engage Students Where Disciplines Converge

13. We promote 3P pedagogical work. 3P means problem-, project-, and/or place-based learning opportunities for students. It is backed by research, is more engaging for students, allows for natural convergence of disciplines--at any ability level of student skills without being "obvious" to other students that they may be working at a different level, allows for authentic study of the content areas while at the same time allowing learners to explore and be exposed to multiple careers and technology uses. Ultimately, 3P pedagogical approaches attend to equity--with students and their communities placed at the center of learning as well as the solutions they provide. Currently we are trying to support the shift to this type of learning systemically. In most cases, this type of learning happens in extracurricular or elective settings. To support this work, we have started using our state dollars for professional learning to begin building the coursework that allows for transdisciplinary learning. There are some research projects and curricular programs that are moving forward in this space that we encourage further work by grant funding. We also are building a soon to be released hub of resources that is intended to be implementation

practice guides that help whole school systems shift to a 3P model. It is integrated with our state school continuous improvement model.

One such [redacted] built curricular model is [redacted]. Each curricular model is centered on a real-world challenge drawn from the Engineering Grand Challenges and each unit requires the integration of content from across the traditional disciplines (including engineering) in order to address the challenge. [redacted]

Develop and Enrich Strategic Partnerships

18. Our state Council business representatives say that we need to recognize that our business and manufacturing communities have stepped too far away from the direct learning that happens in the formal k-12 system. We must have more transparency for students and educators about the work that is done in industry.

19. We are part of the STEM ecosystem organization as a state and we have two regional ecosystems that are recognized as well. The national group opens connections up across the country and provides a learning environment for the professionals in our state that are responsible for the same roles in other states. Every "job" needs a professional learning community and the ecosystems group really helps with that. There is also a potential for connecting to funding that we aren't already aware of across the nation.

It would be helpful if there were more personalized interactions to further the learning that is possible. (We have not experienced the first ever virtual convening yet and that may be different.) Currently, the conferences are too large to walk away with deep learning that helps us get to implementation and success. While the conferences are extremely inspiring and you can learn what other states are doing, the nuts and bolts of implementation come from closer, more spontaneous/organic interactions with individuals.

The private sector can serve in many roles, but the largest is being willing to work directly with local educators and districts. If they open their doors for educator externships, then this is the beginning of helping the community make direct connections in classrooms with what they do in that industry. They could serve as representatives of "who" works in these professions to present a more inclusive picture of STEM for students. We also need them to be open to 3P (project-, place-, & problem-based) learning methods K-12, not just focused on the immediate pipeline that CTE models tend to produce--but the longer term payout and positive community building that comes from partnerships throughout a child's life.

Our STEM ecosystem has done many direct efforts in the local 16 regions that stretch across the state, but as a state we have pulled together curricular experts from each of the curriculum programs that we support with state funds to build the virtual and hybrid learning modules for schools using these programs. Here is a summary of the programming that we supported with state grant funds to help leverage the expertise in curriculum related programming on behalf of the entire state (and in some cases national reach). The following programs are ones that we have supported with former MSP funds and state funds over a number of years. By leveraging the curriculum development experts for these programs and some of our teacher leaders that could describe the constraints and needs for shifting these primarily face-to-face curricula, we were able to impact the largest number of educators using a similar program across the state. Instead of educators having to adapt these programs by themselves, we organized the adaptation for hybrid and virtual learning environments and then are organizing embedded PD throughout the year to support the ongoing usage and modifications needed. As these have just been released, we don't have data collected or formal feedback on these efforts yet, but initial responses have been positive.

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As we continue our efforts and thinking, we are exploring other opportunities for STEM learning where we can leverage the power of a connected ecosystem now that geographical boundaries are removed since most people and activities have transitioned to a virtual space. Initial conversations have been around connecting out of school programming with the formal school "classroom" learning, virtual field trips and career fairs, virtual mentoring opportunities and expanded professional learning communities for educators that reach across the state. The pandemic has accelerated the conversations that we were trying to have to connect the in school and out of school spaces and to bring opportunities and experts only available in certain parts of the state (or world) to all students, families, and educators.

Build Computational Literacy

20. Computational literacy can be found within multiple disciplines so, no matter the subject being taught, educators can incorporate computational thinking skills. By interweaving the computational thinking skills, students are able to enhance their learning of the core concepts. Along with that, they can take their learning to a level beyond traditional subjects. Allowing them to include simulations, algorithms, and complex sequencing. The challenge of

integrating computational thinking requires having the knowledge to apply computer science rather than learning computer science as an isolated disciplicline. Interweaving core subject learning and computational thinking requires a depth of knowledge in both fields of study. Currently, the majority of educators are lacking the efficacy in computational thinking to effectively integrate into other subjects. Emphasizing the importance of content creators to integrate computational thinking at the curriculum level is necessary.

21. To ensure that computational literacy is integrated within STEM education, educators need to understand the added benefits that it provides and not see it as taking away from instructional time in other subject areas. Having a solid understanding of the benefits and how to implement provides educators the willingness to interweave the skills. From a policy perspective, Michigan has adopted K-12 Computer Science standards that encompass computational literacy. This framework provides districts with an understanding of what computational literacy skills they should be incorporating and provides grade band implementation to ensure that it is age appropriate. Unfortunately, without any accountability or funding for districts to do implementation work, integrating computational thinking is considered a secondary priority to traditional subjects.

22. Currently, the majority of programs, content, curriculum, education, and training opportunities in Michigan revolve around teaching computer science as a stand alone course. Educators have access to multiple options such as Code.org, Project Lead the Way, CS Awesome, and CS FIRST for teaching CS on its own but have little support when asked to integrate the computational literacy options. There are a few Michigan Science curriculum teams that are actively revamping curricular materials to naturally include computational literacy. As an example, [redacted], a middle school science curriculum group from [redacted], is incorporating computer science tools districts commonly use into everyday science lessons.

Community Use and Implementation of the Federal Stem Education Strategic Plan

24. By having a federal STEM plan and showing alignment with our state plan, it helps give legitimacy to our work. This helps to recruit and engage potential partners to move forward the goals and build our statewide STEM ecosystem. Fortunately, the work that our state has been doing for STEM was well-aligned to the federal strategy to begin with. Our state STEM definition in policy language speaks to moving forward cross-disciplinary learning and our recently [redacted] also calls for elevating computational literacies and computer science. More specific changes have been focused on preparing students at the post-graduate level to earn more smaller credentials that can stack to larger credentials. This is also something that we hope to accomplish in the classrooms that are focused on truly integrating content areas with technology that could be industry recognized at the k-12 level. We feel like the best way to integrate across disciplines and to explore careers in an

authentic way is by helping communities move towards problem-, project-, and/or place-based learning opportunities that blend learning that happens within and outside of the classroom. This might include integrating general education programs across disciplines using a topical focus (e.g., water). We are currently building and launching a STEM hub that is intended to support communities in transitioning to problem-, place-, and project-based learning. This is directly connected to our state’s school continuous improvement process and communicated by connecting to top industries in our state. Currently we are working across government agencies in supporting a water stewardship and cybersecurity program. Mobility is on the horizon with a pilot program that was begun this summer.

[redacted]

[redacted] Response to National Science Foundation's Request for Information (85 FR 55323)

October 19, 2020

The [redacted], a coalition of youth serving organizations, researchers, and national partners involved in out-of-school STEM learning has gathered the following feedback from across our networks in response to the Request for information from the Office of Science and Technology Policy. The [redacted] is coordinated by the [redacted] and you can learn more about the [redacted] at [redacted]

The [redacted] has submitted responses to the following questions:

Future Opportunities in STEM Education – 1, 2, 4, 5, 6
Increase Diversity, Equity, and Inclusion in STEM – 12
Develop and Enrich Strategic Partnerships – 18
Build Computational Literacy – 20, 22

Future Opportunities in STEM Education

1. What COVID-19 related digital barriers (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?
[redacted] members and afterschool programs quickly transitioned to virtual learning in the spring of 2020 and have continued offering the majority of their programming virtually into the fall. The biggest barrier cited by these programs is a lack of technology and internet access, especially for those programs serving some of the most under resourced communities.

In a survey conducted by the [redacted], afterschool and summer program providers expressed concern about the technology needs of their participants, with concerns higher among providers serving majority low-income students. 78% of providers serving majority low-income students said that it is "extremely" or "very" important to get more online resources and more student access to technology in their summer programs compared to 53% of programs serving a majority of higher-income students. Low-income parents are also more likely to be very concerned about technology and internet access to support participation in distance learning, compared to higher-income parents (50% vs. 40%). These numbers are likely to remain the same or increase over the fall as parents rely even more on afterschool programs for support.

To address these concerns, there should be additional funding and flexibility in Title IV, Part B of ESSA for 21st Century Community Learning Centers to help parents return to the workforce and help children continue their learning in an academically supportive environment, including the hours when schools are operating virtually and not offering classes in-person. This dedicated

[redacted]

assistance will allow afterschool programs to provide engaging learning for school-age children and youth to support low-income parents who are less able to work from home and face greater difficulty paying for care and educational programs for their children. More funds and flexibility would also support investments in safety measures, such as additional PPE, lower staff:student ratios, and increased space requirements.

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (e.g., virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (e.g., pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

Afterschool program providers who move to virtual programming face a steep learning curve that requires an understanding of best practices in remote education; many programs were not equipped with training on how to effectively engage students, not unlike the experiences of formal school day teachers. Going forward, more research and professional development focused on effective remote engagement practices will be helpful to educators, particularly afterschool educators, as the shift to virtual learning persists even after a return to in-person programming.

For students, more opportunities to experiences hands-on STEM learning in a remote environment are needed as we emerge from the pandemic. New remote or virtual opportunities to support science and engineering activities, integrated through computing education, can help students recover some of the lost opportunities to engage in STEM learning. Additionally, remote internships, apprenticeships, and mentorships that allow students in remote parts of the country to engage with mentors or employers in other states or cities could further engage and inspire students to pursue STEM careers.

Finally, Advancing Informal STEM Learning (AISL) funding from the National Science Foundation is integral to supporting and developing new strategies to engage students. AISL has supported numerous out-of-school time STEM projects in the past, and expanding AISL to support new projects that address virtual and remote learning practices will be critical.

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

The greatest inequities that have arisen during the pandemic stem from existing limitations around access to technology and capital (both human and monetary). With many afterschool programs serving some of the most under resourced and vulnerable students and communities, there has been a greater reliance on these community partners to step in and serve the basic

[redacted]

needs of students, like helping students access food, get equipped for virtual classes, and oftentimes acting as mental health supports for those struggling with the day-to-day demands and impacts of a global health crisis.

The STEM education needs of students are clear. Effective and engaging STEM learning experiences that help students understand the potential careers available to them and the pathways to pursue those careers will have an even more important role as our country recovers from the pandemic. Schools will be focused on catching students up on the learning they've missed. ESSA requirements suggest that educators will focus on the subjects relegated to annual testing, often at the expense of science, computing, and other STEM subjects. This will place an even greater reliance on community partners, such as afterschool programs, science centers and museums, and other informal STEM partners to supplement the STEM learning students will need. These are the types of collective partnerships that should be supported and included in federal policies and legislation aimed at rebuilding our economy and education ecosystem.

5. What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

The steep learning curve associated with digital and virtual learning requires training on how to effectively engage students. The federal government should prioritize research on effective professional development and remote engagement practices that provide educators the promising practices to engage students virtually.

STEM educators will also need to understand how the pandemic has adversely affected students' understanding and interest in STEM subjects. Understanding how much learning time has been missed by those students, particularly low-income students who so often do not have the same learning opportunities or support structures that middle and high-income peers have, is necessary to apply interventions that address these gaps and help students recover knowledge in STEM subjects.

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

The STEM education community will need to understand how much learning time, particularly in STEM subjects, students have missed throughout the pandemic. Additionally, the Department of Education should collect and make public information on how states, districts, and schools have utilized CARES Act funds and any additional federal assistance packages.

[redacted]

For the afterschool field, understanding how innovative models have impacted students throughout the course of the pandemic, and helping other communities replicate similar models will be critical moving forward.

Increase Diversity, Equity, and Inclusion in STEM

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

Afterschool programs serve around 10 million students annually, with 7 million of those students participating in STEM educational opportunities in their program. Communities large and small, urban and rural, understand the benefits provided by afterschool programs. Thanks to current public investments, these programs overwhelmingly serve young people from low-income and racially marginalized communities, the same communities that are often underrepresented in STEM professions and careers. Afterschool and summer programs are an effective avenue for reaching the demographics often targeted by efforts to broaden participation in STEM fields. These programs serve students from low-income and underserved communities with proven results, from increased school-day attendance to higher rates of interest in STEM subjects and careers. Nevertheless, for every student in an afterschool program (10.2 million in 2014), there are two awaiting access. In rural communities, the number awaiting access increases to three, showing that demand for afterschool opportunities is high across the nation.

The [redacted] are focused on providing additional opportunities for students to experience STEM programs and activities, understand potential career paths associated with STEM, and equip them with the skills to pursue those new interests. Afterschool programs have the ability to meet students where they are and help them understand how classroom learning can translate to a real world experience. The flexibility of this environment also helps students try new activities or programs without the risk of failing or experiencing success, building interest and resiliency among students. The deep history and experience that afterschool programs have in their communities are a resource that must be engaged as we reemerge from the pandemic and better understand the needs of our students.

Develop and Enrich Strategic Partnerships

18. What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities?

[redacted]

If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

Afterschool programs present an opportunity to support work-based learning programs, and the Department of Education recently acknowledged this when it released a funding opportunity for 21st Century Community Learning Centers to support programming around career pathways through credentialing and internships. Moving forward, leveraging the infrastructure and communications channels of the federal government to share examples of these community partnerships with afterschool programs and work-based learning will go a long ways in helping replicate these models in other parts of the country.

Additionally, understanding how remote career exploration, mentoring, or work-based learning experiences have been successful during the COVID-19 pandemic will help to expand these opportunities moving forward, bringing new opportunities to students in traditionally underserved and rural communities.

Build Computational Literacy

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

Afterschool programs have the advantage of operating outside of the parameters of the school day, providing the flexibility and low-risk environment for students to try new things and connect to future careers and pathways. This flexibility provides more opportunities for students to engage in computer science activities in their afterschool or summer programs. Oftentimes, these CS activities are incorporated into weekly STEM programming like robotics or digital media that combine various STEM concepts.

Persistent obstacles for access to computer science in afterschool are limited professional development offerings, funding, and access to technology. Additionally, a greater integration of afterschool and out-of-school time partners in school district efforts are key to expanding these opportunities. Professional development offered by school districts must be open to afterschool staff to attend and receive this training, allowing for additional opportunity to engage students in CS after the school day ends.

22. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.

The [redacted] published a guide on providing computer science opportunities to students in afterschool programs that provides a list of curriculum, professional development, and programs examples. That guide can be found at [redacted]

[redacted]

[redacted]

October 19, 2020

Suzanne H. Plimpton
Reports Clearance Officer
National Science Foundation
Washington, DC 20002

RE:85 FR 55323 - Document #2020-19681

Submitted online to: CoSTEM@nsf.gov

Dear Ms. Plimpton,

Since 1984, [redacted] has worked relentlessly to ensure that our nation is one where learning has no limits for all individuals. We pioneered [redacted] a set of principles and guidelines for inclusive curriculum design that is now included in the Every Student Succeeds Act (ESSA), the Higher Education Opportunity Act (HEA), the Strengthening Career and Technical Education for the 21st Century Act (Perkins V) and the National Education Technology Plan. [redacted] writes to comment upon the National Science Foundation (NSF) Request for Information (RFI) related to the implementation of the Federal STEM Education Strategic Plan, Charting a Course For Success: America's Strategy for STEM Education.

[redacted] is a non-profit organization that uses educational technology coupled with our expertise in the learning sciences to ensure all learners can and do reach their full potential. With grants provided by the NSF, U.S. Departments of Education (ED) and Labor (DOL) and the private sector, we work to ensure the full power of UDL is utilized to harness technology and instructional practices to remove barriers to learning in digital as well as physical settings. UDL encourages the design of flexible learning environments that anticipate learner variability and provide alternative routes or paths to success; UDL acknowledges that variability across all learners is the *norm* rather than the exception. UDL provides both viable alternatives for *all* learners to benefit from remote education and a responsive framework to support educators in their professional learning and application in the remote teaching environment. [redacted] aim is to create a level playing field where all learners have equitable opportunities to succeed.

Our comments will focus on: Future Opportunities in STEM Education (Q1-Q5); Develop STEM Education Digital Resources (Q9-Q10); Increase Diversity, Equity, and Inclusion in STEM (Q12-Q13); and, Develop and Enrich Strategic Partnerships (Q18).

Future Opportunities in STEM Education.
Q1: Answers:

- **Increasingly, education and training programs of every level and type are incorporating significant digital and online components.** Yet, despite the promise of flexibility, customized, learning solutions, and anywhere/anytime educational opportunity often associated with digital learning – especially for learners with challenges such as those based in poverty, language, disability, or something else, the reality is often dismal. Leveraging the UDL framework is essential to mitigating the current impact of digital learning because the population of digital learners is predictably diverse, and every federally supported training program must plan for that to ensure the effectiveness of these investments. This urgency is only intensified by the need for the U.S. educational system to respond to the COVID-19 pandemic with a wholesale shift to digital learning methods.
- **In these challenging times, the NSF can help states and districts tackle an unprecedented crisis and turn it into an opportunity that changes the future for good**. All students, young adults and others seeking an education as well as career training, including those who may struggle due to low literacy, language, disability or other factors can be taught remotely when they have the right technology including accessible materials and when their teachers and instructors have the right tools and training.

Q2: Answer: The COVID-19 pandemic is creating an inflection point that while unanticipated, can also be viewed as an opportunity to assure equitable access to education and workforce training. [redacted] is directly engaged with teachers and students across the United States in implementing the UDL framework—including during this abrupt, nationwide transition to online and remote learning. Without question, our work with States, districts, schools, and individual educators, as well as students and parents, convinces us that students of all ages and their families are depending on us to support them in their right to receive a high-quality education, especially during COVID-19.

Q3: Answer: Collaboration eliminates geography barrier(s) and promotes all types of professional sharing in K-12 schools that have not previously worked together. A district that was implementing UDL in all of their schools had never collaborated across the six schools before. With remote learning and Zoom they realized that the barriers to collaboration across schools disappeared. They have now begun collaborating among the principals, school trainers/coaches, and teachers -- all working together more seamlessly. Another example of the disappearing barrier of geography is that it is so much easier to have expert visitors 'visit' your professional learning classroom – scientists, engineers, authors, national experts etc. can be invited to support teacher learning. Visitors can also come to 'class' with students as well.

Q4: Answer: **STEM teachers conducting remote teaching do not have access to their lab(s)**. This challenge is frustrating for all STEM teachers involved in remote teaching. Conducting experiments, building and designing in engineering classes gives access to many learners who do not engage in other kinds of classrooms. Not having access to these tools and spaces has cut learners off from a hands-on experience. Online modelling, simulations, virtual experiments, video recorded experiments have helped with this problem. The best solution that [redacted] has experienced is having a teacher teach chemistry concepts by having students use common kitchen ingredients to do their own experiments at home. Connecting with Q3 – if teachers also connect with visiting scientists students can potentially witness experiments that visitors have the capacity and lab to conduct -- even those that are beyond what you would ever be able to conduct in a school science lab.

Q5: **Answers:**

- **Teachers trained in the use of UDL must be more broadly available.**
- **Accessible materials are not widely available to all students, including English Learners, students with low literacy and students with disabilities.**
- [redacted] **urges NSF to ensure that every STEM teacher has the opportunity to be trained and receive a credential in the use of UDL**.

With funding from ED and from private foundations, [redacted] is leading [redacted], a field-building initiative to stimulate, support, and sustain best practices in UDL education program design, product development, and classroom instruction to meet the growing global demand among educators for UDL as a design framework that recognizes variability among all learners. [redacted] is built to support, celebrate and grow with educators and is a new education power tool that supports educators throughout their careers and is especially relevant given the changes hoisted upon educators due to COVID-19. By ensuring credentialing in UDL is supported in teacher professional learning - to increase the capacity of educators - NSF will align its investments and give teachers and other educators access to best UDL practices in program design, product development, and classroom instruction.

Develop STEM Education Digital Resources

Q9/Q10: Answer: [redacted] **has developed web-based resources funded by NSF, other federal agencies and the private sector. Examples are:**

- [redacted]**:** The [redacted] program is led by [redacted] with funding through the National Science Foundation. [redacted] provides an e-portfolio called [redacted], for each student in which they can collect information, reflect and record information regarding STEM careers of interest, chronicle their STEM learning in both classroom and job sites related to those careers, and take actions to connect with STEM postsecondary and employment opportunities. For educators, rubrics are provided so that teachers can evaluate students' understanding of various careers and the quality of materials in the student portfolio.
- **Open Educational Resources and Digital Learning Materials:** Through ED's Office of Special Education, [redacted] leads the [redacted] in creating a suite of innovative tools designed to support today's diverse learner needs by making digital educational materials--including open educational resources (OERs)--accessible, flexible, and engaging for all students. [redacted] is exploring key aspects of digital learning such as: which learning supports should be prioritized when designing curricula? and how can OERs be made more accessible across content areas and for various grade levels and types of learners?
- [redacted] With NSF and ED funding, the [redacted] is designed to support elementary school students with learning disabilities in active science learning. Study results have shown the tool's supports for science learning and the science inquiry process have statistically significant effects on SWD science performance and their motivation for science learning.

- [redacted] With NSF funding, this project is designed to enhance student engagement and learning through a Google application (app) designed for students and teachers to use to collaboratively answer questions requiring higher order reasoning.

Increase Diversity, Equity, and Inclusion in STEM
Q12: Answers:

- [redacted] **is explicitly designed to increase diversity and inclusion in STEM.** By partnering with YouthBuild USA in the design and piloting of the tool, [redacted] has made sure that [redacted] supports STEM learning and career pathways for young adults who are members of ethnic minority groups and who are economically disadvantaged--many of whom have dropped out of traditional high school paths and may also be justice-involved or be young parents. [redacted] is another example of how we are working to increase diversity and inclusion in STEM.
- **Makerspaces can increase access to STEM engagement, learning and opportunity**. Makerspaces have cropped up in schools, libraries, museums, and other settings, but low-income communities have not had the same access to these resources and their learning opportunities as more affluent ones. [redacted] is changing that by working in partnership with an affordable housing complex in Stamford, CT. With NSF funding, we are co-designing makerspace guidelines and workshops that can be hosted and sustained in affordable housing complexes across the country in order to provide an engaging, accessible route to embed STEM learning in families' lives, allowing caregivers, children, young adults, and neighbors to gather and share their existing knowledge and skills and build on it, using STEM to meet personally relevant goals, be these to pursue a STEM career pathway or nurture a hobby or interest.

Engage Students Where Disciplines Converge
Q13: Answer: [redacted] **engages students in multidisciplinary learning.** In addition to encouraging diversity, equity and inclusion in STEM, our [redacted] is also an example of how to engage students in multi-disciplinary learning. The workshops and [redacted] we are creating will support students and their families in participating in problem-based and project-based learning: interdisciplinary learning that will be hands-on, collaborative, and driven by authentic concerns.

Develop and Enrich Strategic Partnerships
Q18: Answer: [redacted] **work with Youthbuild exemplifies how Federal investments in UDL support STEM education that targets students who may otherwise be hard to engage.** Wherever possible, [redacted] works to leverage UDL in partnership with programs and organizations that are already working in the field. For example, instead of creating a separate STEM enrichment program in K-12 schools, we work to help educators improve instructional practice through the application of UDL. In addition, [redacted] utilizes DOL investments in UDL which focus on programs such as YouthBuild--which provides career training pathways for low-income young adults so they can reclaim their education, gain the skills they need for employment, and become leaders in their communities. These youth are also exposed to [redacted] as one example of our partnership and ability to integrate within existing equity programs. Our work with Youthbuild is just one example of how programs can be designed to engage all types of individuals including those who have not been served well by the status quo of public education.

In conclusion, leveraging the UDL framework throughout the *NSF STEM Education Strategic Plan* is essential to mitigating the current impact of digital learning because the population of digital learners is *predictably diverse* and investments made to support teachers and students must plan for that. NSF's urgency in investing in the plan is supported and intensified by the need for the U.S. educational system to respond to the COVID-19 pandemic with a necessary shift to digital learning methods so that students do not experience cataclysmic gaps in learning.

We appreciate the opportunity to comment.

Sincerely,
[redacted]

[redacted]

[redacted]

Comments of [redacted] to Request for Information,

"Charting a Course for Success: America's Strategy for STEM Education"

85 Fed. Reg. 55323 (Sept. 4, 2020)

Submitted October 19, 2020

The [redacted] is [redacted], one of America's top export industries and a key driver of America's economic strength, national security, and global competitiveness. Semiconductors – microchips that control all modern electronics – enable the systems and products we use to work, communicate, travel, entertain, harness energy, treat illness, and make new scientific discoveries. The semiconductor industry directly employs nearly a quarter of a million people in the United States, and is the nation's 5th largest export by revenue. In 2019, U.S. semiconductor company sales totaled $209___ billion, and semiconductors make the global trillion dollar electronics industry possible. SIA seeks to strengthen U.S. leadership of semiconductor manufacturing, design, and research by working with Congress, the Administration and other key industry stakeholders to encourage policies and regulations that fuel innovation, propel business and drive international competition. Additional information about [redacted] is available at [redacted].

The U.S. semiconductor industry accounts for roughly a quarter of a million direct jobs in the U.S.. These jobs are split across a range of occupations, with the largest two segments being production occupations – such as factory technicians and line workers (38 percent of the total workforce) and engineering occupations – such as electronics and electrical engineers and chip design engineers (26 percent). In addition, each semiconductor industry job creates nearly 5 additional jobs in the broader economy, on average, meaning the industry creates more than 1 million jobs across the economy.

The U.S. semiconductor industry's innovation edge rests on the efforts of scientists and engineers to develop innovative products that are better than the competition both here and abroad. One of the biggest challenges U.S. semiconductor firms face is recruiting and retaining top science

[redacted]

and engineering talent. [redacted] companies are actively engaged in workforce and skills development efforts throughout the country, but a comprehensive STEM education strategy is urgently needed to maintain America's talent pipeline and technological edge. Developing the best-and-brightest scientists and engineers domestically, and recruiting talent globally, is critical to ensuring semiconductors remain a top U.S. export and our industry continues to be a key driver of a strong and innovative American economy.

STEM Education Should be a National Priority

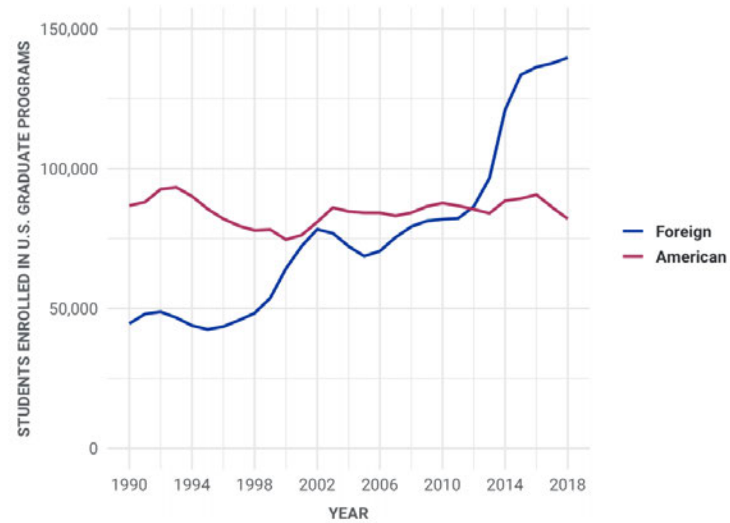
To maintain global semiconductor industry leadership and ensure America wins the worldwide race to develop and implement the technologies of the future, the U.S. needs a highly skilled workforce. Leadership in semiconductor research, design, and manufacturing requires access to the best and brightest scientists and engineers from around the world, as well as skilled technicians and other occupations requiring STEM proficiency. In the global race for talent, the U.S. educational system is failing to produce a sufficient number of American workers and students with the necessary STEM expertise to meet the needs of the semiconductor industry and other technology fields[1].

[1] "Winning the Future: A Blueprint for Sustained US Leadership in Semiconductor Technology" April, 2019.

[redacted]

The U.S. is also falling behind its global competitors in most education benchmarks[2]. China is producing many more bachelor's degrees in STEM fields. At the graduate level — which generates the expertise in materials science, physical chemistry, electrical engineering, and other fields of importance to the semiconductor industry — a large percentage of students in relevant fields at U.S. colleges and universities are from foreign countries. In electrical engineering and computer science graduate degree programs at U.S. colleges and universities, the National Science Foundation (NSF) indicates that approximately 80 percent of students are from foreign countries, a rapidly increasing trend[3]. The U.S. needs a comprehensive long-term plan to attract young students — particularly underrepresented women and minorities — to science and engineering and expose them to work in labs, advanced manufacturing, and apprenticeships.

Figure 3. Number of domestic and international students enrolled in semiconductor-related graduate programs at U.S. universities, 1990–2018.



Source: NSF Survey of Graduate Students and Postdoctorates in Science and Engineering. Data includes students in Electrical, Electronics and Communications Engineering and Computer Science.

The number of American students enrolled in semiconductor related graduate programs (around 90,000) has not increased since 1990. In that same period, the number of international students nearly tripled from 50,000 to 140,000 (Source: "The Chipmakers", Center for Security and Emerging Technologies, Georgetown University, 2020)

The Federal Government Should Double Funding for STEM Education

To meet these needs over the long-term, the federal government should increase U.S. investments in STEM education by 50 percent and implement a national STEM education initiative to double the number of American STEM graduates by 2029. Policymakers should support apprenticeships and training programs and work with industry and academia to develop curricula to match the needs of growing technologies that are critical to the future of the

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[2] "Second Place America? Increasing Challenges to US Scientific Leadership," Task Force on American Innovation, 2019.
[3] "National Science and Engineering Indicators", National Science Foundation, 2019.

[redacted]

semiconductor industry, such as artificial intelligence, quantum computing, and advanced wireless networks. Furthermore, the 200+ federal STEM programs across agencies need consolidation and measurement, in additional to increases in funding.

The Federal Government Should Promote High Quality STEM Education

Over the long-term and in order to build the next generation of innovators in the semiconductor industry, the federal government must do more to promote high quality STEM education at the K-12 level and up through the higher education system. Studies have shown that students who do not get interested in STEM in or before middle school are much less likely to choose a STEM education path and career[4]. Federal agencies and fees collected through the U.S. high skilled immigration system provide some of the funds for federal K-12 STEM programs; however, the majority of the funding for K-12 education comes from the state and local levels. The largest fraction of federal funding for K-12 education comes in the form of Title I non-discretionary grants from the Department of Education, which should be better targeted toward developing STEM capable students.

Math Proficiency a Limiting Factor for The Domestic Pipeline into STEM fields

According to the most recent National Assessment of Education Progress (NAEP) report, 66 percent of fourth graders are not proficient in science and 60 percent were not proficient in math. Mathematics proficiency is a critical to entrance into all STEM fields, and in particular, the semiconductor fields of electrical engineering, computer science, materials science, and other related scientific fields.

The America COMPETES Reauthorization Act of 2010 included funding for the UTEACH program, now part of the National Math and Science Initiative (NMSI). By allowing math and science majors to earn teaching certificates while earning undergraduate degrees, the UTEACH program increases the pipeline of highly qualified math and science teachers[5]. By providing students with highly qualified math and science teachers, the nation can drastically increase the pipeline of

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[4] "State of STEM: Determining High Impact Pathways for the Workforce of the Future", STEM Education Coalition.

[5] National Math and Science Initiative, 2020.

students who are able to achieve math proficiency, subsequent science proficiency, and then enter STEM fields and professions.

STEM Education Initiatives Should Include Apprenticeships

Government and industry should partner to develop industry-led apprenticeship models that are flexible enough to meet the rapid change in advanced manufacturing industries, including semiconductors. Studies have shown that internship or apprenticeship experiences can greatly accelerate new employees' ability to get up to speed and full productivity. Unfortunately, U.S. semiconductor firms find that the existing apprenticeship model is too inflexible for this rapidly changing advanced manufacturing sector. Apprenticeship models must also provide an incentive, potentially in the form of federal funding, for employer participation. Some [redacted] members are pursuing new, industry-driven apprenticeship models to meet their needs[6].

Engage State and Local Governments

State and local governments should actively engage with U.S. semiconductor firms to incentivize siting of new facilities and workforce development. One [redacted] member noted that they have maintained design facilities in certain locales, even as they have shuttered co-located manufacturing operations, because of strong engagement by the state and local government to provide incentives to the company to stay and grow locally. These types of engagements at the state and local level are important avenues for maintaining and growing U.S. semiconductor employment. Firms should also engage workforce development boards and other avenues to build partnerships for workforce development efforts around the country.

Increase Investment in AI Workforce Development Programs

Artificial Intelligence (AI) is bringing disruption across industries and education is no different. AI has the potential to boost rates of profitability by a significant amount (about 14 trillion USD

[6] For example, Citizen Schools, where Western Digital employees lead 10 week in-classroom apprenticeships on a variety of topics including 3D printing, Science, and Mathematics to middle schools students. Other SIA member companies also conduct similar programs.

economic boost by 2035), and AI adoption is just beginning across the industry. The federal government can play a role by funding community college programs that will increase AI workforce readiness and can serve as reskilling centers for workers. Community college systems can be the catalyst for making AI technology skills accessible to as many workers nationwide as possible. Increasing investment in programs such the NSF Advanced Technological Education (ATE) program would help close AI skills gap. With an emphasis on two-year Institutions of Higher Education (IHEs), the focus on educating technicians in a wide array of industry with AI skills will help drive our nation's economy. The program focus on developing partnerships between academic institutions and industry is the right model to build new AI skills sets for future and existing workforce.

Lack of Diversity is Narrowing the Domestic STEM Pipeline

There is a lack of diversity in the U.S. semiconductor workforce and broader STEM pipeline. Representation of women and underrepresented minorities in STEM, and especially in the physical sciences and engineering, has been persistently well below the demographics of the country and enrollment in institutions of higher education overall. Many [redacted] firms have undertaken targeted diversity initiatives to improve their workforce diversity profile to match or exceed diversity within the pool of available talent. Firms both small and large have shown that through targeted approaches that include focused mentorship, bias training in hiring, and workforce cultural changes, they can improve representation of women and underrepresented minorities within their workforce.

The Federal Government and Universities Should Promote Pathways Into Semiconductor Fields

Industry awareness and brand recognition are low among target populations of graduate students in engineering and computer science. With the rise of “new tech” companies, including Google and Facebook, over the past two decades, many STEM students today have a much lower awareness of the critical role of semiconductors in enabling technology and innovation in sectors across the economy. Many of these students thus end up specializing in areas that are not relevant to a career in the semiconductor industry[7]. Firms work to varying degrees to address these shortcomings through targeted engagement with college and university campuses on curriculum development and awareness building efforts. The degree of engagement is often a function of both the size of the firm, and thus the resources they have available to bring to bear on workforce development, and the profit margins available in their targeted market sectors. Another contributing factor to this challenge for some firms is recruits' willingness to relocate outside major metropolitan areas where Google, Facebook, and other tech firms are predominantly located.

Hands On Experiences Are Critical to Student Learning and Pathways into STEM

Government and industry should work to bring more hands-on experiences with semiconductors into more classrooms. There is a large body of evidence that shows hands-on and work experiences contribute to better outcomes for workers over the long run and quicker returns on investment for firms that hire those workers. Hands-on experiences, such as "dissecting a cell phone" – as an analogue to biology curricula that include dissections of frogs, for example – should have a role in the curricula. SIA members and other industry stakeholders are actively working on programs that bring such hands-on experiences to students.

For example, FIRST robotics competition, which is heavily supported by sponsorships and partnerships with the semiconductor industry, brings real world experiences for thousands of students around the country. Further, IBM's P-TECH model brings industry and local governments together to develop industry relevant curricula and work experiences for students who will then graduate with a diploma and an Associate's degree. Qualcomm's Thinkabit Labs targets middle schoolers of all cultural and socioeconomic backgrounds that they can be part of the next generation of invention and innovation. These and other examples of educational programs by SIA member companies are crucial in stimulating student interest in STEM.

[7] "Current and Future Domestic Workforce Needs to Support a Domestic US Semiconductor Industry", [redacted] Response to NIST RFI, 2018.

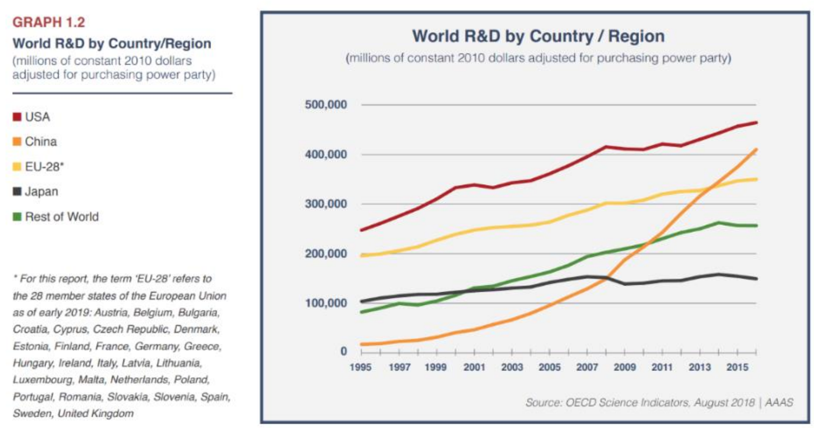
[redacted]

R&D Investments by the Federal Government are Key to STEM Talent Development

Federal government investments in basic and applied semiconductor research have historically been important in domestic workforce development. Consortia efforts like SEMATECH jointly funded by government and industry in the 1980s and 1990s, provided instrumental research and engineering experience that led to a new generation of leaders in semiconductor engineers and scientists.

To make breakthroughs in the key technologies expected to drive future economic growth and to maintain American leadership in the face of global competition, the U.S. needs to invest ambitiously in semiconductor research- and triple its federal investment over the next five years. The U.S. semiconductor industry invests nearly 20 percent of revenue in research and development, among the highest of any industry sector, amounting to approximately $40 billion in 2019.

Unfortunately, government investment in research has been declining or been flat for many years. In contrast, key competitors are dramatically increasing their research spending, including targeted investments in semiconductor research. The U.S. risks losing its innovation edge and the global competition for technology leadership if under-investment persists[8].



Bipartisan legislation pending in Congress calls for significant increases in federal investment in semiconductor research (American Foundries Act, CHIPS for America Act). These investments are needed to maintain U.S. technology leadership and to build the pipeline of talent for the industry

[8] "Second Place America? Increasing Challenges to US Scientific Leadership," Task Force on American Innovation, 2019.

in the future. We call on Congress and the administration to enact and fund these initiatives to ensure the U.S. maintains its leadership for decades to come.

Reform High-Skilled Immigration to Enable Access to Global Talent

As the U.S. takes action to improve STEM education to build the next generation of scientists, engineers, and other skilled workers, it must also reform the broken system of high-skilled immigration. As set forth in these comments, measures to improve our STEM education system will require long-term action with a sustained commitment to funding over decades. Over the near term and while we implement STEM education improvements over the long-term, the semiconductor industry in the U.S. needs the ability to recruit and retain talent from around the world, including STEM graduates from U.S. colleges and universities. Otherwise, the U.S. risks losing the race for talent and the competition for global technology leadership.

[redacted] urges the Congress and the Administration to work together to reform the high-skilled immigration system by eliminating counterproductive caps on green cards so qualified STEM graduates from U.S. colleges and universities, as well as STEM graduates from around the world, can work, innovate, and contribute to U.S. leadership in the semiconductor industry and boost our economy. Foreign nationals in STEM fields, particularly those with advanced degrees, should be automatically eligible to work in the U.S. and contribute to our economy. Finally, restrictions on the entrance of students, researchers, and experts, and others, that were implemented in 2020 need to be lifted in order to ensure a high-quality pipeline of students, experts, and scientists into the research ecosystem.

[redacted]

[redacted]

October 19, 2020

To: National Science Foundation: costem@nsf.gov

From: [redacted]

Subject: [redacted] STEM RFI Response (Federal Register Notice 19681)

Mike Vargas, 9th grade Arizona physics teacher who is currently an Einstein Fellow at the Naval Surface Warfare Center, alerted us to this NSF Request. He wrote*, "Can we start with the fact that the nation has an extreme shortage of qualified high school physics teachers?"* Yes, we MUST start with this fact! Without qualified physics teachers, the nation is doomed. Chemistry and math teachers are in short supply, too – almost as bad as physics. **(This is category "Future Opportunities in STEM Education, question 5. We respond to it on pages 1 & 2.)**

We respond to questions 1, 2, 3, and 4 in that category on page 2. We respond briefly to the category "Build Computational Literacy" questions 20 to 23 on page 3. On page 4, we address "Develop STEM Education Digital Resources" questions 9 and 10. (Notably, we are developing video labs and have applied for the Open Science Education grant.)

The shortage of physics, chemistry, and math teachers precedes all questions in the NSF request. The [redacted], a nonprofit organization of, by, and for STEM teachers, is a national leader in addressing many of the 24 questions through science teacher development. (We want to add math but lack funding). Teachers know what they need. The [redacted] is teachers!

The [redacted] has overseen teacher-led summer institutes at partner universities and schools nationwide for 15 years. Since the Covid-19 pandemic, [redacted] summer institutes are live remote. [redacted] semester-long professional development (PD) courses have been live remote for years. (Origins of the [redacted] are the Arizona State University (ASU) Modeling Instruction program, which began in 1990. It was founded by David Hestenes and an expert Phoenix high school physics teacher, Malcolm Wells. ASU summer 3-week Modeling Workshops were so successful - and effective in the classroom - that when NSF funding for them ended in 2005, teachers demanded that Modeling Instruction continue, and they founded the [redacted]).

Whether in-person or remote, the essential PD need of teachers is in-depth content and pedagogical content knowledge. The NGSS and Common Core require the kind of PD that the [redacted] provides - interactive engagement centered on building and deploying basic scientific models. Teachers do agree that in-person Modeling Workshops are better than live remote ones!

The National Academies initiative, Rising above the Gathering Storm, in August 2005, is important (http://www.nap.edu/catalog/11463.html). Appendix C summarizes the K-12 Focus Group. It expresses the crucial need for in-depth content and pedagogical knowledge. Experts in K-12 education provided input to the committee on how the United States can successfully compete, prosper, and be secure in the global community. ***The top recommendation for teachers included summer institutes – and this top recommendation was never implemented.*** Summer Institutes are desperately needed, because all other government funds which COULD be used for summer institutes have been discontinued. Teachers must pay for [redacted] PD, which often results in the $750 registration being too expensive for many public school teachers.

We quote from Appendix C:
Top Recommendations
1. The federal government should provide peer-reviewed long-term support for programs to develop and support a K-12 teacher core that is well-prepared to teach STEM subjects.
a. Programs for in-service teacher development that provide in-depth content and pedagogical knowledge; some examples include summer programs, Master's programs, and mentor teachers.
b. Provide scholarship funds to in-service teachers to participate in summer institutes and content-intensive degree programs.
c. Provide seed grants to universities and colleges to provide summer institute and content-intensive degree programs for in-service teachers.

Future Opportunities in STEM Education.
Question 1. We did not find digital barriers that were difficult to overcome. The free Zoom is a godsend, as are free online learning management systems. (Bigger barriers are funds for lab supplies for at-home labs; and funds to pay wages for a co-leader(s) to help manage breakout rooms.)
Question 2. Modeling Instruction enhances remote synchronous education. Teachers who took the live remote 65-contact-hour Modeling Instruction courses for 5 ½ weeks in summer 2020 were glad to have experience and resources that they could use this year, while teaching remotely.

Question 3. *Pivot Interactives* and *Vernier Video Analysis* software are boons for physics labs done remotely. Some teachers cannot afford them, however ($5/student for Pivot, $149/year for Vernier). The Federal government is supporting two dozen free *Pivot Interactives*, temporarily.
Question 4. Inequities DECREASED! Live remote summer Modeling Instruction courses at ASU resulted in much higher enrollment by long-distance rural Arizona teachers who had state-funded $2000 scholarships for ASU tuition, to prepare to qualify to teach dual enrollment chemistry or physics. If they had not had the $2000 scholarships, they could not have afforded the courses.

The Federal government should give scholarships to teachers, as in the above "Top Recommendation." The Federal government should provide grants to universities and to nonprofits like the [redacted], for summer institutes.

Two press reports on the 3 ASU live remote Modeling Instruction courses in 2020 are:
-- 3BLmedia (by ON Semiconductor Foundation, which provides teacher scholarships):
[redacted]
-- ASU NOW (mentions Phoenix companies' investments for at-home lab supplies for courses):
[redacted]

"Build Computational Literacy". We address questions 20 to 23 together, as a story. We summarize an invited presentation by Colleen Megowan-Romanowicz at the American Association of Physics Teachers (AAPT) virtual Summer 2020 Meeting.

An entire session was on computational thinking in physics in high school, and its leadoff speaker was Colleen Megowan-Romanowicz of the [redacted], who described how she has taken the lead in establishing "Computational Modeling Physics First with Bootstrap." Acknowledging the Science & Engineering Practices (SEP) of the NGSS, she observed that computers and algorithms have reshaped our world, but data science and programming have not yet penetrated K-12 education systematically.

To a computer scientist, Megowan-Romanowicz observed that computational thinking is formulation of a problem to be solved on a computer. But, to a science educator it connotes a broad range of things "that bring the affordances of computers to the field of science education..." However, she emphasized, "it's not just coding" – a phrase that was expressed again and again by other speakers.

"How to bridge the gap between theory and practice?" she was asked. Her response was to establish a partnership between physics and computer science education. It's important to produce something teachers can use confidently and competently in their classroom, she added.

Her goal is to integrate computing with 9th grade physics; i.e., physics for all students at the level of Physics First. To achieve it she obtained NSF funding for workshops in summers 2016 and 2017, in which teachers developed units for such a Physics First course, using the Bootstrap language, Pyret. In the following two summers multi-week in-person workshops were held to train leading teachers nationwide to teach the Computational Modeling Physics First course – followed by a distance learning semester-long course.

After those four years, she found that students taught with Computer Modeling showed mathematical ways of thinking different from those in traditional Modeling Physics Instruction. Teachers noted that "computing is a natural extension of Modeling Instruction." A relevant action research report by three ASU Master of Natural Science degree candidates is available from [redacted] or [redacted].

"Develop STEM Education Digital Resources" questions 9 and 10. (Notably, we are developing video labs and have applied for the Open Science Education grant.)
Question 9.
For video labs, Pivot Interactives is excellent - www.pivotinteractives.com.
The [redacted] is a partner in a grant proposal from the University of Florida for the Carnegie-funded Open Science Education high school initiative. This web-based resource will be open-access curriculum for physics, chemistry, and biology. It will include distance learning options as well.
Question 10. The primary audience of the [redacted] is high school and middle school science teachers, although a secondary audience is college faculty who teach undergraduates in science.

Response to the NSF Request for Information on STEM Education
[redacted]
Responses to Questions: 9 - 12, 20 - 23

Develop STEM Education Digital Resources: Questions 9 - 11

Question 9: A comprehensive Federal website for STEM education digital resources has the potential to be transformational. There is a wide range of possibilities for its content and audience. Our experiences indicate that such a website faces significant challenges due to its breadth and requirements for usability, quality, and sustainability.

This web resource will need to cover a wide range of topics and serve a diverse set of potential audiences, from the general public and students to university professors. The content will be in many formats, from static worksheets to interactive simulations and immersive learning environments. The contexts for the digital resources are broad, from eighth-grade biology in-class activities to introductory calculus homework assignments to advanced undergraduate physics laboratories to resources for entire classes.

This breadth of content, audience, and context creates many usability challenges for a comprehensive website of STEM resources. For example, instructors will need to be directed quickly and correctly to content appropriate for their discipline, class-format, and pedagogy. Instructors will also need help to use resources effectively and more background about some science topics.

Of course, the quality of digital resources on the website is crucial to its impact on teaching and learning. Research-validated pedagogical resources should be highlighted along with best-practices for their use. Establishing and maintaining quality requires continual editorial efforts and curation by experts in the subject matter, effective pedagogy, and digital learning tools. A central repository that provides information on student outcomes back to education researchers and resource developers would enhance the quality of the digital learning resources.

It will be imperative to have a sustainability plan for both the STEM education website and the high quality learning resources in it. The products of many learning resource development and online repository projects have disappeared due to a lack of funds to maintain them. This web resource will be a vital part of the STEM infrastructure in this country. Although sustainability will include, in part, partnerships with commercial entities, a comprehensive website will need continuing infrastructure support like the nation's laboratories, observatories, and computational facilities.

The [redacted] has developed and hosted educational digital resource collections for nearly two decades, addressing the issues described above. The [redacted] online resource infrastructure, [redacted], began as a project of the National Science Digital Library and then as one of the NSDL Pathways. (NSF: 0226129, 0532798, 0937836) [redacted] continues to provide the infrastructure for many physics education projects. The use of a unified infrastructure facilitates the sharing of resources across different projects.

- [redacted] digital collections are built for specific audiences. Editors select quality materials suitable for each audience and put them in context. Early examples include the [redacted] for K-12 teachers [redacted] and the [redacted] for quantum courses [redacted]

- The most successful [redacted] products are those developed for and with an active user community. Collaborations and sharing by the community improve the quality and freshness of the content. Examples include the website for the physics education research community [redacted], advanced physics laboratory instructors [redacted] and the Open Source Physics community [redacted]
- Many STEM educators need help understanding best practices in pedagogy and a practical guide to educational research. The [redacted] site is available to help meet these needs [redacted]. (NSF: 0840853, 1245490, 1726113)
- Recent [redacted] projects provide even more context for the collections' content, including instructor guides with information about how and why the resources are used. The [redacted] website supports a group working to increase the use of computation in physics classes ([redacted]). The [redacted] is a community website for instructors of introductory physics courses for life science majors [redacted]. (NSF: 1624185)
- [redacted] also hosts materials developed for the use of students, including simulation-based curricular materials for introductory physics, [redacted] and the [redacted] content for life science students [redacted]

There are, of course, a wide range of other examples of excellent STEM education resource collections. The Science Education Resource Center, SERC, is a leader in these efforts (https://serc.carleton.edu/index.html) as is the OER Commons (https://www.oercommons.org/). A retrospective of ten years of the NSDL provides insight into the successes and challenges of online STEM education resource collections (https://serc.carleton.edu/p2p_redux/index.html).

Question 10: The [redacted] and [redacted] support physics education and instructors at all levels. The AAPT has communities focused on grades 8 – 12, two-year colleges, undergraduate, and graduate institutions. These are very different audiences, but they share many of the same pedagogical issues. As described above, [redacted] supports more focused communities such as physics education researchers and instructors of specific courses.

Question 11: Many existing metadata schema are available for educational resource categorization: IEEE LOM, IMS Global, Dublin Core, Dublin Core LRMI, etc. Starting with these standards will allow existing projects to more easily be integrated into any new web interface. [redacted] uses IEEE LOM to index resources and can export information in other formats as needed. Additional information about resources in a STEM education collection will be useful, such as research validation, student learning activity types, and best practices for use. Information regarding allowed use and reuse, such as Creative Commons licenses, is also important. Instructors generally wish to make modifications to materials to fit their classes. A Federal STEM Education digital resource collection should strongly encourage this sort of adaptation for reuse.

Question 12 Increase Diversity, Equity, and Inclusion in STEM

[redacted] diversity, equity, and inclusion activities target groups that are underrepresented in physics, primarily Black, Latinx, Indiginous, women, and people with disabilities. We do this by providing professional development to teachers of physics and spanning all education levels (K-12 through graduate education). We have developed or are in the process of developing the following programs and activities:

- [redacted] In 2015, NSF provided funding to the [redacted] to address the underrepresentation of women and minorities in physics and astronomy by providing support to women faculty, especially minority women, in physics and astronomy departments in institutions of higher education. The purpose of this project is to enable women faculty to create their own eAlliance, a peer mentoring group of other women physicists or astronomers, with whom they share important characteristics. This project builds on the work of previous ADVANCE grants as well as best practices from research on faculty mentoring, all of which demonstrate that mutual mentoring of women science faculty positively impacts their professional development. By supporting women and enabling them to persist, these women will serve as role models for female (and male) students. This project is evaluated by an external evaluator who has experience evaluating other projects like this one. (Support from NSF ADVANCE-PLAN D HRD-1500529.)

- [redacted] Drawing on research evidence, [redacted] is mobilizing thousands of high school physics teachers to reduce barriers and inspire young women to pursue physics degrees in college. Our lesson materials are research-driven and will help shift deep-seated cultural views about who does physics. Evidence-based teaching resources to facilitate female students seeing themselves as a "physics person," and becoming interested in physics careers are available including:
    - Everyday Actions - strategies for reducing marginalization in the classroom and recognizing students as physics people
    - Careers in Physics - a lesson on careers in physics, particularly those that help solve societal problems
    - Women in Physics - a lesson on the underrepresentation of women in physics and the role of implicit bias and cultural stereotypes.

  These are NGSS-supported reflective activities that engage student discussion. The [redacted] are a group of [redacted] teachers and other [redacted] members who are committed to empowering fellow teachers to inspire young women to pursue physics. This is done through training and supported implementation of the [redacted] curriculum in classrooms around the country. This project is in collaboration with the American Physical Society, Florida International University, and Texas A&M Commerce. Effectiveness of this intervention is being determined by an external evaluation. In addition, there is emerging evidence that these interventions contribute to the interest of all females and underrepresented males in pursuing careers in physics (see [redacted]). (Support from National Science Foundation under Grant Nos. 1720810, 1720869, 1720917, and 1721021.)

- [redacted] is a video that shares words of wisdom and encouragement from women in physics from around the world as they describe the challenges they've had to overcome in order to pursue their life's passion. In addition to the video, four lesson plans have been developed to provide materials for K-12 teachers to use in the classroom and introduce their students to women in physics. This project is evaluated by the number of views on Youtube and the number of teachers who have downloaded the lesson plans. (Funded by the National Science Foundation Grant PHY-1419453)

- Gender bias website [redacted] The [redacted] is a space where women and people who are gender and sexual minorities can share experiences of gender and sexuality bias in physics, find resources, and report responses to bias. (Funded by the National Science Foundation Grant PHY-1661340.)

- [redacted]. For the past three years, the [redacted] has led a coalition-based working group comprised of representatives and staff from [redacted], American Institute of Physics (AIP), American Astronomical Society (AAS), American Physical Society (APS), AVS (Science and Technology of Materials, Interfaces, and Processing), National Society of Black Physicists (NSBP), National Society of Hispanic Physicists (NSHP), the Physics and Astronomy Division of the Council on Undergraduate Education, and The Optical Society (OSA). This working group is establishing a framework to pilot the first STEMM Equality Achievement (SEA) Change Departmental Award, which will be for physics and astronomy departments. This Physics and Astronomy Working Group's goals have been to assess community interest, develop a physics and astronomy departmental award application based on the AAAS SEA Change institutional award (https://seachange.aaas.org) that addresses the specific needs of our community, design a pilot program, and begin to draw up working agreements among our professional societies, and with the AAAS. (Pilot project supported by a Venture Partnership Fund grant from the American Institute of Physics.)

- [redacted] The Fellowship partners early career or pre-service physics teachers from underrepresented populations with more established Physics teachers who are also from underrepresented populations to build a community of experts all working to increase diversity of Physics teachers, and the broader field of Physics. This program is aligned with [redacted] strategic plan to increase diversity in physics. The priority on mentoring and instructional leadership emanates from [redacted] report, [redacted] Teachers of color have lower retention rates than their White counterparts, often because teachers of color are found in underserved school environments. The lack of African American teachers and, independently, the lack of quality secondary physics education, is a likely cause of the lack of African American students pursuing undergraduate physics. (Supported by a Venture Partnership Fund grant from the American Institute of Physics.)

- Workshops, Sessions, and Plenaries at [redacted] National meetings. [redacted] has been featuring a variety of special workshops, sessions, and plenaries for physics educators at [redacted] national meetings. For example, [redacted] has offered special workshops open to all registrants on the following topics: ally and bystander training, whiteness and racism in a multiracial classroom, teaching intersectionality across the curriculum, the art of effective negotiation skills for women, inclusive communicating, communicating across difference, resilience when the only underrepresented person in the classroom, identifying and responding to racial microaggressions at (K-16) schools, and consciously overcoming unconscious bias in the workplace. The number of registrants attending these and responses to questions on the post-conference survey help us assess the effectiveness of these workshops and plenary sessions.

- [redacted] has had several special issues addressing inclusion and equity. In particular, the September 2018 issue was on [redacted] and the September 2020 issue was on [redacted]

Build Computational Literacy: Questions 20 - 23

Question 20: With support from NSF (grants 1812860 and 1812916) the [redacted] hosted a conference on [redacted]. The Conference brought together 40 computer science, physics, biology, mathematics, and engineering educators, high school teachers, and education researchers who work in those disciplines. The Conference report (available at [redacted] emphasizes that there is no single notion of computational literacy or computational thinking. Consequently, effective integration of computational thinking with STEM depends on making the computational work germane to the particular STEM field. What works in physics might not be appropriate for biology or for mathematics.

Currently, we lack even plans for how such integration would work with different age-levels and across different STEM disciplines. Although the integration of computational thinking in STEM courses can enhance both workplace skills and conceptual understanding of the STEM subject matter, the Conference participants recognized the need for professional development for STEM educators in computational work and the associated pedagogies, the development of discipline-specific and age-appropriate curricular materials, and the creation, testing, and validation of new assessment tools for student learning of computational work. The Conference participants also emphasized the importance of making computational work available to all students, not just students in well-off schools and colleges.

Question 21: [redacted] emphasizes integrating, wherever possible, computational work (in all its forms) with instruction in other disciplines; so that students view computational work as one tool among many others that help solve problems and enhance conceptual understanding. Students should also become experienced with the kinds of problem-solving that can be accomplished only with computational work. The key principles are

1. How to translate STEM scientific questions into a form that computational work will help answer those questions.
2. How to use computational resources to explore conceptual understanding of fundamental concepts.
3. How to evaluate the results generated by computers to test their validity and to make sense of how those results answer the question posed and how they increase our scientific and mathematical understanding.

The Undergraduate Curriculum Task Force of the [redacted] has produced a white paper providing recommendations and guidelines for integrating computational thinking into the undergraduate physics curriculum. That report is available at [redacted]. That report provides a detailed description of the many ways computational work can broaden and enhance work in physics.

Question 22: At the K-12 level, the NSF-supported project (NSF STEM+C 1640791) brings together physics teachers and computer science educators to foster the integration of computational work in schools in which "Physics First" courses are taught to all ninth grade students. So far, the program has hosted more than 75 teachers who are implementing STEM+C activities in their courses reaching more than 7000 students. The project includes extensive research on the effects of the program on teacher and student attitudes towards computational work and how the use of computers affects students' approaches to problem solving.

At the undergraduate level, the Partnership for Integration of Computation in Undergraduate Physics has hosted NSF-funded (grant 1540574) professional development workshops for several hundred physics faculty members. The project has also established a website (www.gopicup.org), which hosts extensive exercises sets deploying computational work in every area of undergraduate physics.

Question 23: [redacted] is promoting the development of online resource sites that are not merely collections of materials (a library model) but are designed to be highly curated and community-focused sites. Such a site engages users who may contribute materials to the collection, provides opportunities for users to provide feedback on existing materials and to contribute adaptations of other materials. The site also assists users in assembling collections of materials for different courses and different audiences with advice about the appropriate pedagogical strategies for those materials and diverse student audiences. Most importantly the sites build a community of users who can provide peer support and collaborative efforts on developing and testing new materials. Two examples of such sites are [redacted] which focuses on pedagogy and assessment tools, and the [redacted] which focuses on physics for life science students.

[redacted]

10/19/2020

National Science Foundation
Via email

To whom it may concern:

On behalf of the [redacted] we submit the following comments in response to Request for Information on STEM Education. We appreciate the opportunity to provide comments on this critical topic.

[redacted] is the principal trade association for the software and digital content industry, representing more than 700 technology companies. Our membership is very interested in America's strategy for STEM education on two fronts. One, many of our members are developing education technology products used in by our country's learners – things like digital instructional content in STEM subjects, online learning services and related technologies, hardware used to access the content, and more. Two, our larger membership is acutely aware of the shortage qualified people in the workforce as they look to hire employees with STEM skills.

We are grateful the National Science Foundation is soliciting input from stakeholders on this important topic. We are particularly pleased to share our thoughts on STEM education and COVID-19, developing STEM Education resources, increasing diversity, equity, and inclusion in STEM, and engaging students where disciplines converge. Our responses to select questions are below.

Future Opportunities in STEM Education (Questions 1-6)

In March 2020, Americans transitioned from learning and teaching in classrooms to learning and teaching at home. A number of barriers emerged as soon as that transition happened. Kids and teachers without internet at home were unable to connect with learning and teaching. Homes with one device and multiple users couldn't adequately access materials. Students with diverse learning needs did not have proper accommodations.

Some of these issues were addressed, at least temporarily, with funds from the CARES Act. In our initial analysis, it appeared that a number of recipients were planning to use funds for internet connectivity, hardware, and education technology so students could access learning from home. It was, however, more of a band-aid approach with schools purchasing mobile hotspots that may or may not work in students' home or opening up school wifi so students could sit in the parking lot to connect and download schoolwork. This isn't a problem just for COVID-19 times. A Michigan State University study found that students without home internet access or those that rely on a mobile plan for internet access have weaker digital skills than their peers.[1] It is imperative that the federal government address this

[1] https://quello.msu.edu/broadbandgap/

critical issue by funding broadband expansion, expansion of the E-rate program, or other innovative solutions that will ensure learners of all ages and educators can connect to their education.

Additionally, the rapid transition from classroom learning to at-home learning did not allow for any thoughtful approach to professional development for teachers that were accustomed to connecting with students face-to-face. Many institutions and education technology providers worked together over the summer to provide professional development on the tools the teachers were to use in the classroom this fall. One of our member companies, Edgenuity, developed a tool to help schools make a plan for fall learning. Not only did this tool help schools pivot for hybrid or fully online learning for students it helped give teachers training to support students throughout the year.[2]

In addition to Edgenuity's work, there are a number of other companies that have deployed new remote learning techniques. A Utah-based start-up, Infini-D Learning, found all of their labs in classrooms around the country empty. Infini-D staff hosted remote "missions" for the classes that were now meeting virtually. Students connected with their classmates to explore Earth, space and the human body in their homes. Infini-D Learning is an official research partner of the National Science Foundation through the Small Business Innovative Research program.

Develop STEM Education Digital Resources (Questions 9,11)

In March 2020, [redacted] partnered with the White House to launch a web-based resource for schools and parents to find education technology products for remote learning. This website, Tech for Learners[3], was developed over the course of a matter of weeks and allowed users to search for tools for both synchronous and asynchronous learning for all ages of learners. These tools were categorized by subject, topics, price, as well as whether or not the product was a full-course or supplemental learning material. While some of the search fields were critical in March 2020, they may not be applicable moving forward. For example, searching by pricing structure isn't applicable right now. The ability to search by grade, subject, and synchronous/asynchronous are important for any repository of education tools.

Other web-based resources were launched after March 2020. ISTE launched Learning Keeps Going[4] to highlight free products from companies and organizations to support learning. The Educating All Learners Alliance[5] launched to ensure the continuity of special education services during remote instruction and to spotlight best practices.

Increase Diversity, Equity, and Inclusion in STEM (Question 12)

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[2] https://www.edgenuity.com/solutions/school-reopening-plan/#matrix
[3] https://www.techforlearners.org/
[4] https://www.learningkeepsgoing.org/free-tech-for-learning
[5] https://www.educatingalllearners.org/

[redacted] is dedicated to supporting our members as they work to increase diversity, equity, and inclusion in STEM. Over the last three years, we've hosted both virtual and in-person sessions to help companies think through how to develop a more inclusive and equitable workplace as well as how to approach building out tools that work for a diverse customer base. In December 2017, for example, we hosted an all-day seminar on accessibility for education technology companies bringing together government officials, advocates, and industry to help companies understand how to conform to federal accessibility laws as they build educational technology products.

Engage Students Where Disciplines Converge (Question 13)

Our member organizations have long recognized that transdisciplinary learning is critical to developing a robust skillset. Our members work to produce products that consider the whole child and help develop cognitive skills and social-emotional skills. Amplify Science, for example, is authored by UC Berkley's Lawrence Hall of Science and blends literacy-rich activities, hands-on investigations, and engaging digital experiences to empower students to think, read, write, and argue like 21st-century scientist and engineers. Additionally, Amplify launched Amplify Science@Home in August 2020 to support science instruction in no-tech, low-tech, and high-tech environments.

Thank you for your time and attention to this critical matter. Please reach out to me if you have additional questions.

Respectfully submitted,

[redacted]

[redacted]

October 19, 2020

Dr. Cindy Hasselbring
Office of Science and Technology Policy
STEM@ostp.eop.gov

[redacted] STEM RFI Response

Dear Dr. Hasselbring,

Thank you for the opportunity to submit comments regarding the Federal STEM strategic plan.

The comments are from the perspective of the [redacted] whose scientific members and faculty share a commitment to advancing knowledge in the behavioral and cognitive sciences.

Our comment is limited to question 24 under Community Use and Implementation of the Federal STEM Education Strategic Plan.

Despite the clear alignment with and value of the behavioral and cognitive sciences to serve the goals of the STEM Education Strategic Plan, these disciplines are not currently included in NSTC definition of STEM. The behavioral and cognitive sciences are central to technological innovation, such as speech synthesis, pattern recognition, and decision making, and are important in making improvements in areas such as artificial intelligence, robotics, and predictive analytics that will help strengthen our national security and grow our economy.

Federal agencies including the National Science Foundation, National Institutes of Health, Department of Defense, and Department of Homeland Security recognize the behavioral and cognitive sciences as essential in building foundational knowledge to understand complex problems and in applying this knowledge to agency-specific missions. [redacted] strongly encourages the NSTC to adopt a more inclusive definition of STEM to better reflect the spectrum of disciplines contributing to discovery and innovation and to best prepare our future workforce.

Many thanks for your consideration,

[redacted]

[redacted]

[redacted]

[redacted]

A Response from [redacted]

[redacted] is the oldest institution of higher education in the [redacted] region, with microsites in [redacted] and other campus locations in [redacted], and Tbilisi in the Republic of Georgia. [redacted] was founded on [redacted] as the [redacted], training elementary school teachers. Seven faculty and 91 students met in temporary quarters over a downtown drugstore before moving to a newly constructed 17-acre campus on [redacted]. On July 1, 1961, the college became part of the newly created [redacted], now known as the [redacted].

Serving the [redacted] region has always been and continues to be a core part of the mission of SDSU, which has since grown to become a leading public research university nationally known for its scholarship, campus diversity, and value added to the lives of its graduating students. Each year, [redacted] provides more than 34,000 students with the opportunity to participate in an academic curriculum distinguished by direct interaction with faculty, and an international emphasis that prepares them to become global citizens, compassionate leaders, and ethical innovators who will transform the world.

Today, under the leadership of [redacted], the university is known for providing transformative experiences for its undergraduate and graduate students. [redacted] is designated as a Hispanic-Serving Institution, which recognizes its diverse student population and commitment to serving students with demonstrated financial need. This Fall, SDSU enrolled more than 54% students of color. Now with 20 Ph.D., two Ed.D., the Au.D., and Doctorate of Physical Therapy (D.PT) degrees, [redacted] ranks 170th in federal research funding in the nation – making [redacted] one of only a handful of institutions to be both a Title III/Title V eligible institution for diversity, and in the top 200 for federal research funding. [redacted] has a strong track record in serving underrepresented minority students. [redacted] is No. 11 in the nation and No. 4 in [redacted] for bachelor's degrees awarded to Hispanics. The university also ranks No. 31 in the nation for master's degrees awarded to Hispanics according to Hispanic Outlook in Higher Education's "Top 100 Colleges for Hispanics".

Contents

Future Opportunities in STEM Education, Questions 1, 2, 4-6

(1) This answer relates to observations relevant to the postsecondary students: Critical to barriers related to COVID-19 is the safety and comfort of students learning in variable environments, especially as it relates to emotional connection to the instructor, and emotional connection to other students. We have anecdotal evidence that suggests students of color may be more hesitant to fully engage with online learning platforms by, for example, turning on video cameras when they are learning in their own home. In addition, students are having difficulty finding spaces that are private enough (from multiple roommates or household members) to connect online with courses or to get work done. Courses and classrooms might not be viewed as safe spaces for students of color due to effects such as stereotype threat, microaggressions, or even overt racism, and students may be hesitant to open their homes. As one SDSU leader states: “Students open their homes to friends, not intruders.” This hesitancy can amplify the challenges of connection, understanding, accessibility and success already inherent in the digital learning environment. Lack of access to computers is not common but disproportionately an issue for students of color and low income students. Our Economic Crisis Response Team program (and CARES money) has been able to help some students. Access to reliable broadband is a more common issue that we have been less equipped to handle. We have offered access to free wifi in outdoor spaces of campus (outside library) but have been unable to help student who live further away.

(2) This answer relates to observations relevant to the postsecondary students: Access to high-speed and reliable networks remains a critical barrier to equity and justice in postsecondary education. Although [redacted] is largely an urbanized county, the county contains critical residential environments including Native American reservations and communities close to the US/Mexico border that are under- or un-served as it relates to reliable and sufficient internet access. In addition, [redacted] serves the rural communities of [redacted] with two physical campuses serving the community. While the campuses are well-served with respect to connectivity, the students in Imperial County experience a wide variety of reliability and access as it relates to internet stability. The COVID-19 pandemic remains a missed opportunity to accelerate distribution of broadband access to underserved communities as a tool to maintain educational access and to stimulate economic growth and employment opportunities in those communities.

(4) This answer relates to observations relevant to the postsecondary students: Effective STEM education requires the following elements, which remain substantial challenges in the face of online education and training:

1. Problem/project based iterative learning where the student offers a solution to a research problem that is revised several times during the course of developing solutions based on the instructors’ feedback and discussions.

2. Hands on experience in manufacturing and testing labs which requires students to be present on campus and work on test, design or validation experiments.
3. Design systems using software that requires high powered workstations with graphics adaptors.
4. Working in a team on coursework especially lab and project based learning. Peer-to-peer mentoring and training.
5. Online learning specifically asynchronous online learning is not for everyone. Student motivation and the capacity to effectively self-pace is a major challenge. Inequities emerge that might otherwise be addressed through intrusive advising programs, which are limited due to COVID-19.
6. Curricular requirements to interact with mentors and project sponsors with industry.
7. Transdisciplinary interactions is a must in STEM majors because the problems cross disciplines. For examples, the problem-solving capacity of engineering students is often applied to challenges where the discovery is in another discipline.

(5) This answer relates to observations relevant to the postsecondary students: Educators should be trained to de-colonize their course structure, syllabi, learning outcomes, and evaluation. COVID-19 provided an important opportunity to reassess the structure, format and goals of course syllabi. Social and cultural events related to police brutality and the Black Lives Matter movement placed an important lens on equitable course structures. Given this opportunity, [redacted] has engaged in an ad-hoc effort to de-colonize course structures, syllabi, and learning outcomes by interrogating the materials, references, and evaluation processes looking for artifacts of implicit bias, overt racism, and inclusion of a variety of academic voices representative of the equity goals of the field or course. At the same time, modifications appropriate to address elements of racial, ethnic or gender bias, are also impactful in relation to access and equity in distance learning.

(6) This answer relates to observations relevant to the postsecondary students: Tracking a variety of data related to preservation or degradation of interaction is critical under these conditions. For example, in closely tracking faculty performance during SDSU's pandemic response, we have observed two important, and concerning features related to grading. For the Spring 2020 semester, we saw significant grade inflation. That is, the grades registered for the students are statistically significantly higher than other comparable Spring semesters. In early returns of the Summer 2020, and Fall 2020 semesters, we are seeing an amplified bi-model distribution. That is about half high grades and half grades that are not passing (DFWithdraw). We further see that URM students are more likely to have a DFW than in previous semesters. This student/faculty performance data suggests that some of the social/cultural inequities we have outlined elsewhere in this response are, in fact, having a negative impact on student performance and success.

Collecting and analyzing this, and other data related to the strength of interaction continues to be critical.

Increase Diversity, Equity, and Inclusion in STEM: 12

(12) This answer relates to observations relevant to the postsecondary students: We have very specific success metrics for the involvement of women in STEM in our program. Each semester including summer we recruit a new cohort through our application process. Our goal is to recruit 1/3 of our teams (consisting of one or more persons) with founders that are women in STEM majors. We have various events that introduce women in STEM students to entrepreneurship and help inspire them to apply.

For instance:
[redacted] - We held this event in 2019-2020 to encourage women in STEM to develop ideas and apply to the [redacted].
We also established a flagstone event we call [redacted] that we could in Fall and Spring. We bring in women in STEM careers from our community to discuss their career journey and inspire our students. The students mainly women in STEM students paint, listen, network and ask questions.
They paint an "idea" bank that will be used to drop ideas as they come to them and hopefully inspire their application. In Spring we flipped the event to virtual via zoom. Shipped out 50 painting kits and held a very successful event. For Fall, we will continue to hold the event virtually and we just shipped 90+ kits, doubling our participation with a new panel of inspirational speakers from the STEM community.

Engage Students Where Disciplines Converge: 13

(13) This answer relates to observations relevant to the postsecondary students: One innovative example is The [redacted], an incubator at [redacted], which works with students from across the campus. We use the cohort model to create a supportive and cross discipline experience. Students begin with a problem that they are passionate about solving and work to bring to life an innovative solution to solve the problem. Each semester we admit through an application process a new cohort. It is common for a cohort to consist of 10-12 different ideas represented by students from different colleges. Typically a cohort will include students studying engineering, business, science, graphic design, finance, accounting, nutrition, communication, international business and other areas of study.As the team evolves their idea, they also must evolve their team to ensure they have the skills necessary to execute their idea. [redacted] offers the ability for a team to hire up to 2 paid interns per semester. We offer support and services to identify students seeking internships in their major and match them with teams seeking their skillset. For example, a business student whose solution is based on a mobile app might seek a graphic designer to help develop the wireframes and a computer

science student to program the app. Finally we work hard to recruit women in STEM majors to our program. We have dedicated funding that helps us market and run special ideation programs to encourage women in STEM's participation.

Develop and Enrich Strategic Partnerships: 19

(19) This answer relates to observations relevant to the postsecondary students: STEM learning has been a success if the students acquire an understanding of key concepts, can describe how the concepts apply to other scientific concepts, are able to think critically about the concepts, understand how the concepts were discovered and what evidence supports the concepts, know how to learn more about the concepts from the scientific literature, and are able to communicate the concepts to others. In other words, to be a success, students need to be able to apply the new knowledge rather than simply memorize “facts”.

Because science is a collaborative discipline that requires interdisciplinary teamwork, students should gain an appreciation of working with diverse teams on common goals both in the classroom environment and during laboratory experiences. Each of these criteria for success can be measured by comparing students’ pre- and post-learning ability to solve problems related to the learning objectives.

Many STEM students are focused on using their education to pursue specific careers after graduation or to go on to a graduate/professional program. Both of these goals benefit from private sector input into the education process. This includes bringing successful individuals from the private sector to talk with students about career opportunities, exposing students to alternatives they may not have considered otherwise. It also gives students insights into the academic requirements sought for new-hires in these careers, helping students gain the training needed to enter the workforce in STEM disciplines. In addition, many STEM fields have specific needs that change faster in the private sector than in the university environment, so the private sector can provide valuable input to faculty about educational/curricular changes to meet the needs for their workforce.

The [redacted] STEM ecosystem has responded to the COVID-19 pandemic in several ways: providing faculty with extensive training on effective online teaching approaches that emphasize student engagement and critical thinking; providing opportunities for upper division students to do hands-on research in research labs under low-density, safety-focused conditions; provided hands-on problem solving exercises that can be done with materials readily available in a grocery store, allowing experiential learning while working from home.

Different STEM programs are continuing to innovate novel approaches to provide engaging, experiential learning experiences that are effective in the virtual environment, and will continue to enhance educational opportunities post-COVID.

AGENCY: [redacted]

(b) (6) [redacted] **I am an** [redacted]

1. What COVID-19 related digital barriers (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

Two of our programs have experienced significant digital barriers because of COVID-19. The first program experiencing barriers is our [redacted] which is typically held at middle or high schools where team personnel utilize school computers to download materials, access links, and compete. COVID-19 has disrupted the accessibility to schools – though some school districts across the country have opened, many have not, and students are not able to access the school's technical resources. Therefore, we have had to be flexible with regards to adjusting rules so that students and coaches can still compete but from various locations. Another challenge is having a level playing field with everyone having the proper technical specifications and hardware necessary for teams to download and access training materials, modules, and software. The barriers are not resolved completely, but we are making every effort to accommodate teams so that they still can compete despite locale challenges and access to the software and hardware necessary to participate.

The other program significantly impacted by COVID-19 is our newest program, [redacted] – the Senior Citizen's Cyber Safety Initiative. With support for AT&T, [redacted] was created to equip older individuals with the knowledge and skills needed to protect themselves from a variety of cybercrimes, threats, and scams. [redacted] also offers resources to victims of cyber scams. Some of the topics covered in the workshops include password management, common internet threats, scams and fraud, and social media safety. The program can be done as a self-paced guide, or it can be presented as a workshop in a group setting.

COVID-19 has introduced some challenges presenting these workshops in person, so [redacted] is researching virtual, interactive modalities to continue to offer these services to the elderly population. One possible strategy is to partner with secondary and post-secondary institutions to have students who are interested in STEM related fields or gerontology and establish a collaborative inter-generational synergy of technologically savvy students interfacing with a vulnerable population to protected them, by teaching cybersecurity skills.

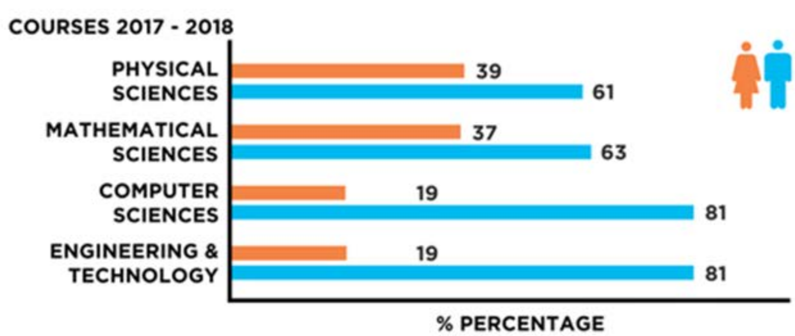
Why is [redacted] is so important? According to the FBI's 2018 Internet Crime Report, people over the age of 59 years old filed approximately 62,000 fraud complaints totaling almost $650 million (https://www.ic3.gov/Media/PDF/AnnualReport/2018_IC3Report.pdf). As the

American population gets older and the digital demand in our society increases, it is imperative that the elderly learn how to protect themselves in the cyberworld. [redacted] is researching possible virtual meeting platforms such as Google Classroom, WebEx, or Zoom as tools to reach out to seniors in assistant living facilities where participants can post questions and receive answers from our trained and certified Tech Caregivers from local high schools and colleges across the country.

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

STEM education and careers are lacking in female participation. Female and male students in general perform equally in mathematics and science except in computer science and engineering in higher education (NSF, Science & Engineering Indicators, 2018, https://www.stemwomen.co.uk/blog/2019/09/women-in-stem-percentages-of-women-in-stem-statistics).

SUBJECT BREAKDOWN – FEMALE STUDENTS



One of the biggest culprits is a lack of exposure to STEM related opportunities. [redacted] encourages female participation in our [redacted] by waiving the registration fee for teams comprised of all-female competitors. We believe this will motive and encourage school personnel and students to form all-girl teams as indicated with the annual increase in participation of all-female teams. Female participation in [redacted] programs is at 31%, which far exceeds the national average of female participation in STEM programs.

[redacted] also understands there is a socioeconomic barrier to STEM opportunities as well. A new study in the International Journal of Science Education indicates “low socioeconomic status is the biggest barrier to STEM participation.” To encourage students from all economic backgrounds to participate, we offer registration fee waivers for students attending Title I schools. We hope and anticipate female and low-income, first generation students are motivated through their participation in the competition to pursue higher education and careers in STEM. Minority participant in [redacted] is 48%.

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

[redacted]

The annual [redacted] consist of high school and middle school teams from around the country to compete through a series of online competition rounds. Teams are given a set of virtual operating systems and are tasked with finding and fixing cybersecurity vulnerabilities while maintaining critical services. The top teams in the nation earn all-expenses-paid trips to Maryland for the National Finals Competition where they can earn national recognition and scholarship money.

[redacted] uses several distance and electronic learning in its educational programs. The [redacted] is the world's largest cybersecurity competition and is open to all schools and approved youth organizations. Students use modules that simulate real life situations, where for example, a bank has received an alert that a hacker is trying to steal information and data. The students are tasked to go through a series of cyber defenses operations to thwart off the attack. Students can earn points based on achieving several levels of cyber security.

Training materials and additional cyber resources are available online and with the assistance of coaches and IT professionals, teams may meet at and compete from any location – classroom, computer lab, public library, home, etc. [redacted] uses Cisco Networking Academy to help prepare the students for the competition. The goal is to offer American and International youth exposure, simulations, and technological skills through real-world scenarios, preparing them for careers in cybersecurity and STEM.

Every two years, the [redacted] Program Office conducts an Alumni Survey, polling current and former [redacted] competitors on their future or current plans education and career plans. The most recent results, collected in April of 2020, indicate the following:

- 83% of [redacted] students (currently in middle or high school) plan to enroll in a 4-year institution after graduating, with 75% of these students planning to study a STEM field.

- 84% of the [redacted] alumni already enrolled in or graduated from college are studying or employed in a STEM field.

85% of the survey respondents indicated that [redacted] played a positive role in their decision to pursue an education or career in STEM.

23. What technologies and resources do you currently use (e.g., apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

[redacted]

Held during the summer months, [redacted] emphasize fun, hands-on learning of cybersecurity principles that are relevant and applicable to everyday life. Our [redacted] use several technologies and resources to teach students. Camps throughout the country have middle school and high school students learn the importance of cyber safety and how to protect their personal devices and information from outside threats. Standard [redacted] teach beginner students the basics of cybersecurity, while Advanced [redacted] incorporate more complex concepts geared towards students who have previously participated in a camp or in the cyber defense competition. [redacted] are designed for high school and middle school students who are just getting into cybersecurity or who have cybersecurity knowledge and want to learn more. Camps are hosted by approved organizations and institutions by the [redacted] Program Office. These organizations include but are not limited to [redacted] Chapters, schools, universities, CAP squadrons, companies in industry, boys and girls clubs, etc., that purchase our state-of-the-art cyber curriculums that introduces information on cybersecurity & careers, cyber ethics, online safety, how computers work, virtual machines, and cyber threats using Windows 10, Linux, Ubuntu, and Cisco platforms. Students are immediately tested on the information they learn by using a quiz-based platform called Kahoots, where students answer multiple-choice questions presented by the host organizations.

What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (e.g., virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (e.g., pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

Cloud Computing, which offers computer services and deliverables via the Internet, offers several benefits when it comes to competitive advantages in education, the public and private sector. Here is a list of just a few.

Security. Cloud base security offers encrypted data transmissions and the ability to store an enormous amount of data with less hardware space. Automated upgrades are a key component of cloud computing to offer the latest in cyber protection and services. Encrypted data storage and transmissions are a barrier to hackers and enhances cybersecurity.

Mobility. Cloud Computing offers the ability for users to access data on multiple devices, including mobile phones, tablets, laptops, and desktop computers from anywhere and anytime, where Internet connectivity is available.

Flexibility. Personal Data can be remotely accessed, shared, and distributed just about anywhere. Cloud base computing also helps improve the ability for local and federal governments to interact with the population by providing information, improving communications and applications for services. Companies, institutions, and organizations also spend less time and money hosting IT infrastructures. Flexibility in Cloud based learning can enhance any educational environment through accessibility.

Cost. Not only does Cloud based computing offer less overheard, workspace and workforce cost, but many cloud base services offer pay-as-go packages. This includes data storage options for internal cost but also trickle-down savings to clients or education personnel as well. The Return on Investment over time can be lucrative and offer expansion in other lines of business.

Cloud base services in education can be used in Distance or Electronic Learning utilizing several mobile devices. Unlike traditional brick-in-mortar learning, Cloud base learning is on the go, and learning outcomes can be stored. In addition, documents, data, and applications can run and also shared. Examples of how Cloud based learning can be used in education include registrations, live chats, links to videos, portal websites, scoring, etc., all under one unified platform. The sustainability of using Cloud base platform in education can be the future in adaptation of learning skills and teaching strategies.

10. Please describe your primary audience (e.g., I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.

[redacted] has an audience ranging from elementary school to senior citizens. Our primary audience are students in grades 6-12, who participate in our [redacted] and [redacted]. However, when it comes to cybersecurity, one of the most vulnerable populations are young children.

The [redacted] offers interactive learning modules aimed at increasing grade K-6 students' awareness of online safety and cybersecurity principles. Cybersecurity needs to be incorporated in elementary school curricula to ensure safety as quickly as possible in our technological evolving society. Safety includes identifying people who can be trusted, avoiding strangers, to introductions to cybersecurity and sharing information on phones, gaming chatrooms and social media. Experian, the consumer credit company, in 2019 reported, "About one in four youth in the US will experience identity theft or fraud before they reach the age of 18 (https://www.experian.com/blogs/ask-experian/know-protect-child-identity-theft/)." Cyber thefts were looking to establish fraudulent credit reports. Furthermore, the Journal of Adolescent Health recently published that "about one in five American young people experience unwanted online exposure to sexually explicit material, while one in nine experience online sexual solicitation (https://www.jahonline.org/article/S1054-139X(18)30134-4/pdf)."

Our learning modules teach children of elementary school age basic knowledge of sharing personal information, computer operation systems, malware, phishing, firewalls, and passwords, just to name a few. Instructors are fortified with curriculums that align with the modules, installation instructions, social media guides, and a certification awarded to students who successfully complete the modules. Modules are Windows and Mac OS compatible and can be played in English or Spanish. Reading is still a necessary component in the development of elementary students, so [redacted] also offers the Cyber Education Literature Series which was developed to introduce cybersecurity awareness to young children in a fun and interactive way. We offer two colorful characters in books named Sarah the Cyber Hero and Ben the Cyber Defender. Both age appropriate books address cyber security.

Other existing education programs not included with [redacted], but we feel add value for younger students are SelfCAD and Socrative. SelfCAD is a cloud-based 3D CAD software package that allows students to create 3-D images and print 3-D designs. It is free and a powerful tool to motive future engineers and STEM learners. Socrative is similar to the Kahoots platform [redacted] uses. Socrative uses mini quizzes assigned to students and can use multiple choice, short answers and true and false. It is a great tool to use for not only students but for workshops to test participants on the knowledge they just learned.

[redacted] STEM RFI Response

The [redacted]

Responses are provided to the following questions:

- **Future Opportunities in STEM Education 3, 5, 6, 8**
- **Develop STEM Education Digital Resources 9-11**
- **Increase Diversity, Equity, and Inclusion in STEM 12**
- **Engage Students Where Disciplines Converge 13**
- **Build Computational Literacy 23**

Future Opportunities in STEM Education

3. *What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?*

The involuntary shift to a largely remote learning environment had a profound impact on the work of [redacted]. We have had positive experiences in our professional development program, which is primarily geared towards college-level instructors. For example, our annual meeting, the [redacted], normally held in person for approximately 350 participants, moved online in summer 2020. Participants met for workshops, discussions, presentations, and keynote talks through Zoom, and collaborated with each other using technologies such as Google Suites. Likewise, our [redacted] has been partially converted from our usual in-person workshops into a virtual format. Further NSF funding could help with formalizing the conversion to digital platforms, allowing greater participation from around the world and different types of participation than are possible in person.

[redacted] also sponsored projects that brought communities of instructors together to address a need related to the COVID-19 pandemic, including Designing Remote Field Experiences [redacted], which was funded by NSF through a RAPID grant. The research team put together webinars over Spring-Summer 2020 to help field instructors use digital tools and develop virtual field trips. Digital tools included StraboSpot, GigaPans, Google Earth, SketchUp, Virtual Landscapes, Geologic Map Data Extractor, Tour Builder, Slack, Solocator, ThingLink, EazyZoom, Kuula, MetaShape, MeshLab, Could Compare, SketchFab, VisualSFM, GeoExplorer, and Flyover Country. Some of these are custom geoscience software developed with support from NSF.

5. *What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?*

College-level geoscience instructors could benefit from professional learning in all of the areas mentioned in this question (utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband). In addition, and more specific to the geoscience community, they would benefit from professional learning that supports field-based and lab-based instruction remotely. [redacted] has provided some of this support, particularly through the Earth Educators' Rendezvous and its webinar series, but could benefit from more resources to broaden access to these professional development opportunities.

6. *What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?*

[redacted] would benefit from access to data about post-secondary geoscience enrollment, changes in the nature of instruction across different institution types and geographic areas, impact on student learning, and changes in the geoscience workforce. The American Geosciences Institute (AGI) is currently collecting some of these data.

[redacted] is sponsoring a project, funded and conducted by SERC at Carleton College and the Research and Spatial Cognition lab at Temple University, that collected responses through a "daily diary" survey over two weeks in the spring (n = 262) and is collecting additional responses this fall that assess the level of disruption in respondents research, teaching, work/life balance, and communication. They also responded to two open-ended questions about the most important thing they have done that day and the most important insight from the previous day. Preliminary results show that participants are experience moderate disruption across all domains, and that the level of disruption varies by day (within individuals) and between individuals. The open-ended questions reveal that faculty are worried about all levels of the educational system, and have discovered new ways of doing things. That project is currently under review for NSF funding through the IUSE program, and would provide insight into the factors that support instructors' adaptive flexibility and their ability to provide equitable instruction.

8. *What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?*

[redacted] took several actions to support learning in its community of geoscience educators:

1) We moved the [redacted] online and added programming explicitly about learning online, including a three-day workshop "Teaching your upper-level course online: A community collaboration to build robust online geoscience courses" and a roundtable discussion "Transition to Teaching Online." Other programming incorporated components about virtual learning and teaching.
2) [redacted] and SERC's portal to resources for Earth educators, Teach the Earth (https://serc.carleton.edu/teachearth/index.html), now includes a curated collection of resources for converting courses to an online format, including online teaching activities and courses, how-to guides for transitioning to online teaching and for teaching virtual

field exercises, a guide for best practices for teaching about Earth online, and a Teaching Geoscience Online community of educators.

3) [redacted] sponsored the virtual-teaching project Designing Remote Field Experiences [redacted], which was funded by NSF. [redacted] supported the development and implementation of webinars over Spring-Summer 2020 to help field instructors use digital tools and develop virtual field trips.

These three actions were helpful, and very positively received and appreciated by our community. However, as a non-profit organization with a limited budget determined in large part by member dues, [redacted] took a financial risk, in that each of these actions incurred greater expenses to [redacted] without corresponding increases in revenue. NSF funding for workshops, as well as robust NSF funding to collaborating organizations (e.g., the Geological Society of America and the American Geophysical Union), can help increase the resources available for the geoscience community. In fact, almost all [redacted] resources are available without a paywall, because we feel strongly that the entire community should benefit from our materials and events.

Develop STEM Education Digital Resources

9. *What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?*

An extensive, curated, and reviewed collection of web-based resources (https://serc.carleton.edu/teachearth/index.html) is one of the primary products that [redacted] provides to its community of geoscience educators through a collaboration with the Science Education Resource Center (SERC). There are several elements of this set of resources that we feel should be incorporated into any STEM education website:

- Resources that are designed using evidence-based practices in STEM education,
- Descriptions of and links to the research base,
- Support to help instructors implement the resources,
- Mechanisms for community members to contribute resources,
- Mechanisms for peer review of resources and elevation of the most comprehensive and complete resources in searches,
- Mechanisms for users of the resources to share their experiences implementing them and adapting them.

One of the biggest challenges we face with digital resources is keeping them current and updated. This is a very difficult problem to address when many of the resources are developed through grant funding, and once the grant funding ends, there is little or no support to update and maintain the resources. [redacted] has piloted the concept of volunteer editors within content areas of our resources, but the current situation has stretched many of our community members to their limits and their volunteer time is limited. All websites that host digital STEM education resources would benefit from a mechanism to ensure maintenance and updating of resources to keep them current, usable, and fresh.

10. *Please describe your primary audience (e.g., I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.*

[redacted] serves educators at all levels, in both formal and informal educational settings. The large majority of our members are college faculty, and thus the majority of resources that we provide online are geared towards college faculty. We also count K–12 educators in our membership, however, and have resources targeted for use in high schools and middle schools. The education resources mentioned above would help educators in the geosciences optimize their positive impacts on students and learners, including in the transition to online learning and teaching.

11. *How would you like to see resources categorized (e.g., subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.*

The Teach the Earth website (https://serc.carleton.edu/teachearth/index.html) has resources categorized in several ways to enable educators to quickly find appropriate resources for their needs. The materials are tagged by course topics, societal issues, grade level and setting (e.g., two-year versus four-year college), professional development needs, review status, and use of evidence-based pedagogical practices, allowing users to search and browse to find what they need. You can also navigate to resources that were developed as part of specific programs and events. The website also has highlighted parts of the collection, including peer-reviewed materials that have been rated "exemplary," and opportunities for educators to become part of the geoscience education community.

Increase Diversity, Equity, and Inclusion in STEM

12. *What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?*

[redacted] broad commitment to valuing all voices is stated in our mission which is "to support a diverse, inclusive, and thriving community of educators and education researchers to improve teaching and learning about the Earth." In late 2019, at the recommendation of an *ad hoc* task force, we established a high-level Diversity, Equity, and Inclusion (DEI) Committee. The DEI Committee's charge is "to facilitate [redacted] efforts to achieve its goals related to diversity of its membership, leadership, committees, award winners, and participants in all events." The DEI committee began its work in May. The charge includes a statement about the goals of the organization related to diversity. These goals do not yet exist; we are in the very beginning stages of a strategic planning process that will help us establish these goals, among others. We are currently working on a member survey that will include questions generated by the DEI committee that relate to our members' experiences and interests; the results will help inform our efforts and strategic planning process.

We have recently received funding from NSF to incorporate professional development in DEI for all of our workshop leaders (Early Career Workshop, Traveling Workshop Program, and others). This includes funding to bring in (virtually or in-person, as the times dictate) people with lived experiences very different from the majority-white leaders for leader development in early 2021. A second workshop proposal to NSF is currently under review that will support the implementation of DEI and anti-racist sessions into our Traveling Workshops Program during the 20-21 academic year.

In the last five years, we have moved all of our nominations for committees and leadership to an open nomination process from what was an informal process that limited nominations to people already known by the individuals in leadership roles. With open nominations, individuals may self-nominate or be nominated by others, and the process is intended not to be onerous. This has led to several successful nominations that have expanded the diversity of our leadership.

This year, a benefit of the move of many conferences to online allowed us to participate as exhibitors when otherwise the expense would be too high. We had a virtual booth at the National Association of Black Geoscientists (NABG) meeting, and are hosting a joint social with SACNAS as part of our GSA efforts.

Engage Students Where Disciplines Converge

13. *How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?*

[redacted] is keenly aware that geoscientists are critical for solving some of the most difficult societal problems, particularly related to mitigating and adapting to climate change, finding and using natural resources sustainably and equitably, and avoiding the severest impacts of natural disasters. All of these problems are transdisciplinary, and therefore require a systems approach that integrates social sciences and humanities with the geosciences and other STEM disciplines.

[redacted] recently co-sponsored [redacted] which received NSF funding. [redacted] sought to improve Earth literacy and build a workforce prepared to tackle urgent environmental and resource issues facing humanity. To this end, the project supported interdisciplinary teaching about Earth and environmental issues across the undergraduate curriculum. The project collected and synthesized existing work into an extensive website; developed, tested and published 26 curriculum modules, 6 courses, and 16 program models; implemented large professional development programs involving more than 1500 educators; and created a national scale community which continues to work toward these goals. One goal of this project was to broaden participation in the geosciences.

Teach the Earth (https://serc.carleton.edu/teachearth/index.html) brings together [redacted] and other multi-, inter-, and trans-disciplinary teaching resources for the geoscience education community. Some of these resources include opportunities for co-teaching, and all center student learning through meaningful formative and summative assessments that have been shown to improve learning for all students.

Build Computational Literacy

23. What technologies and resources do you currently use (e.g., apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

[redacted] contracts with the Science Education Resource Center (SERC) to support its operations; SERC hosts [redacted] website and we make use of all of the custom tools that SERC has developed (collectively called Serckit) to support collaborative web editing, hosting and sharing of resources, designating groups and providing tiers of access to internal web pages and workspaces, and handling membership. SERC recently received NSF funding through a RAISE proposal to improve resource discoverability, and [redacted] will benefit from the work done through this grant.

In addition to Serckit, we make use of Zoom, Google Drive, and Remo. One challenge of Zoom is that it does not adequately allow for spontaneous collaboration among small groups of people in meetings and workshops. Solutions to this challenge in any software package would be welcome.

“Making the Case for GeoSTEM”

Response to Question 18:

> “What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?”

Introduction:

As the national Science-Technology-Engineering-Mathematics (STEM) policy makers work through reports, findings, forums, and workshops, etc., there emerges an opportunity to present the strong case of why and how the role of the Geosciences community can and should be at the forefront of these discussions. Currently existing within the Geosciences scientific and educational community are policies, frameworks, guidance, innovative technology, and unique interdisciplinary Earth System data sets that will establish a pathway to the role of the Geosciences in the classroom, 21st workforce, and society. The question may be raised, “why GeoSTEM”? The real question is … “why not”?

As we face future natural and human-generated hazards and disasters, the geosciences have a critical role in the public awareness, safety and national security of our nation. This past year, we have experienced volcanoes, earthquakes, tsunamis, hurricanes, tornadoes and severe flooding, yet it is becoming increasingly more difficult to find opportunities in K–12 education for students to engage in relevant related studies. What implications will this have on the 21st century workforce? Teachers are using satellite and remote sensing technologies to incorporate imagery, data and real-time observations in the classroom. Geographic information Systems (GIS) content is being taught as a technical skill, and issued to develop “geospatial thinking” in problem solving. Today, pre-college students and teachers are collaborating with the commercial aerospace industry and NASA to build “CubeSats” (small cube shaped satellites) ready or spaceflight, creating authentic science experiences. Students are engaged in observing the Earth and visualizing their future. Our community has an opportunity to inform policymakers in the development of emerging national STEM (Science, Technology, Science and Math) education initiatives. The interdisciplinary nature of our discipline lends itself to providing the required leadership.

GeoSTEM provides direct applications with *and* between each discipline of STEM which is at the core of STEM philosophy. This instructional strategy, GeoSTEM, is clearly is present in the NGSS. The NGSS identifies skill sets to be developed by students.

The Science and Engineering Practices (National Research Council, 2012) are outlined as follows:

- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics, Information and Computer Technology, and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

From Big Data to Virtual and Augmented Reality, a picture of a new classroom laboratory emerges, The Remote Sensing Laboratory … Monitoring the Earth as a System. The Geosciences community explores the interdisciplinary sciences while studying the interactions of the Oceans –Earth – Atmosphere- Space thus meeting one of the criteria of STEM and clearly justifying the creation of GeoSTEM. One can see that through developing a GeoSTEM approach it will be possible to meet the above goals and provide opportunities for students to engage in *authentic* science by *practicing* real science.

Achieving Data Literacy Through the Geosciences:

For our students, Acquire and Analyze is only the beginning. There must also be "Apply" for all to make sense. "Apply" provides the answer to "So what?" As students look at understanding climate, land cover, water quality, migrating wildlife, severe weather, wildfires (the list can go on) -- what a great answer to the universal student question, "Why do I have to learn this?"

Simply put, A^3 presents the essential parts of any problem solving, in any discipline. In Career Technical Education (CTE), for example, A^3 can lead to the development of essential workforce readiness skills. Working through any type of problem solving requires these three steps: Acquire, Analyze, Apply. Employment of these three phases can make working toward the future simpler, easier, and faster -- all good research goals.

Acquire — how do we get satellite imagery and/or remote sensing data, store it, and share it? Building antennas and computers that were robust enough to hold these precious images, the technology rapidly evolved. The advancement of such technologies moved us to **Analyze**. Programs such as Multi-Spec and ImageJ opened more opportunities to conduct investigations using the acquired geoscience-related data. Geographic information systems (GIS) were introduced to the education community and today remain one of the most powerful tools of analysis available to students, researchers, and professionals.

Acquire and Analyze inevitably lead to **Apply**. NASA, NOAA, NSF, and the Academy of Sciences provide multiple answers to that question now, and THAT opens the doors to student research. The Geosciences provide ample opportunity to observe, investigate, and collect data on a wide range of important science issues that impact society, our economy, and our national security. The question that should be addressed on a national level is, “Why doesn’t science education mirror the science community? If data literacy is an important concept for the science community and the nation, then why is it so hard to find it in our educational systems?”

Preparing a Satellite Literate Workforce: STEM and Career Technical Education (CTE):

The Geosciences have a critical role to play in the public awareness, safety, and national security of our nation, all of which impact the US local to national economies yet it is becoming increasingly more difficult to find opportunities in K-12 education for students to engage in relevant related studies. What implications will this have on the 21st Century workforce? Teachers must begin to use satellite and remote sensing technologies to incorporate imagery, data, and real time observations in the classroom.

Historically (over 5 decades), NASA and NOAA have been the leading edge of developing and launching remote sensors of all kinds on spacecraft, and gathering the data and imagery that have so strongly influenced of our daily lives. NASA and NOAA have also set the path for future missions into the solar system and beyond using similar instruments and data verification techniques.

Does the need exist to prepare a GeoSTEM literate workforce? Consider the future opportunities emerging from NASA/NOAA, SpaceX, Northrup Grumman at the three major US launch facilities – Florida’s Kennedy Space Center, Wallops Island in Virginia, and Vandenberg Air Force Base on California’s west coast. NASA has recently announced the new group of astronauts. Consider that plans are moving forward for humans to return to the Moon by 2024, and eventually Mars. Commercial and tourist spaceflights are just around the corner. If that is not enough, consider the recent announcement of a newly created, military-oriented United States Space Force. There is no question of the role and value that our current satellite systems play, whether for weather and environmental observations of Earth, global positioning and navigation, communications, the near-Earth space environment and other astronomical studies, national security, and the list goes on! What new challenges lie ahead in the coming decades?

Over the last thirty years the United States educational system changed as it continued to search for pathways leading to success in terms of academic achievement, recognizing and leveraging diversity, and training workplace readiness skills. About ten years ago, the National Research Council (NRC), the National Science Teachers Association (NSTA), and the American Association for the Advancement of Science (AAAS) worked together to develop the Next Generation Science Standards (NGSS). A movement away from fact-based standards, NGSS was thought by many to provide the desperately sought answers for creating equity across the states and would lead to a more competitive workforce in a global economy. At about the same time, the acronym STEM (science, technology, engineering, mathematics) became popular. These four letters remind us of the interdependence of the four often siloed fields they represent. The popularity of their application and use has risen nearly to the level of a national educational policy. Many feel NGSS and STEM will fill the gaps and provide skills leading to future careers, enhance national security, and keep the USA competitive in the global market. There is a strong correlation between STEM and Career Technical Education (CTE). However, implementation efforts in all three areas have remained, in large measure, uncoordinated. Some approaches have been successful, some not. The CTE community can be the bridge between providing an academic-oriented education AND the skills that prepare students for, and lead them to, the challenges of moving into the space community.

In 1981, I began teaching at a career technical high school where I was tasked with developing a non-existent Environmental Studies Program. Over time, that became Geoscience and Remote Sensing, and then Geospatial Technologies. The evolution of that curriculum was the direct result of the inclusion of applications of satellite imagery, remote sensing, and computer visualizations I developed for the environmental science course of study. There are notable differences in Career Technical Education that opened the door for those curricular changes. A CTE curriculum is nonlinear, meaning that skills and topics often are revisited building on previous learning. It is proficiency-based, not standards-based. The proficiencies are generally developed through the creation of an Advisory Board, consisting of educators, industry, and workforce representatives. Thus, the proficiencies are constantly updated in reaction to innovations and new trends in industry. The CTE curriculum is designed to be fluid. The contact time with students is much greater, two hours per day for four years. It is hands-on – what to do and how to do it! It is workplace-based meaning the proficiencies are developed to lead to the workforce not necessarily college or university, although most students continue with post-secondary education before entering the workforce. Specific tasks over the years that have been developed that contribute to workplace readiness skills: building antennas, developing electronics for signal acquisition, use of image analysis tools such as ImageJ and MultiSpec, creating visualizations from data, mapping, use of GPS, programing and coding, and ground-truth verification of satellite data/imagery. Acquire-Analyze-Apply (A^3) is the overarching theme summarizing the skill sets students will need for these tasks.

In recent years, Career Technical Education received a boost in national and local attention as many students sought academic degrees while preparing to get a job. While some universities are now offering some workforce skill preparation, the community colleges are the most prominent in responding to the challenges of preparing technical workers. There is also a CTE resurgence in the precollege arena. If students ask, “Are there opportunities for me in the GeoSTEM community?” The answer is, “Yes! Your journey can take you places you may not have imagined possible; you may not be able to see the connections yet. Follow the opportunities!”

A Vision for the Future:

Planet Earth will be monitored, observed, and studied as an Earth System, in real or near real time. Policy-makers, decision-makers, scientists, teachers, students, and citizens will not only participate in the process, but come to use such information and data routinely in their daily lives. In 2020 plans are underway to return to the Moon, and send the first human to the surface of Mars. These very same GeoSTEM skillsets will be used in those investigations and research.This vision for the future ***ENGAGES*** students. 3-D data visualizations, virtual field trips, interactive imagery from space all will contribute to doing real science in real time. Policy-Makers have linked STEM Education to our future economy and national security, the GeoSTEM community can deliver added value through leveraging current and future Geoscience-related resources that monitor our planet and the protect life and property of our citizens.

[redacted]

Dr. Sethuraman Panchanathan
Director, National Science Foundation
2415 Eisenhower Avenue
Alexandria, Virginia 22314

October 15, 2020

Re: [redacted]: STEM RFI Response

Dear Director Panchanathan,

For more than 40 years, [redacted] has worked with teachers and educational specialists to deliver playful learning experiences in PreK-12 classrooms. We bring Science, Technology, Engineering, Arts and Math (STEAM) to life in the classroom and make learning fun and impactful. Our wide range of physical and digital educational resources encourage students to think creatively, reason systematically and release their potential to shape their own future.

During this time of unprecedented crisis, [redacted] has worked closely with school districts and teachers across the country to continue to uphold a high standard of learning for students in virtual and hybrid learning environments. We have partnered with technology companies to help bridge the digital divide while also ensuring that students have the hands-on learning materials that are crucial for holistic skills development.

I hope that by sharing our experience in response to Future Opportunities in STEM Education, questions 1-5; Engage Students Where Disciplines Converge, question 13; and Build Computational Literacy, questions 20-22, we can help to support the federal response not only to the COVID-19 crisis, but also beyond.

We recommend that implementation of the Federal STEM Education Strategic Plan supports strong federal funding and program support for:

1) Playful, hands-on learning experiences in every subject area, including STEAM and computational literacy, that help children to engage fully while coping with stress and anxiety;
2) Access to hands-on materials necessary to maintain quality learning during the transition to hybrid and virtual learning, including through “take home” kits to support at-home hands-on learning; and
3) Teacher professional development of skills necessary to transition playful and purposeful STEAM education into distance learning environments.

[redacted]

[redacted]

The [redacted] Approach

[redacted] is deeply committed to providing solutions that address the needs of the learner, and build lifelong STEAM skills in PreK-12 classrooms. It is critical that we prepare children with the skills needed to adapt to the ongoing process of technological change that impacts how we live and thrive. As educators, this means helping children to hone a broad set of holistic skills — social, emotional, physical, cognitive and creative. Delivering highly engaging, hands-on, playful STEAM learning is one of the ways that educators can help children achieve this goal.

[redacted] is a strong advocate for hands-on learning and learning through play and offers solutions that are easy to implement with ready-to-go lessons aligned with educational objectives and learning standards. Playful, hands-on STEAM learning puts an emphasis on skill development and learner agency, where students benefit from collaboratively learning by doing and connecting concepts and content with real-world applications. These approaches support national learning standards and objectives, such as the Next Generation Science Standards (NGSS), standards from the Computer Science Teachers Association (CSTA), and Common Core. Research-based playful learning solutions work in any learning environment from within a classroom to distance or virtual learning or some blend of the two to engage students to understand abstract concepts, inspire them to engage in STEAM subjects and be the problem solvers we all crucially need in current times.

Section Response: Future Opportunities in STEM Education

Key Section Recommendations:

- Children need access to high-quality hands-on materials and learning experiences, even in a mostly virtual environment. The federal government can help limit learning loss during the COVID-19 crisis and mitigate equity challenges by providing strong funding and support to schools to provide STEM learning materials and well-rounded educational experiences.
- Ensuring that districts, schools and teachers have the guidance and funding to prioritize the distribution of hands-on materials must be prioritized alongside internet access.
- Strong professional development and instructional resources for teachers are needed to support playful, hands-on learning experiences in virtual and hybrid learning environments.

Input to questions 1-5

Q1. Digital resource barriers

When learning moves online for PreK-12 students, it is important that we do not sacrifice best practices. Evidence shows that **students learn best through hands-on, inquiry-based instruction**. Hands-on learning builds student confidence, which means they will be more likely to try new things and keep trying even when they

[redacted]

don't get it right on the first try. Further, students and educators are also attempting to learn and teach in widely disparate home environments and circumstances.

When teaching students through digitally supported virtual interaction, schools are focusing on providing internet-connected devices, internet access, and teaching platforms. While these approaches provide a baseline set of tools to guide instruction and can simulate in-classroom learning experiences for students, **children need access to high-quality hands-on materials and learning experiences even in a mostly virtual environment.** Hands-on learning, even in remote classrooms, can continue to engage students, build confidence in learning and provide opportunities to learn outside of using a computer or other internet-connected device.

[redacted]

Even in a virtual environment, students need hands-on tools. This student is engaged with his teacher and classmates, preparing for a hands-on lesson with a [redacted]

Q2. New approaches during COVID

Strong learning environments are characterized by playful, collaborative experiences that leverage project-based activities to deliver playful, hands-on learning. Playful learning allows students to experience learning in an engaging way that can easily move from the classroom to online environments. However, while these kinds of experiences are both optimal and recommended, moving these pedagogical approaches out of the classroom can be challenging for teachers, and strong professional development and instructional resources are needed to support that transition. In virtual and hybrid learning environments, this means experimenting with new ways to scaffold learning experiences. By ensuring that in addition to online direct instruction, students also have offline, hands-on activities integrated into hybrid learning environments students are given the time they need to connect with ideas and apply their thinking.

Many schools across the country have opted to return to the classroom. To support these efforts in the midst of ongoing public health concerns, [redacted] works with our district partners to ensure that [redacted] are in place where our hands-on materials are shared.

Q3. Positive Learnings from Remote Learning

The move to virtual learning has provided several positive learnings for the future of education, beginning with providing students with work-relevant experience, such as working with others in a virtual space. Skills in navigating a learning management system, etiquette for video calls, and use of collaborative tools will prepare students for different types of work environments they may encounter. [redacted] tools are helpful for developing these skills both in and out of times of crisis. Reinforcing the value of these experiences and

[redacted]

expanding their utilization even after the COVID-19 crisis has passed will help students prepare to enter a workforce that is increasingly global and reliant on digital communication.

Remote learning has also increased the level of parent and caregiver engagement. While schools are in remote-learning mode, parents have had to assume to role of a teacher's assistant to help facilitate the learning at home. By taking an active part in their child's education, we have seen parents' understanding of educational goals and learning needs improve. There is an opportunity to [redacted] during and after this period of concentrated remote learning on key educational methodologies, especially learning through play, to promote learning at home in out of school times, which could reduce learning loss resulting from this pandemic.

In our observation, federal funding – including Title I, Title IV and Perkins Career and Technical Education resources – has been useful for school districts to provide students with take-home materials. However, funding levels remain low compared to the scale of the need. One of the most important learnings from this period of crisis is that there is a deep need for more funding and national strategic support for education resiliency.

Q4. Deepening Inequities

Without proactive support to distribute necessary hands-on learning materials to children, gaps are inevitable, and those gaps will reinforce existing inequities. **Ensuring that districts, schools and teachers have the guidance and funding to distribute hands-on materials must be prioritized alongside internet access.** Hands-on materials should be understood to include a wide range of manipulatives that include everything from paper and pens to materials used in art, physics and science instruction. Without these materials, it is difficult to maintain the integrity of a STEM discipline learning experience. Although internet access through a digital device can support student learning, nothing replaces the utilization of hands-on materials when trying to learn abstract concepts, particularly in science, engineering, and mathematics.

By providing funding and guidance to support the equitable distribution of hands-on materials, the federal government can 1) support students by maintaining the integrity of the learning experience, 2) empower caregivers who facilitate the at-home learning experience and 3) set teachers up for success in reaching children in a range of circumstances.

Outcomes for students are a top priority for any educational environment. However, it is very challenging to maintaining the integrity of a learning experience in the transition to virtual and hybrid learning when students have limited resources in the home. Even when access to Internet-connected devices and an Internet connection can be provided, it is difficult to sustain a high-quality learning experience without hands-on materials.

Support for parents and caregivers should also a be a priority in all-virtual and hybrid learning environments. In the context of distance learning, access to learning materials is dependent on parents providing them. Unless a teacher has the time and resources to gather, sort and distribute materials to each student, different children in the same classroom will have different materials available to them. The quality and range of those materials will

[redacted]

depend on their home circumstance. **Easily transported materials that are familiar to caregivers are ideal for at home STEAM learning to avoid creating frustration and anxiety for parents and caregivers.**

And finally, we should **provide extensive and considered support for teachers.** Not all teachers are comfortable teaching STEAM, and this is especially true at the elementary level. Adding the strain of navigating virtual and hybrid learning environments has, in our observation, led to STEAM teaching being deprioritized or taught through reading and video resources online. Hands-on, experiential learning is less likely to happen unless students have access to high quality, ready-to-use materials that are designed to teach STEAM skills and knowledge. If the trend of deprioritizing STEAM teaching in online spaces continues, the gap will widen – both in terms of learning loss during this crisis, but also in terms of equity impacts for underrepresented groups in STEAM.

To address the issue of the digital divide intensified by the COVID-19 pandemic, [redacted] collaborated with First Book, CDW-G and Intel Corporation to build [redacted]. This initiative provides learning solutions to several thousand students and families in Title I schools in the United States impacted by the pandemic. Students received critical at-home and in–the-classroom learning resources, including internet connectivity, technology devices and [redacted] hands-on STEAM learning solutions.

Q5. Professional Development for Remote Teaching

Professional learning opportunities that are practical and help teachers to develop robust hands-on learning strategies are critical for effective digital instruction. **Teachers should have access to professional development that features the same high caliber, hands-on and immersive learning experiences that they are expected to deliver to students.** Teachers need virtual coaching that is delivered dynamically, develops a wide range of skills and includes hands-on experience with high-performing teaching practices

Teachers need support to transform learning methodologies designed for in-person classrooms to virtual environments. Areas to be considered when moving from in-person classroom environments to online environments include:

- Supporting and recognizing high levels of student engagement;
- Purposeful scheduling of digital and non-digital, hands-on experiences;
- Leveraging in-home materials and hands-on resources in digital environments;
- Planning and facilitating collaborative work in remote settings; and
- Designing assessments that account for different learning environments.

Response: Engage Students Where Disciplines Converge

Q13. How we approach transdisciplinary learning, and why.

[redacted] solutions encompass robust and engaging teaching and learning tools. Our lessons integrate science, technology, engineering and math to provide students with [redacted] and computational

[redacted]

thinking experience combined with [redacted]. We take this approach to **ensure that learning transcends disciplines and provide students with authentic, inquiry-based learning experiences.** They afford students with the opportunity to acquire STEM content knowledge while developing critical 21st century thinking skills in both scaffolded and self-directed playful learning experiences.

Using a lesson technique that embraces the "5E" approach, students are able to Engage with ideas, Explore them, then Explain them before Elaborating and Evaluating the concepts. This approach unlocks the natural curiosity in students to explore. Students are able to design, build, and program physical models to represent their ideas or solutions to solve problems. This gives students a chance to make ideas come to life, play with concepts and engage in exploratory thinking. These **hands-on experiences build confidence in students** for understanding how to approach problems, communicate solutions and innovate on ideas, no matter what the discipline.

Response: Build Computational Literacy

Key Section Recommendations:

- Guidelines for computational literacy education should prioritize the integration of hands-on STEM learning.
- By integrating STEM subject matter into computational literacy education, students are better able to engage with computational concepts because they have an authentic real-world connection.

Input to questions 20-22

Q20. Benefits & challenges of computational literacy in STEM

STEM education and computational literacy naturally fit together in an educational environment, because computational thinking allows us to comprehend complex problems in STEM fields and develop possible solutions using computing.

[redacted]

Students collaborate on Scratch-based coding project using [redacted] hands-on materials.

Computational literacy often refers to the knowledge and use of various technologies, many of which can be explored and practiced within a STEM course. However, computational skills can also be used to explore and learn about STEM subject areas – encouraging, for example, investigation into real life science and engineering problems. Computational skills can be used to model experimental approaches and develop new and improved technologies. Solutions can then be communicated in a way that a computer, a human, or both, can understand. Leveraging computational thinking in a STEM classroom can provide meaningful engagement for students by having them explore concrete ideas while developing computational literacy.

[redacted]

The biggest barrier to integrating computational thinking into STEM learning is a lack of understanding and expertise from teachers. Many, if not most, teachers did not learn computational thinking in their own K-12 education, so they must be supported through pre-service and in-service professional development. Teachers need experience to know what successful computational thinking looks like for their students and resources that support authentic approaches to combining computational literacy and STEM. **Too often, teachers turn to using technology exclusively for simulations and rely too heavily on coding without incorporating any real-world or hands-on elements.** In this way, computational literacy taught in a STEM context can be taught only at a surface level, leaving students without the depth of experience necessary to truly develop computational thinking skills.

Q21. Key components of computational literacy in STEM

Computational literacy components are foundational within problem-solving and are similar to other science and engineering processes. Digital literacies historically have included proficiencies in the use of computing systems and productivity tools such as spreadsheets, word processing, and presentation software. [redacted] for using these tools is a far more impactful learning experience than using them in isolation. [redacted] playful STEAM learning approach gives students the agency to select and use appropriate tools for digital journals, presentations, and data collection and usage. Additionally, students are able to collaborate together, adding social skill development into the experience.

Newer additions to computational literacies include cyber and data ethics, cyber security and cyber safety. Students face a career and personal environment where these types of literacy are vital. Students need a foundation of computational thinking and data ethics to appropriately engage new tools such as artificial intelligence when they encounter these topics later in education, or understand how to and why they need to protect information. Additionally, conversations about the impacts of computing need to happen so students understand issues like that of intellectual property and the impact of remixing the work of others.

Q22. Existing case studies for computational literacy in STEM

[redacted] solutions provide concrete, hands-on experiences to afford teachers an innovative way to present content and skills to students. [redacted] curriculum is designed to provide students the opportunity to [redacted] within the context of real-world problem solving. [redacted] solutions also engage and create explicit dialogue and learning around computational literacy while supporting science, computer science, English language arts and applied mathematics. [redacted] approach to learning helps students develop a wide range of skills and knowledge, helping them succeed in school and in life. In addition, [redacted] opportunities for teachers are designed to help teachers make changes in their instructional practices to better facilitate hands on learning in STEM while promoting creativity and innovation within their classroom.

STEM RFI Response

Reference: Notice of Request for Information on STEM Education, dated: 09/04/2020

Submission date: 10/17/2020

The comments in this response are addressed towards "**Future opportunities in STEM education, questions: 1-2, 4**"

I am an [redacted]. I teach courses related to software engineering in a graduate program titled [redacted] and have taught several courses in a hybrid remote learning environment since the COVID-19 national emergency was declared in March 2020.

I would like to start by thanking you for opening up this opportunity for us to share our experiences and thoughts on our response to this crisis. It is first time in the history that the entire education sector has undergone the experience of online-education, and that makes now the perfect time to find out how technology can help us be better prepared for the future. What I wish to express here are not just my reactions to sudden switch to online modality. I have been teaching and doing some research in online teaching and learning since over seven years now. The recent crisis has helped me focus into the gaps that have been overlooked thus far because of the natural affordances of in-person teaching and learning. Evidently, we cannot overlook such gaps anymore.

The key idea that I would like to present here is the need for digital learning platforms. These platforms should fulfill two critical needs - discipline-oriented pedagogy, and synchronous active learning - which are discussed below.

Discipline oriented pedagogy

Research has shown the importance of tailoring pedagogy to subject matter (Donald, 2002; Shulman, 1986), which then indicates that technology used in teaching should also be designed to fit the pedagogy needs. I teach software engineering courses which to a large extent are about building 'software'. There is a lot more hands-on 'doing' in my classes than reading or talking. When I conduct lectures, I need to display my code and presentation slides to the students. But in labs where students are required to solve programming problems, I should be able to see their work as they are working through the problem. In face-to-face setting, I was able to do that by just walking across to them, look at their computer screen, and reach out to help if needed.

But now, as our university, like many others, adopted Zoom©[1] as its default platform to deliver instruction for all programs and courses, those in-person affordances are gone. I have to wait for students to ask for help, then assign them to a breakout room where the student can share their screen while a teaching assistant can look at their code and answer their questions. My role now is to triage students needing help to next available teaching assistant in a breakout room. It is

[1] https://zoom.us/

almost ironical that the course that teaches students how to build technology platforms lacks one for itself. And it is not because of any dearth of technology, but to my understanding, because the need was never felt so starkly. Video-conferencing platforms such as Zoom do not offer affordances for conducting lab classes. I am sure that instructors in other STEM courses also feel such missing affordances. In my experience, putting one digital platform to conduct classes for all disciplines is pedagogically wrong, especially in skill-oriented courses. Such use of technology is not only suboptimal but also harmful. We are trying to fit the traditional model of teaching across all disciplines into a common technology platform which was not even designed for teaching in the first place. Zoom was designed for conducting meetings and not for teaching.

We can think about it as analogous to the way colleges and universities designed campuses and buildings to suit their educational needs. In a similar fashion, we need to design technology platforms for different courses and disciplines differently. A brick-and-mortar physics lab is designed differently from a chemistry lab which is different from a lecture room for an English literature class. This differentiation starts with identifying educational needs around each discipline, program, and course. Often this detail is left to instructors to somehow design their pedagogy around the technology given to them.

We should not leave such a gap for individual instructors to fill, both in-person and remote. For example, specific to computer programming, which is one of the critical skills for STEM students to acquire, we need a platform that supports students when they are learning to code, with live-support from faculty and teaching assistants. I, as an instructor, should be able to see what each student is doing on their laptops so that I can identify who needs help, who is doing well, and where I can improve my instruction.

Synchronous active learning

I am currently teaching an intermediate level programming course. Before COVID, the pedagogy in my resident class was semi-flipped in which most of the lecture material was posted on Learning Management System (Canvas©[2]) in the form of pre-recorded videos, self-assessment quizzes, and some practice problems. Each week, I used half of the class-time in demos and discussions, and the other half in closed programming labs where students solved a programming problem within a fixed time. Research shows that closed-labs help in engaging students, especially at beginners level in programming courses (Kumar, 2010; Soh, Samal, Person, Nugent, & Lang, 2005). Closed-labs are the most effective pedagogical tool in my kit since I started teaching programming about ten years ago. Students respond well when they work alongside their peers on a well-defined programming challenge along with some help in terms of peer-collaboration and guidance provided by the instructors and teaching assistants. The collective synchronous experience of problem solving sets up a learning environment that is supportive as well as competitive. They feel motivated to solve the problem, offer help to each other as needed, and get an implicit feedback by observing how well they are doing in comparison to the other students.

[2] https://www.instructure.com/

To bring a similar synchronous learning environment in remote or socially distance classes, I envision a platform with audio-visual capabilities of a video-conferencing tool, an integrated development environment (IDE) on a cloud that supports different programming languages, and various collaboration features to create a synchronous learning environment. Fig.1 and 2 provide images of a mockup user interface that a team of my students designed as part of a class project where they were asked to design an app for conducting coding labs remotely. The key idea here is that it is not sufficient for instructor and students to see each other's faces. They should also be able to see each other's work. This allows them to collaborate, review, and provide feedback. This is the essence of teaching and learning in synchronous mode and is critical for creating active engagement.

Figure 1: Teacher's view during coding class. Teacher can see all students as well as their work. When needed, she can establish one on one communication to help a student, as needed

Figure 2: Student's view during coding class. A student can see her peers, and reach out to them, as needed, which creates a synchronous collaborative learning environment.

Such a platform also needs to be responsive to social, cultural, economic, and geo-political needs. Limited internet access, narrow bandwidth, and individual learning disabilities must be thoughtfully considered when designing platform features.

Although I am currently working on a proposal to build a prototype for such a platform for software programming courses, I believe that we need a much wider effort driven by universities across the spectrum that can pool resources together to create discipline-based pedagogical platforms. These platforms will not only offer better learning experience but will also provide the agility we need to be more prepared in future.

Currently Available Platforms

To avoid reinventing the wheel, we need to explore the currently available tools and platforms being used. Table 1 indicates a framework of the gap that I am currently trying to explore. In my knowledge, the platform that comes closest to the need described above is Zybook©[3] which offers individually assisted coding experience. As students write their answers into the coding platform, it gives them hints and evaluates their progress using artificial intelligence in the backend. This is surely a better platform than Zoom designed for a coding course. But Zybook offers offline-learning in isolation without any collaboration with peers or instructors, which results in lower engagement and eventual fatigue. Also, it doesn't offer much opportunity for instructors to tailor their instruction or extend help to those who need it at the time when the students are wrestling with a programming problem. It restricts instructors from designing their own problems that suits their pedagogy and their course's learning objectives. On the other end of spectrum, we have video conferencing platforms such as Zoom that give is synchronicity but not the other aspects needed by a programming class.

Table 1: Currently available platform options

Instruction Mode	Lecture	Lab
Synchronous	Most video-conferencing platforms such as Zoom and MS-Team©[4]	None
Asynchronous	Recorded videos posted on learning management systems such as Canvas or Blackboard©[5]	1. Zybook: an interactive eBook for students to go through learning material and hands-on exercises with continuous feedback 2. Platforms such as Google Docs[6] to collaborate asynchronously for teamwork assignments 3. Other coding platforms where students can post their code such as GitHub[7] 4. Emerging platforms such as Eclipse Che[8]

[3] https://www.zybooks.com/
[4] https://www.microsoft.com/en-us/microsoft-365/microsoft-teams/group-chat-software
[5] https://www.blackboard.com/
[6] https://docs.google.com/
[7] https://github.com/
[8] https://www.eclipse.org/che/

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Comment On: NSF_FRDOC_0001-2546
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Document: NSF_FRDOC_0001-DRAFT-0451
Comment on FR Doc # 2020-19681

Submitter Information

Name: Anonymous Anonymous

General Comment

It's vitally important for all of us to vote against the GOP's racist candidates.

Two days ago Georgia senator David Perdue thought that it would be amusing to mock the name of Kamala Harris, an Indian-American senator:

"Ka-MAH-la or what, KAH-ma-la or Ka-MA-la, Ka-mala-mala-mala, I don't know. Whatever" - David Perdue, October 16 2020

And to make things even worse, Perdue's communications director laughably tried to defend him:

"Senator Perdue simply mispronounced Senator Harris' name, and he didn't mean anything by it." - John Burke, October 16 2020

Sure. Right. Whatever. Look: up and down the ticket, from President to local school board the GOP is running racist, sexist, homophobic, corrupt, anti-science, anti-Democracy ignoramuses. Vote them out and keep them out. Thank you.

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Request for Information: STEM Education

Document: NSF_FRDOC_0001-DRAFT-0452
Comment on FR Doc # 2020-19681

Submitter Information

Name: [redacted]
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General Comment

Good Afternoon - As a former special education instructor, a building-level administrator in a large [redacted], a PhD student finishing my work in eduction leadership and policy studies at the [redacted] at a local/state /federal educational advocacy organization, I am pleased to see the detailed and thoughtful questions posed by the National Science Foundation. My response today specifically addresses question 5: What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

There are three types of professional learning opportunities (PLOs) that would benefit educators, families, and students. First, PLOs focused on culturally responsive instructional practices are vital for STEM programs. Virtual, online learning leads to disproportionately adverse outcomes for students of color, students identified with disabilities, and emerging multilingual students (Kumi-Yeboah et al., 2018). The lack of diversity in STEM programs exacerbates this problem (Allen-Ramdial & Campbell, 2014). One way to address this concern is to integrate culturally responsive pedagogical practices into the virtual learning environment. Woodley et al. (2017) recommend the following:

1. Validating students' pre-existing knowledge with relevant activities;
2. Providing comprehensive and multi-dimensional learning opportunities;
3. Transforming student learning with synchronous online meetings;
4. Empowering students through liberatory leadership opportunities.

Educators can learn about these practices in PLOs.

Second, educators must learn effective strategies for student and family engagement. Because students require scaffolding and families may lack the requisite skills and knowledge regarding STEM content, educators must spend time helping the families understand the content and providing instruction to students (Alamri & Tyler-Woods, 2017). This is particularly true for students identified with dis/abilities (Hasler Waters & Leong, 2014; Smith et al., 2016). Through the use of PLOs, teachers can learn how to deliver material to families and students and learn effective teaching strategies to keep historically targeted and oppressed students engaged in the course materials.

Third, educators need PLOs to understand the most up-to-date research regarding the virtual learning environment. There is a considerable research-to-practice gap for educators and PLOs focused on current interventions that lead to positive student outcomes are vital (Runesson Kempe, 2019). For example, bi-weekly text messages to families regarding specific literacy and enrichment activities parents and children can engage in during remote learning can help increase learning and decrease opportunity gaps (Kraft & Monti-Nussbaum, 2017).

STEM education is vital for all students. However, it is equally important to recognize the uncharted territories teachers are in due to the events of 2020. PLOs provide the only way to provide real-time information to educators in an otherwise volatile, ever-changing environment.

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Comment on FR Doc # 2020-19681

Submitter Information

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(b) (6) [redacted]
Email: (b) (6) [redacted]
Phone: (b) (6) [redacted]

General Comment

[redacted] sent me:

I can help address two items listed:

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

A: It has been interesting to see some students who might be reserved otherwise, become more vocal while using remote technologies. In particular I have made use of Flipgrid for asynchronous discussions and as a platform for students to showcase their work. It has been an excellent tool and provides students with a flexible time frame to work within. I do believe that Microsoft is involved with funding Flipgrid, but again it has proved useful.

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

A: The biggest challenge I have run into are the assorted devices that students and families have access to. This has caused multiple issues with regards to running software on outdate OS and platforms. As a solution entering into this year, I sought out options that ran lightweight on as many platforms and OS as possible. Even with that solution, I loaned out several computers from our engineering shop as some students were trying to use machines that just could not run CAD programs etc...

I hope that these couple insights prove useful and I appreciate that people are looking at needs and bset practices.

Best:

(b) (6) [redacted]

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Request for Information: STEM Education

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Submitter Information

Name: [redacted]
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Submitter's Representative: N/A
Organization: N/A
Government Agency: N/A

General Comment

What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

The inequities in STEM shift online education and training can be a benefit and issue for students depending on servers that is provided in the home. This being the wifi serves and place to study in the home. STEM students will benefit from having online #3D serves with labs that will assist the students to gain knowledge in the lab and be able to learn as a group. 3D labs or virtual simulation of labs can work if faculty are able to design the curriculum with a flex class.

Gap-The need of wifi at the home for the STEM students to deliver and receive services. This can change the serves or how the students can develop soft skills and also be able to learn the hard science.

Postdoctoral students also need an opportunity to shift online to serve as a internship or experience to gain knowledge be able to learn how to develop a virtual simulation lab.

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Submitter Information

Name: (b) (6) [redacted]
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General Comment

1. As a highschool student, I have found it difficult to access some resources based on my school device's inputted firewalls. I've noticed some online resources have been made temporarily available due to the pandemic, but they will apparently end that access within a year.

2. For my Chemistry class, my teachers have recorded experiments for us to watch for online learning, but it would be much more engaging to have another type of simulation format to "conduct" the experiments ourselves.

3. For my Environmental Science class we have been using Gizmo, and that's fairly effective. A broader access to realistic simulations or real studies that are interactive would be helpful.

17. My online Environmental Science course has been a good forum for me to make transdisciplinary connections. I don't really know if that is the best method for me, but it works well.

[redacted]: STEM RFI Response

On behalf of [redacted], we submit the comments here in response to the Request for Information on STEM Education.

[redacted] and powered by a coalition of organizations representing stakeholders across the education sector. We are focused on the goal of optimizing education data by ensuring system level interoperability under the guidance of a [redacted] including Data Quality Campaign, Future of Privacy Forum, CCSSO (Council of Chief State Officers), SIIA (Software and Information Industry Association), CEDS (Common Education Data Standards), ISTE (International Society of Technology and Education), CoSN (Consortium of School Networks), and more. [redacted] leads the development of events, tools, technical resources, and narrative resources to support schools and school districts with interoperability. We seek to bring awareness to the importance of interoperability for understanding every student's path to graduation, regardless of income or zip code. [redacted] has a growing constituency of 625 school networks and 150 edtech vendors who have signed the [redacted], continue to share our [redacted] and cultivate a strong coalition in collaboration with our Steering Committee.

We believe interoperability is an essential foundational support for enabling STEM education at scale in a remote learning context. By developing strategic partnerships with school districts, edtech companies, and non-profit organizations across the K12 sector, and encouraging secure, portable, equitable, and shareable data practices nation-wide, we believe interoperability can be implemented and utilized to benefit all learners.

Future Opportunities in STEM Education, questions 1-2, 7
1) What COVID-19 related digital barriers have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

Remote learning cannot be fully realized unless the technology used is interoperable. Interoperability makes remote learning possible with secure, portable, and connected data. With shared information between tools and applications, administrators can make necessary interventions in a remote context, guardians and parents can eliminate the frustration of multiple logins and passwords in their students' digital classrooms, educators can contextualize their students' learning with actionable insights and save valuable time, and students can focus their time on learning. When COVID-19 struck and closures were imminent, schools with interoperable data infrastructures were able to make rapid transitions to remote learning overnight, including the use of **real-time data in different data visualizations** to support deployment of resources, provide lunch, wifi, and devices to maintain student equity and inclusion goals. **Interoperability is essential for operational functionality within a remote learning context especially for rostering applications and tracking attendance.** Learning cannot keep going without an interoperable data infrastructure, particularly in districts that are less financially resourced. In those schools, students did not have the ability to keep learning because their administrations lacked the data they needed to make specific interventions, and students did not have immediate digital access to their learning tools. Project Unicorn conducted four interviews with school districts to understand how data interoperability supported their transition to a digital classroom [redacted].

Barriers:
In a national survey of data needs conducted by [redacted] and ISTE of educators and non-educators (librarians, IT leaders), 61% of respondents said that having access to data/assessment results was highly important, and 43% reported that data sharing between apps was highly important. A survey of topics related to interoperability show that educators and non-educators lack data literacy and confidence in their ability to work with education data. Moreover, in a recent study conducted by DQC and The Harris Poll, DQC found that teachers are strongly committed to using data in service of students – **but are left on their own to make this happen**. While more than 86% of teachers reported that their use of data is an important part of being an effective teacher, more than 81% find themselves dipping into their personal time to apply data to their lesson plans and teaching practices. Schools and districts need more support in making data use easier for all educators, from the teacher in the classroom to the superintendent on their board. **Interoperability can be a key lynchpin to unlocking effective teaching practices and meeting this demand**

In order to implement interoperability, districts need financial resources and technical expertise to sustain its development **over time**. Achieving an infrastructure that supports data standardization and interconnectivity is a multi-year project and requires equal participation from SEAs and LEAs. States and districts often do not have common tagging systems and core standards, which creates multiplicity. CARES Act ESSER and GEER funds provide financial flexibility to support students most susceptible to learning impediments during the COVID-19 crisis, but we believe interoperability supports the equitable distribution of resources based on student demographics and each school's need-specific support for building data infrastructure and keeping up in a digital world.

.

2) What new or existing educational programs, opportunities, or concepts would enhance remote education?

[redacted] is in the process of developing **baseline instrumentation** to track challenges and opportunities with interoperable infrastructure in the remote learning context. The instrumentation will be deployed to school districts nationwide with a focus on the needs of Title I schools to understand specific functions of technical assistance that could realistically and sustainably be deployed to those districts. [redacted] is developing this instrumentation in close collaboration with the Council of Chief State Officers, the Council of Great City Schools, and the Consortium of School Networks. We plan to deploy a baseline instrumentation tool to state leaders to identify how we can create connections. [redacted] offers broad support, programming, and resources for LEAs, SEAs, and education technology vendors, but **we are not currently able to deploy targeted, individualized technical assistance for district teams lacking technical support**.

7) What experience does your school system have with interoperable learning records of precision learning systems? If used, please share any barriers, solutions, or other information relevant to their effectiveness particularly related to digital barriers and the impact or effectiveness related to distance education. How were these concepts used or modified in response to COVID-19?

Through [redacted] Technical Advisory Committee, we have identified barriers, solutions, and information to support interoperability in the remote context and published best practices for data infrastructure applications [redacted] These recommendations include building to an assessment standard such as SIF Unity Specification, Ed-Fi ODSD, and API, or Question and Test Interoperability® to enable the exchange of test content and results between tools, learning platforms, assessment delivery systems, etc. Recommendations also include data standardization for content delivery, so content providers can seamlessly share content with learning management systems. Most key to student success in remote learning is rostering and single sign-on so that school rosters can be integrated across systems using standards such as OneRoster®, xPress Roster, or Ed-Fi Enrollment API. [redacted] **is committed to providing best practices and guidance, but obstacles still exist with coordinating stakeholders in the K-12 education sector,**

breaking down data barriers with student information systems, content providers, and learning management systems in terms of data sharing and proprietary data, and ensuring that districts have sustainable means by which to implement interoperability.

Increase Diversity, Equity, and Inclusion in STEM, question 12
12) What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

Data interoperability is integral to identifying interventions that can support equity for underrepresented students interested in STEM. Without interoperability, education technology systems can obscure student data, allowing students to fall through the cracks. But, with connected, accessible, and contextualized student data, you can easily identify student challenges and successes, thus unlocking their ability to grow and engage in the classroom.

Thank you for your consideration of our comments. Please reach out with any questions.

[redacted]

National Science Foundation
Request for Information
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Responses are provided to the following questions:

Future Opportunities in STEM Education: Questions 1, 2, 3, 5, and 6.
Increase Diversity, Equity, and Inclusion in STEM: Question 12

Introduction to [redacted]

The [redacted] is very pleased to participate in this request for information providing one perspective of a non-profit organization whose mission is to revolutionize post-secondary STEM education by providing faculty and future faculty with pedagogy training in evidence-based practices.

The [redacted] is a recently established non-profit organization that continues the work of the [redacted], an organization originally funded by the Howard Hughes Medical Institute and the brain-child of Dr. Jo Handlesman and Dr. Bill Wood. Since its inception, more than 3,000 faculty have participated in week-long programs offered by the [redacted].

Recently the [redacted] has provided weekly and monthly support to interested faculty through a variety of synchronous online opportunities and a newsletter. The newsletter and online events are open to the public and have engaged many STEM educators who had not previously participated in any of our programs. These programs, now offered by the [redacted] will be described in the appropriate sections below.

The coronavirus pandemic is going to decimate the availability of funds to support professional development for faculty and future faculty of post-secondary institutions. This pandemic has cost universities millions, tens of millions, and hundreds of millions of dollars. Institutions of all types will struggle for the next 3+ years to reestablish a norm. While doing this, each institution will have to decide where to focus now even more limited resources. It is almost certain that opportunities for professional development will be curtailed at many universities and colleges while these institutions focus on re-balancing their budgets. In addition, faculty, many for the first time in their careers, are thinking deeply about how they are educating their students. Some faculty have the depth of knowledge and resources to understand how to teach during these trying times. However, most faculty are ill-prepared for this crisis. They are doing their best and colleges and universities are doing their best to provide crash-courses in online pedagogy. Throughout this struggle, students are doing their best. Again however, those most at-risk students undoubtedly suffer the most during these times due to lack of financial resources, unstable internet if they have access, lack of high quality computing, and loss of community, among undoubtedly many other challenges.

The [redacted] has capacity and programs to engage faculty at institutions of higher education across the country in a discussion of evidence-based practices that support student engagement and success.

[redacted]

Future Opportunities in STEM Education

In response to the COVID-19 pandemic, education systems (including preK-12, postsecondary, adult, and informal) were required to make a sudden shift to remote or asynchronous teaching and learning, and this may continue in the near term. Please provide insights to the questions below based on current experiences. For each response below please indicate the education system (preK-12, postsecondary, adult, and informal) that covers your response and whether you are addressing school systems, schools, teachers/faculty/instructors, learners, other, or more than one category.

1. What COVID-19 related digital barriers (*e.g.*, access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

We have found instructors and students are struggling with access to uninterrupted broadband nationwide. Some universities have provided hotspots for their students who cannot afford internet to gain basic access to broadband. However, many faculty and students are still experiencing frozen screens and unable to have smooth video conference calls. Another major challenge for students is to become organized to navigate through various different digital learning platforms and remain motivated throughout the semester. Also, faculty have been looking for a community with which to engage in discussions on best practices, and sometimes just to talk with others who are struggling to teach online. To meet this need the [redacted] quickly ramped up our offerings to provide professional development opportunities on a regular basis online. These opportunities take the form of a friday afternoon topical discussion (happy hour), a monthly webinar, and a six session short course (see the next section). We developed these opportunities for faculty to help build a digital community and to provide a safe forum for faculty to discuss the challenges and opportunities of teaching online.

2. **What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education?** Please indicate which education system you are addressing and if the interventions are targeted toward schools, **teachers/faculty/instructors** (*e.g.*, virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, **micro credentialing**), learners (*e.g.*, pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

The [redacted] offers synchronous trainings to post-secondary faculty and future faculty in evidence-based teaching practices centered around inclusivity, assessment and active learning. The pedagogical training programs and ongoing support programs offered by the [redacted] provide all participants with tools that have been demonstrated to improve student success and reduce equity gaps. Our workshop leaders and facilitators (faculty at institutions around the country) have varied expertise to help participants improve student performance in lecture courses, laboratory courses, and field courses, in person and online (synchronous and asynchronous).

The [redacted] workshops have been developed over the past 17 years based on a rigorous evaluation model to ensure that our programs focus on inclusivity, assessment, and active learning, to ensure evidence-based modifications in the programs themselves, and to evaluate the impact on participants and their classroom practices. The [redacted] has developed and delivered week-long workshops both in person and synchronous online, an online 6 week short course (six two-hour sessions, one per week), and a one day workshop series focusing on one of the three pillars of scientific teaching (inclusivity, assessment, active learning).

Since the onset of the coronoavirus pandemic, the [redacted] has also offered monthly [redacted] webinars, an interactive webinar related to the practice and dissemination of scientific teaching, and weekly less formal hour-long Friday afternoon sessions (we call these "happy hours") to share challenges and successes around the rapid transition to remote teaching and learning. Both new formats provide time for participants to learn, reflect, question, while developing a community in which they can share experiences, and discuss challenges. The [redacted] webinars and weekly Friday meetings are available to all interested individuals independent of whether they may or may not have attended a [redacted] workshop. We have seen a tremendous demand for both of these events. Nearly half of the participants had not previously attended any of our programs. The success of these events with minimal advertising demonstrates to us the pent-up need in the community for these opportunities and others like them.

The faculty leaders of the [redacted] are constantly innovating, looking for opportunities to revolutionize STEM teaching with the ultimate goal of helping our students succeed including our most challenged and historically excluded students. To this end, while the [redacted] programs were originally designed for faculty at research intensive universities, we have for many years expanded our mission to include all faculty and future faculty at the varied types of post-secondary institutions of higher education.

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

Since the onset of the pandemic, the [redacted] has provided an array of means to engage our members and provide a strong sense of community. Those structures include weekly happy hours, webinars, and short courses that support post-secodnary instructors from around the country. Those structures are built upon technologies including virtual conference platforms (e.g., Zoom), collaborative tools (e.g., google suite, padlet), video sharing platform (e.g., Flipgrid), curriculum sharing (e.g., libretext). - Using these technologies we have engaged hundreds of new faculty that we weren't reaching before demonstrating that these technologies may be used for frequent engagement, community building, and rapid flexible deployment of new training modules.

The [redacted] has been able to bring together post-secondary educators from around the country who are looking for a community to share and learn about evidence-based practices that they can bring to their classrooms (in person or online). Many have previously participated in our workshops, however ~half have had no prior experience with the [redacted] or [redacted] programming. These faculty found us and come back week after week for an hour of interactive discussions about implementing evidence-based teaching practices in their classrooms and teaching laboratories (in person or online, synchronous and asynchronous)

The federal government could help by providing funds to support faculty and future faculty professional development in the area of evidence-based teaching. Under the current higher-education economic climate, it is almost certain that the resources from our institutions will become more sparse. It is critical for organizations like the [redacted] to continue offering the training that our faculty desperately need. Federal funds supporting faculty training in evidence-based teaching practices is certain to be one of the most impactful ways to improve classroom pedagogy quickly. The [redacted] would be very excited to assemble a proposal outlining our capacity to participate in training.

We also believe that our federal government could provide additional funds to facilitate the creation of a variety of different networks to facilitate communications, coordinations, and collaborations. Although the culture within each institution might be different, we are all facing the same challenge. Therefore, it is critical for institutions to work together creatively on solutions. The [redacted] has a network of 300 institutions and is positioned to take on this charge to facilitate communication, coordination, and collaborations among institutions.

5. What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.*, utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

Instructors would benefit from evidence-based programs that are focused on a student-centered classroom (active learning in a remote setting), assessment (both frequent formative assessment and innovative summative assessment), and inclusive strategies (ensuring the engagement and success of all students). Programs offered by the [redacted] focus on these three central themes.

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

It will be critical to understand the impact of COVID-19 on our most fragile population of students, those underrepresented, underserved, and historically excluded populations. Data related to student performance are outside the scope of the [redacted].

Increase Diversity, Equity, and Inclusion in STEM

STEM education practices and policies at all levels should embody the values of inclusion and equity. All Americans deserve access to high-quality STEM education, regardless of geography, race, gender, ethnicity, socioeconomic status, veteran status, parental education attainment, disability status, learning challenges, and other social identities. For each response below, please indicate the education system or career experience for which you are responding.

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

Inclusivity is a foundational principle designed into every [redacted]. We strive to improve the success of underrepresented, underserved, and historically excluded students by providing faculty with knowledge to understand the myriad issues faced by these students and to provide faculty with tools to make their classrooms more inclusive. Improving the success of these most challenged students increases the diversity of job/graduate school/professional school candidates upon graduation from an institution of higher learning.

In more recent years, we have been targeting faculty at minority serving schools and community colleges. Community colleges have the most diverse population of students in higher education. Thus the attention we have been paying to minority institutions and community colleges has without question increased the impact our programs have had and continue to have on the learning environments of underrepresented, underserved and historically excluded groups across the country. We have also increased the participation of facilitators who come from diverse backgrounds. In 2019, 40% of our facilitators identified as a member of an underrepresented, underserved or historically excluded group.

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[redacted]

[redacted]

STEM RFI Response October 19, 2020 Submitted by: [redacted], [redacted] **Contact information:** [redacted]

Section: *Future Opportunities in STEM Education* ***Question 5.*** *What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?* The [redacted] envisions *a world where family engagement is universally practiced as an essential strategy for improving children's learning and advancing equity*. Its mission is to advance high-impact policies and practices for family, school, and community engagement [redacted] to promote child development and support student achievement and school improvement. [redacted] advances this mission in multiple ways. A professional membership program supports capacity building and networking through member online communities, Communities of Practice, professional development resources, and an online resource center containing over 900 best practice examples, sample program plans, and policy briefs. [redacted] reaches the broader field through its robust website [redacted], its monthly [redacted] newsletter, over twelve webinars annually, as well as virtual and on-site special events. It addresses strategic obstacles to the advancement of [redacted] through research-based initiatives, convenings, and technical assistance. In September of 2020 [redacted], in partnership with Erikson Institute's Early Math Collaborative, was named as the backbone organization to support a burgeoning family math initiative that brings together family math-focused organizations from around the country. One of the areas of professional learning that would be most beneficial to educators providing remote instruction is support in engaging families meaningfully and collaboratively generally, as well as in STEM. Research shows that family engagement is foundational for student achievement, particularly in low-income and culturally 2 diverse communities, where the achievement gap is most severe. This is particularly true in the area of STEM. The extent to which families are engaged – by virtue of their expectations for STEM learning and the ways they support and advocate for STEM opportunities in their homes and community – is one of the strongest predictors of student STEM achievement and interest in STEM careers

(Caspe, M., Woods, T. & Kennedy, J, 2018). And families are more likely to be engaged when school and community educators open doors to families' engagement by reaching out to them, raising up their voices, and expanding on their skills and knowledge. Yet, too often, educators lack the training and capacity to effectively engage families (Epstein, 2018; Epstein & Sanders, 2006; Shartrand, Weiss, Kreider & Lopez, 1997). The global COVID-19 pandemic has only exacerbated these gaps. [redacted] survey of over 1,552 respondents in the family engagement field found that educators do not feel they were adequately trained to engage families. • Only 17% of early-childhood and K-12 educators who responded to the survey strongly agreed with the statement, "I was properly prepared and trained to engage families in their children's learning during my training and preparation program." • Only 33% of those respondents strongly agreed with the statement, "My school/organization provides me professional development opportunities to improve the way I work with families." As families are struggling to support student learning in the home and community, educators need even more tools and ideas to do this meaningfully in the STEM space. We recommend a strong priority on both weaving family engagement practices, skills, and dispositions into all STEM professional learning, as well into policy and research and evaluation strategies for new and innovative programs that are being built.

[redacted]

October 19th, 2020

__Subject:__ [redacted] STEM RFI Response

__Document Number:__ 2020-19681

__Response to Questions:__

Increase Diversity, Equity, and Inclusion in STEM, question 12
Engage Students Where Disciplines Converge, question 13

Members of the Committee on STEM Education (CoSTEM), OSTP, and NSF,

The [redacted] is an association of more than 200 North American academic departments of computer science, computer engineering, and related fields; laboratories and centers in industry, government, and academia engaging in basic computing research; and affiliated professional societies. [redacted] mission is to strengthen research and advanced education in the computing fields, expand opportunities for underserved groups in computing, and improve public and policymaker understanding of the importance of computing and computing research in our society. We write today to submit comments on "Notice of Request for Information on STEM Education" Document Number 2020-19681.

We commend the NSTC Committee on STEM Education, as well as the Office of Science and Technology Policy, for the opportunity to provide feedback and information on the implementation on the Federal Government's STEM education strategic plan. Our detailed responses to certain questions in the RFI are:

__Increase Diversity, Equity, and Inclusion in STEM, question 12__
__*What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?*__

[redacted] is dedicated to increasing the number of individuals from underserved groups in computing (UGC) who participate and succeed in computer science research. Achieving this mission requires understanding and supporting the myriad pathways into and through computing education and careers. The expressed identities of the individuals we serve include:

- Women
- Black/African American
- Indigenous/Native American
- Hispanic/Latinx
- Lesbian, Gay, Bi-Sexual, Trans, Queer, Asexual, Intersex, and others
- Persons with disabilities
- Veterans

[redacted] offers programs for individuals from undergraduate to senior professional levels. Different career stages require different types of interventions. The goal of all [redacted] program activities can be described within the unifying framework of Social Cognitive Career Theory, which finds that interest in and choice of a particular career path will be increased by interventions that improve one or more of the following: (1) outcome expectations (understanding and valuing the rewards of a particular outcome), (2) self-efficacy (a belief that one can successfully achieve an outcome), and (3) social supports that help one persist and overcome obstacles.

Serving as a national resource, the reach and impacts of [redacted] activities described below are further amplified through varying levels of partnerships and collaborations with many other organizations committed to broadening participation in computing; these groups include, but are not limited to, the NSF funded Institute for African-American Mentoring in Computing Sciences (iAAMCS) and the NSF funded Alliance for Access to Computing Careers (AccessComputing), the NSF funded National Center for Women & Information Technology (NCWIT), the AnitaB.org organization, the NSF funded Future Leadership in the Professorate Alliance (FLIP), the Association for Computing Machinery (ACM), and the Center for Minorities and People with Disabilities in IT (CMD-IT).

[redacted].

[redacted] provides positive research experiences for teams of undergraduates who work during the academic year. Each research team consists of undergraduate students and sponsoring faculty members. In multidisciplinary projects, each team consists of both faculty and students from computing and non-computing fields. Beginning in the fall, the [redacted] program runs the academic year. Students maintain a weekly journal and website documenting their progress. A mid-year progress report and final report are required. Also, students submit a one-page summary of their work, which is posted on the [redacted] web site. Students are also strongly encouraged to submit papers to appropriate journals and to present papers or posters at national or regional conferences. The program provides travel funds to support such participation.

[redacted]: The objective of [redacted] is to increase the number of individuals from underserved groups in computing research entering graduate studies in computer science and engineering. This highly selective program matches promising undergraduate students with a faculty mentor at another university for a summer research experience at the faculty member's home institution; several successful research mentors around the United States volunteer their time to supervise [redacted] students. Students are directly involved in a summer research project at a university other than their own and interact with graduate students and professors daily. Students maintain a weekly research journal and website, documenting their progress, as well as write a final report. These research experiences frequently result in research posters and publications. This experience is invaluable for students considering graduate school, providing them with a close-up view of what graduate school is like, and increasing their competitiveness as an applicant for graduate admissions and fellowships.

The [redacted] and organizers of the [redacted] program decided to modify the 2020 [redacted] program from an onsite format to a virtual one. Given the devastating impact of the COVID-19 virus, we felt offering a [redacted] would better ensure the safety of all participants while continuing to provide research-intensive opportunities to students considering advanced degrees in computing.

Discipline-Specific Workshops (DSW): Each DSW provides mentoring support and builds communities of UGC researchers within the context of a specific sub-discipline of computing. These focused discipline-specific efforts aim to develop sub-discipline research knowledge, perspective, and community. For example, discussions that differ by discipline include research methods, publication expectations, the most desirable and appropriate conferences and journals, where to apply for funding, and important, emerging research topics. DSWs offer in-depth technical information, community, conversation, and potential collaborators. They provide UGC attendees with technical information and skills to increase their ability and confidence to succeed and thrive in their research discipline. Over time, research areas in computing have adopted this model of mentoring and have begun to take over the funding and organization of such workshops. As a result, we have been able to put this program on hold and may be able to retire it in the near future.

[redacted] The [redacted] is a program for undergraduates attending the Grace Hopper Celebration of Women in Computing who have a strong interest in computing research. Research Scholars participate in a customized program providing small group mentoring, interaction with other research-interested students, and participation in research-focused events. A "passport" provides Research Scholars with a roadmap for navigating research content at the conference. This roadmap includes the ACM Student Research Competition, technical talks, [redacted] tables at the Mentoring Circles Session, [redacted] presentations and the student poster session.

[redacted] and many others have the opportunity to talk with mentors at the Mentoring Circles session, where they join small-group 20-minute discussions on specific topics of interest. [redacted] typically hosts tables on topics such as: (1) How to Be Successful Post-Bachelor's, (2) Is Graduate School for You?, (3) Master's or Ph.D.?, (4) How to Successfully Apply to Graduate School, (5) What is Computing Research? How Can Undergraduates Participate?, and (6) Research Careers: What Are the Options? How Do I Get There?

Graduate Cohort Workshops (Grad Cohort): [redacted] organizes two Grad Cohort Workshops every year. One workshop aims to increase the ranks of senior women in computing, and the other workshop seeks to increase the ranks of other underserved groups in computing, including persons with disabilities, by building and mentoring communities through their graduate studies. Grad Cohort Workshops bring together graduate students in early, middle, and later years of graduate school for a two-day workshop on graduate school survival, career planning, and networking.

How are these interventions evaluated for success?

[redacted] programs are evaluated by the [redacted] using comparative and longitudinal evaluation methods that utilize data from a national level survey (the Data Buddies Survey) to obtain samples of non-participant students that are comparable to the program participants. [redacted] staff, in collaboration with program organizers, formulate an evaluation plan customized specifically to the goals and structure of each of these [redacted] programs. The evaluation results are shared as written reports with the organizers and other parties as appropriate to communicate the results as well as recommendations. The programs are evaluated using a number of evaluation methods including pre-post, comparative, and longitudinal analysis. In addition to evaluating immediate impacts of and collecting participant feedback about the programs, [redacted] tracks program participants over time to assess long-term impact of these programs. [redacted] programs are refined over time using these evaluation results and, as such, their success is continually maintained through evidence-based recommendations.

[redacted] is an evaluation and research center that fulfills the need for national data collection, comparative and longitudinal evaluation, and engagement with the community for dissemination of BPC related research and evidence based best practices. [redacted] was originally established to address a need for rigorous evaluation of programs aimed at promoting success in computing career paths among individuals from groups underrepresented in computing by the [redacted] in collaboration with staff from the [redacted] The center has been fully operational since 2013 and has grown in scope and scale over the years. At present, [redacted] utilizes its extensive data collection infrastructure, and evaluation and social science expertise to provide various resources to the computing community as a whole. The center supports the computing community's efforts to broaden participation through its activities and the resources it generates. In this way, the intended population for [redacted] activities is all individuals who are underrepresented in computing including but not limited to, people who identify as women, African Americans, Hispanics, Native Americans and indigenous peoples, and persons with disabilities.

[redacted] implements [redacted], which is a data collection and dissemination effort that collaborates with volunteering academic departments across the US (and some in Canada). At present, more than 140 computing departments participate in [redacted] and more join each year. The project utilizes an annual national level survey, the [redacted] to gather large-scale information from undergraduate and graduate students as well as non-degree earning and post-graduate individuals. This information is then shared with customized aggregate level reports with the participating departments and is made available to researchers and the general public through various channels. [redacted] collects information regarding the academic and demographic background, various indicators related to the recruitment and retention in computing, and career pathways. [redacted] is a unique resource for the computing community to understand the impact of various broadening participation efforts and to generate evidence-based best practices to inform future interventions.

[redacted], an online resource portal, is a clearinghouse for the computing community to learn about and engage with ongoing projects to address the underrepresentation in computing including, but not limited to, people who identify as women, African Americans, Hispanics, Native Americans and indigenous peoples, and persons with disabilities. [redacted] provides knowledge resources, access to statistics and data, information about [redacted] efforts across all organizations, and organizes workshops and other community events to create awareness of [redacted] and encourage collective action toward broadening participation in the field of computing. [redacted] was established in order to support the National Science Foundation's (NSF) Directorate for Computer and Information Science and Engineering (CISE)'s goals to scale up broadening participation efforts of the community to encourage all members of the computing community to contribute to these efforts. This portal brings together the knowledge and resources generated by organizations and individuals with extensive experience in BPC over the years to scaffold the larger computing community's efforts.

Engage Students Where Disciplines Converge, question 13

How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

[redacted] As described in the response to question 12 above, the objective of [redacted] is to increase the number of individuals from underserved groups in computing research entering graduate studies in computer science and engineering. [redacted] provides positive research experiences for teams of undergraduates who work at their home institution during the academic year. Each research team consists of undergraduate students and sponsoring faculty members. Given the significant and wide-ranging impact that computing has on virtually all disciplines, the [redacted] program includes not only computing research, but also multidisciplinary research. In the case of multidisciplinary projects, a team consists of faculty from both the computing and non-computing fields as well as students from these respective fields. Research shows that peer support can have a significant impact on persistence in computer science education and in particular that students from underserved groups in computing benefit from having a critical mass of UGC colleagues. Thus in providing students with research support, the [redacted] program emphasizes collaboration and cohort. Multidisciplinary projects provide opportunities to bring together students from underserved groups who may be among the very few in their disciplines at their institutions. These projects provide opportunities for students to learn to collaborate and communicate across disciplines. For computing students, they highlight the relevance of computing to different areas of study. These projects also have the potential to bring students from other disciplines into computing, once they have had the opportunity to learn more about its relevance to their work.

Thank you for the opportunity to provide feedback and information on the implementation of the Federal Government's STEM education strategic plan. Should you require additional information, please contact [redacted]

Respectfully submitted,

[redacted]

[redacted]

Memorandum

To: CoSTEM, National Science Foundation

From: [redacted]

Re: [redacted]: STEM RFI Response to "Increase Diversity, Equity, and Inclusion in STEM" Question 12 (https://www.federalregister.gov/d/2020-19681/p-46)

We are faculty members and scientists from private and public universities. [redacted] we urge the committee to consider the critically important role of effective mentorship for the success of all students in STEMM higher education, including students historically underrepresented in STEMM fields.

We ask the committee to draw from that consensus report[2], from which we excerpt below (page numbers after quotes below refer to page numbers in the published report), and to raise awareness of the evidence-based tools provided in the report's associated online guide: https://www.nap.edu/resource/25568/interactive/

The Need for *Evidence-Based* Mentorship Practices in STEMM

> *"Mentorship has rarely received the focused attention, evaluation, and recognition of other professional responsibilities associated with academic STEMM, such as teaching or research. Because mentorship can be so influential in shaping the future STEMM workforce, its occurrence should not be left to chance or idiosyncratic implementation."* (p. x).

Recommendations for Funding Agencies that Support STEMM Mentorship

The NASEM report presented nine categories of recommendations, one of which (category #8) relates directly to funders. Below we draw your attention to the four specific recommendations under this category (start on p. 191 of the report).

> *"Funding agencies play a key role in shaping the values of institutions and the projects that scholars pursue. As such, funding agencies' role in encouraging and supporting effective mentorship practices is essential.* (p. 191)

[redacted]

[2] National Academies of Sciences, Engineering, and Medicine. 2019. The Science of Effective Mentorship in STEMM. Washington, DC: The National Academies Press. doi:10.17226/25568.

> *"8.1: Funding agencies should encourage the integration of evidence-based mentorship education for mentors and mentees and assessments of mentorship into grant activities that involve undergraduate and graduate student research, education, and professional development to support the development of the next generation of talent in STEMM.*
>
> *"8.2: Funding agencies, when supporting STEMM student development, should require tools such as mentoring compacts and individual development plans to operationalize intentionality and promote shared understanding of the goals of mentoring relationships on sponsored projects.*
>
> *"8.3: Funding agencies should support the study of the process and impacts of mentorship and the development and validation of new or adapted measures for use in STEMM mentorship to comprehensively understand the relationship between mentorship processes and outcomes, as well as demographic disparities in student outcomes.*
>
> *"8.4: Funding agencies should support in-depth, cross-program evaluation and research to better understand the processes and outcomes of mentorship, particularly on the outcomes of diverse student populations."*

Why Quality Mentorship Matters for Diversity, Equity, and Inclusion in STEMM

The NASEM report specifically addresses why and how quality mentorship experiences are essential for advancing diversity, equity, and inclusion in STEMM:

> *"Talent is equally distributed across all sociocultural groups; access and opportunity are not. This is particularly true in science, technology, engineering, mathematics, and medicine (STEMM) professions that are expected to grow as a percent of the total workforce in the coming decades. The underrepresentation of marginalized groups in STEMM contexts is pervasive.*
>
> *"Individual STEMM professionals identifying as African American, Latinx, American Indian, first-generation, or sexual or gender minority individuals and individuals with disabilities continue to be less likely to be successfully integrated in STEMM environments. These individuals may be questioned about their competence, challenged in their science, and simultaneously invisible as scientists, yet under the microscope as members of underrepresented groups in STEMM. Scores of commissioned reports and empirical studies document that these experiences are all too common as features of the landscape against which the academic and career development unfolds for many from*

underrepresented groups. Unfortunately, good science can be hampered in uncivil and neglectful environments.

"Broad integration of all segments of society in STEMM will yield significant innovation and social benefits for our nation. But how can access and opportunity be facilitated within affirming environments in support of a STEMM talent development model for all?

"Mentorship is one catalytic factor to unleash individuals' potential for discovery, curiosity, and participation in STEMM and subsequently improve the training environment in which that STEMM potential is fostered. Mentoring relationships provide developmental spaces in which students' STEMM skills are honed and pathways into STEMM fields can be discovered. Mentoring relationships are high-stakes, interpersonal encounters and exchanges. These relationships have the potential to assist nascent STEMM professionals in seeing themselves through the eyes of an influential guide, finding their place in STEMM education and careers, and receiving support to realize their next stages in development."

Why Quality Mentorship Matters for Inculcating Science Identity in STEMM

The NASEM report furthermore addresses how quality mentorship experiences can inculcate a "science identity" in students, which research shows is an important ingredient for persistence and success in STEMM:

"*Social science research documents the pivotal role of identity in the formation and development of social relationships such as mentorship.5 Specific dimensions of identity (e.g., science identity, cultural identities) have been linked empirically to academic and career development and to the experience of mentoring relationships in STEMM. However, despite mentorship's benefits for underrepresented (UR) students and their development of a science identity, studies have reported that UR individuals enrolled in STEMM degree programs typically receive less mentorship than their well-represented peers (p. 3)."*

Personal Experiences with Mentorship for Inclusive Excellence in STEMM

We are persuaded by the science on mentorship. However, our personal experiences and stories motivate our deep commitment to this topic and give a face to the facts and figures. We have many such stories. We share two of these stories below.

[redacted]: "I am supported by a National Foundation grant, with a PI, [redacted], who has a visual impairment. The project encourages middle and high school students with visual impairments to pursue STEM careers. I will never forget being at the week-long Sky School on the top of 9,000 foot Mt. Lemon with these young people. These students had been told by their science teachers that they could not do science, and yet, here they were -- measuring soil depths, studying a 3-D printed meteor crater, and well -- engaged in science. I was there when they met their mentors from industry, who had visual impairments, and saw the students realize they could pursue a STEM career. Inclusive mentorship matters."

[redacted]: "I am supported by a grant from the Howard Hughes Medical Institute to run a mentored research internship program for STEMM undergraduates with autism, with the goal of increasing autistic students' transitions to STEMM PhD programs and/or into the STEMM workforce. This is an especially vulnerable population of students; even with a college degree, about 80% of autistic adults are unemployed or underemployed relative to their skill level. A particularly important challenge for this population is mastering social communication in the context of collaborative work, an increasingly necessary skill for success in STEMM. But I have found that social communication is a skill that can be learned through effective mentorship, and especially through the use of a 'mentoring network model' in which the students benefit from multiple mentors, including potentially future graduate school mentors and/or future employers. I have now had the privilege to watch more than a dozen autistic students grow in their social skills to the point that they have transitioned into PhD programs in physics, chemistry, and biology, and have transitioned into high-paying jobs with Microsoft, Ernst & Young, and SAP. One student who majored in computer science became confident enough to complete an entrepreneurship certificate, spin off a company based on a data visualization system he invented, and license his technology to NASA. His inspirational story was featured on the CBS News show 60 Minutes[3]."

In Closing

There are economic and moral imperatives that demand we improve the mentorship of all of our nation's scientific talent. If we are to effectively support the success of scholars from diverse backgrounds, then we must invest in educational interventions known to positively impact their training experience. Mentorship is one such critical intervention which can be learned and optimized through education. We thank you for the opportunity to highlight the scholarship and practice of effective mentorships.

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[3] Aired October 4, 2020: https://www.cbsnews.com/news/autism-employment-60-minutes-2020-10-04/

[redacted]

October 19th, 2020

To Whom It May Concern:

On behalf of [redacted], the world's leading youth-serving nonprofit advancing STEM education, thank you for the opportunity to comment on the National Science Foundation's Request for Information related to the implementation of the Federal STEM Education Strategic Plan and responses to the COVID-19 pandemic.

The COVID-19 pandemic has disrupted all aspects of our society, and the effects on education have been felt at every level. It has created unfathomable challenges for students, teachers, administrators, and organizations like [redacted] that help guide the next generation of STEM leaders. As we adapt to this unprecedented challenge, it is important for the federal government to follow the strategy and principles laid out in the STEM Education Strategic Plan to allow states, communities, and programs like ours to maintain current efforts and aptly respond to changing circumstances.

Through a progression of team-based robotics challenges and backed by a global network of mentors, coaches, volunteers, alumni, and sponsors, [redacted] inspires young people to discover a passion for STEM and develop the skills they will need to succeed in today's competitive workforce. [redacted] programs use strategies known to increase STEM interest among students in PreK-12, including hands-on learning, working as a team on real-life problems, exposure to careers and mentorship, and opportunities to celebrate and be recognized for their achievements. This gives students from diverse backgrounds the opportunity to build STEM skills and also develop additional skills such as digital literacy, teamwork, leadership, self-confidence, creative problem solving, and project management that will help them for the rest of their lives.

We are committed more than ever to delivering the life-changing experiences our programs offer to young people. Despite some changes to our competitions, we have responded to the pandemic by bringing our programming to a hybrid and remote environment—allowing students to continue to pursue STEM and the related skills that our programs develop in a variety of learning situations. We have provided responses in the following areas and questions.

- Future Opportunities in STEM Education, Questions 2, 4, 5, & 6
- Develop STEM Education Digital Resources, Questions 9, 10, & 11
- Increase Diversity, Equity, and Inclusion in STEM, Question 12
- Engage Students Where Disciplines Converge, Question 13 & 14
- Develop and Enrich Strategic Partnerships, Question 18
- Build Computational Literacy, Question 20 & 21

[redacted]

Future Opportunities in STEM Education, Questions 2, 4, 5, 6

#2 – [redacted] has created a series of free STEM activities that can be completed with little or no technology. We recognize that a wide variety of barriers to in-person [redacted] activities and access to STEM exist, so we developed lessons that can be implemented in an asynchronous format using items from around the home. These lessons are targeted for teachers, schools, and caregivers who need to support consistent learning at home.

#4 – In addition to the in-person participation obstacles, one of the greatest challenges that has emerged related to the inequity in access to STEM education is the tremendous number of new tasks that need to be completed to effectively implement a STEM program remotely. The solutions we identified provide a digital learning platform and specific guidance with resources for continuing the facilitation of the [redacted] programs in various learning environments. This was done with the goal to create a consistent way to facilitate the programs and demonstrate the students' achievements while providing an easy-to-use tool for our adult facilitators.

#5 – Our professional development for educators has shifted to small group collaboration and hands-on practice. The goal of our remote professional development is to continue the hands-on elements of our STEM programs and allow educators to participate and learn best practices for using small group collaboration in a remote hands-on learning environment.

#6 – COVID-19 has disrupted the implementation of [redacted] programs in several ways. While teachers and coaches continue to run teams and provide [redacted] experiences for participating youth, the program model is not being implemented as designed. For example, teachers and students who are remote or learning through hybrid models may be unable to meet in person for their [redacted] activities. Some students who typically participate in [redacted] may not have access to computers or internet at home and thus are unable to participate. Hands-on learning through our challenges require different approaches. As a result, the evaluation plans for this year are focused on understanding how teachers and coaches have implemented the [redacted] experience, what modifications to the program model were made, and assessing the level of engagement, interest, and learning students have had as a result. [redacted] will be collecting data on these areas, which will inform future program development, as well as assess the needs of teachers, coaches, and youth who participate in the programs.

Develop STEM Education Digital Resources, Questions 9, 10, & 11

#9 – Web-based STEM education resources need to be delivered in an accessible and useful format. There should be opportunities for professional learning, the promotion of STEM, STEM activities, and links to organizations that are effective advocates of STEM education. The most useful resources would reach a wide variety of audiences, including educators, parents, and students.

#10 – [redacted] primary audience is PreK to 12th grade students with an interest in robotics and STEM. We work with teachers, parents/caregivers, volunteers, and other adult mentors who deliver our programs to students. We have identified STEM education resources that target the continuation of skill building for our youth participants and provide the resources adult facilitators need to offer [redacted] programs.

#11 – In response to the COVID-19 shutdown and the continued health barrier to an in-person experience for our programs, we developed [redacted]. This online resource provides grade and age bands, skill level, and topic stratification for STEM learning.

Increase Diversity, Equity, and Inclusion in STEM, Question 12

#12 – [redacted] has a strategic plan to address equity, diversity, and inclusion (EDI). Our goal is for the diversity of our student and mentor participants to reflect the diversity of the communities where they are located. Populations we target through our EDI work include girls and women, those with disabilities, those who identify as LGBTQ+, underrepresented racial and ethnic groups including Black, Latinx, and Indigenous youth, those from economically disadvantaged communities, and those living in rural and urban settings. Initiatives focused on recruitment, retention, and inclusion of these historically underrepresented and underserved individuals include: free, online training for coaches, mentors, volunteers and youth on inclusive practices, understanding micro-messaging and unconscious bias, promoting self-efficacy, and disability inclusion; the [redacted] AmeriCorps VISTA program which provides approximately 37 VISTAs in underserved communities across the U.S. supporting [redacted] programs; the [redacted] STEM Equity Community Innovation Grant providing micro-grants to communities who are starting new [redacted] teams and/or creating inclusive practices on existing [redacted] teams; a growth strategy focused on high-poverty schools and partnerships with youth serving organizations such as 100 Black Men of America, Girls Inc., City Year, Boys and Girls Clubs, and Society of Women Engineers. The goals of each of these strategies is to reach youth who would normally not have an opportunity to participate in [redacted] by providing financial support, robot kits, tools and supplies, mentors, resources, and training.

The [redacted] Research & Evaluation Department conducts formative and summative evaluations of the EDI initiatives. Surveys of participating teams, interviews with points of contact at each site, demographic data collection, and surveys of participating youth are conducted each year to assess the implementation of the [redacted] programs, monitor reach, and assess effectiveness and short-term impacts on participating youth. Overall, the results each year are very positive – the majority of youth are experiencing gains in STEM learning activation, STEM interest, engagement, STEM skills, problem solving, and teamwork (see: [redacted]). [redacted] has made a significant difference in reaching a high number of underserved and underrepresented youth through the EDI initiatives. For example, last year of the youth [redacted] reached through the EDI initiatives, 90% were economically disadvantaged, about half were girls (48%), 46% were Black/African American, 18% were Latinx, and 14% were Indigenous. Findings from evaluations are used to improve the program, address gaps in access and equity, and inform the development of resources and supports.

Engage Students Where Disciplines Converge

#13- [redacted] programs are designed with integrated STEM principles where students use the engineering design process to solve a real-world challenge using robotics. This year, we have added our innovation challenge across all our divisions. Teams of students will research, design and prototype a solution to a real-world STEM-based challenge. Students use a variety of transdisciplinary topics in the programs to achieve success in solving the problems presented to them. All our programs have a public demonstration element that involves communication to both present and defend the students' design choices. Our [redacted] curriculum directly teaches concepts related to computer programming, physics, basic algebra, research and communication. These concepts are all presented using a project-based learning approach, where they are built as prior knowledge needed to successfully complete the task presented in the lesson.

Using a project-based learning approach has been the philosophy of [redacted] since our founding over 30 years ago. The approach to have students working through real-world problems in teams, guided by mentors, has proven to have a high level of engagement for participants, schools and administrators. Students become connected to their team members and community as well as having a voice and choice in their learning. Combined with our ethos of [redacted], our program design and philosophy has led to gains in student interest, engagement and skills in STEM and the development of holistic skills that prepare students for their future careers.

#14-Due to the pandemic, it has been challenging to continue a hands-on approach to learning; however, we have redesigned our programs and provided guidance on a pathway forward to continue project-based learning in a remote environment. We designed remote opportunities that continue to allow for kinesthetic and tactile learning in STEM. We are providing a variety of engagement opportunities online through [redacted] and our digital engagement within our programs to gain the variety of STEM skills that our hands-on programs have proven to accomplish. It was a priority to keep our kinesthetic and tactile learning experiences, and using digital tools, we created resources with video and guidance materials to address our visual and auditory learners.

Develop and Enrich Strategic Partnerships

#18 - Successful work-based learning requires several factors:

- An authentic experience for students where they understand what it is like to be in a career. This experience goes beyond job shadowing and emphasizes working with professionals to solve problems and learn by applying the same methods found in the work environment.
- Connection to classroom instruction, work-based learning provides the relevance for traditional classroom content. Work experience should reinforce content at the right time and right level to help cement the connection and context of content.
- Positive mentorship where students are given feedback on the process, so they may better understand the reasoning behind doing certain tasks, including what is needed to understand the tasks, how to persevere, and reflect on accomplishments, and how it applies to long-term career goals.

Elements that encourage or discourage students, schools, or industries from participating?

- Finding, retaining and connecting mentors to students
- Engagement and understanding the workforce pipeline between schools and industries where work-based learning could occur

Build Computational Literacy

#20 – At [redacted] we integrate computational literacy as part of the engineering design process instead of treating it as a lone concept. [redacted] students develop programming skills starting with the application of algebraic thinking as an important step in the learning process. Other computational thinking concepts such as decomposition, abstraction, and pattern recognition are used in various ways throughout our programs and alongside the engineering design process. [redacted] aligns our programs to Computer Science Technology Association standards (CSTA).

#21 – The key concepts of decomposition, abstraction, pattern recognition, and algorithmic thinking should be the focus of computational literacy. Additionally, computational literacy should not be used as a replacement for coding or programming knowledge building. Rather, computational literacy should be used to guide the practice and building of coding and programming skill if that is the purpose of the STEM education desired. Computational literacy is not a replacement for programming skill, in the same way that the engineering design process does not replace mechanical engineering concepts but rather is the introductory way of thinking through solving problems. Each of the four areas of computational thinking can be used in a transdisciplinary manner that builds 21st century skills for students over multiple grade levels.

Thank you for the opportunity to respond to this request for information as you work to implement the Federal STEM Education Strategic Plan. We appreciate your review of our comments and welcome any questions or clarifications you may have. Please contact [redacted], (b) (6) [redacted], at (b) (6) [redacted] if we can provide any additional information.

Sincerely,

(b) (6) [redacted]

(b) (6) [redacted] (Oct 19, 2020 21:48 EDT)

(b) (6) [redacted]

[redacted]***: STEM RFI Response***

The [redacted] is a non-profit STEM organization. [redacted] is widely recognized for its effective and innovative teacher training and ability to partner with teachers, schools, and districts to increase their capacity for high-quality STEM teaching, including Computational Literacy.

Future Opportunities in STEM Education, question 4

Educational attainment for underrepresented K-12 students is a critical component for increasing opportunities in STEM. As studies have shown, students from lower socioeconomic backgrounds often perform poorly and fail STEM courses, which are a necessary step for high school graduation, college attendance, and the pursuit of a lucrative STEM career. These achievement gaps then contribute to increased income inequality and decreased workplace diversity. One way to narrow achievement gaps in STEM for underrepresented students is through experiential learning. Hands-on activities that promote "learning through reflection on doing" provide engaging experiences that impart new knowledge and skills, allow students to test those skills in a safe environment, and connect experiences to real world situations.

Unfortunately, online education is often a more didactic method of learning in which the teacher delivers a lesson or lecture and the students passively receive the information. This type of instruction promotes memorization without understanding and causes many students to mentally and physically disengage from online learning—especially younger children (age 13 and under) in homes with little or no adult supervision or guidance. Student disengagement as well as unreliable internet connectivity and unsafe online learning environments have emerged as some of the greatest challenges related to STEM inequities—especially for students in a lower socioeconomic status.

The solution identified by our organization, the [redacted], was to provide a safe and engaging online learning environment enriched with fun and creative hands-on STEM Justice activities for 2nd through 8th grade students. The students, 90% of whom qualified for free or reduced-price lunches, faced other significant challenges including lack of access to healthy food, unreliable internet service, and family members working outside of the home unable to provide supervision to keep their children engaged with online learning.

The museum provided the space, the reliable internet service and the [redacted] staff to help the students learn and succeed amid the challenges of the pandemic and online learning. The diverse team of [redacted] instructors provide technical support and guidance to keep students engaged during their morning online sessions which are conducted virtually by the students' public school teachers. Students receive a healthy breakfast, lunch and afternoon snack with physical and mental health activity breaks throughout the day. In the afternoons, [redacted] instructors lead the students in fun and creative hands-on STEM activities that reflect [redacted] mission to empower youth to change the world through science. Based on a STEM Justice framework, the activities demonstrate how to use STEM as a tool to pursue social justice and dismantle inequitable systems.

This carefully-cultivated learning environment will help negate issues that contribute to the achievement gap, while empowering young people to see themselves in STEM. The gaps that remain in our ability to deliver equitable STEM education services include a lack of diverse representation (racial/ethnic and gender) in the STEM professionals we need as role models and guest presenters in our STEM education activities, and resource materials that include Indigenous and non-Western approaches to STEM.

This pilot program is being evaluated by the museum's Evaluation and Research Department. They will be evaluating numerous indicators of success including student engagement, student educational progress, student interest in STEM, and student understanding of their personal STEM identity and how they can reframe STEM to include social justice and equity.

Increase Diversity, Equity, and Inclusion in STEM, question 12

The [redacted] located within the [redacted] has developed a programmatic approach to encourage and empower girls and young women, youth of color and youth from low income families to learn and take action through an innovative STEM Justice framework that strategically positions STEM as a tool for social justice and a pathway to STEM careers.

[redacted]***: STEM RFI Response***

In the [redacted], young people (from kindergarten through early adulthood) participate in a comprehensive pathway program that begins in primary school, continues through middle and high school, and then flows into paid internships after high school graduation. This program of out-of-school-time STEM learning, work, and leadership experiences focuses on four content areas: Media & Technology; Engineering & Design; Individual & Public Health; and Environmental Stewardship & Sustainability, and seeks to change STEM narratives by bringing STEM and social justice together.

[redacted] STEM Justice programming works to transform existing systems while also navigating within systems that are often exclusionary or discriminatory. In addressing dominant cultural worldviews such as white supremacy, capitalism, and patriarchy, STEM Justice redefines STEM to not only expand what it means to do science, but also to reveal, challenge and deconstruct structures and systems that reinforce and perpetuate those dominant views. This includes engaging Indigenous and non-western ways of knowing, and to recognize that all people, including scientists, engineers and mathematicians, have bias.

Through a combination of activities, projects, group discussions and reflections, speakers, and field trips, youth and young adults are encouraged to bring in and share experiences from their own lives. Rather than science being something only for credentialed experts with certain degrees and specific class, gender, racial, and other identities, the [redacted] narratives about STEM promote inclusiveness and include the following messages:

- STEM is for everyone, not just a select few; everyone has the ability to do and relate to STEM.
- STEM is more than just a pathway to a career or to make money; STEM skills, practices, and knowledge can be applied in multiple careers and life experiences.
- There's more than one way to do STEM.
- STEM is in everything, big and small.

This framework also challenges the narrative that people of color, people from lower socioeconomic backgrounds and girls/women are “underperforming" or “underrepresented” in STEM classrooms and careers. According to this narrative, the goal should be to expand representation and the economic benefits of STEM careers.

But if this goal perpetuates or advances STEM that harms individuals and communities (e.g., contributing to climate change, environmental destruction, endangered or extinct species, erasure of community-based knowledge and languages, and widening gaps in access to services such as health care), it needs to be reexamined. Rather than focusing on statistical representation or potential individual earning power in STEM, the [redacted] presents a counter narrative that fosters STEM skills, knowledge, and identities as tools in the service of social justice and community wholeness, connection, and healing.

The [redacted] STEM Justice programming is continually evaluated by the [redacted] Evaluation and Research Department to determine programming impact. Areas of focus include STEM skill development, community connectedness and contribution, and evolving participant attitudes about the importance of STEM and their personal STEM identities.

Build Computational Literacy, question 21

Consider Big Picture Instructional Implications: When considering big-picture instructional implications around teaching computational thinking in K-12 classrooms, three related key factors emerge: creating space for students to play with and explore computers as integrated tools, the intersections between students’ STEM identities and their other sociocultural identities, and classroom structure and the role of teacher leadership. Computational thinking differs from “traditional” subjects in that it’s concerned largely with the underlying thought process, attitudes, and approaches students take to solve problems. Because of this focus on thought, it is especially important to provide students opportunities to play, iterate, and integrate computational problem solving and computers as tools into a wide range of subjects at all stages of learning. “Unplugged” activities, offline lessons that allow students to explore CT Practices by using themselves and classmates as the “information processing agent” without computers, are effective for introducing CT and basic coding concepts, but their use is limited in teaching more advanced applications of CT. Using computers only during clearly delineated computer lab time or time for “doing computer” is just as limiting, however, because it artificially isolates computing from the rest of students’ learning.[1]

Educators should provide opportunities to engage in open exploration of how to actually apply computers as versatile creative tools through play, iteration, and open inquiry,[2] especially in concert with other subject areas. Fostering critical thinking about how to use the computational tool effectively across a range of situations is key, for example by: helping students explain and predict how processes work, fostering attitudes of persistence and experimentation, supporting open-ended project-based exploration, and examining problems in concrete, real-world contexts. Maintaining open space, time, and open minds allows students to engage in inquiry at any age. Classroom structure and the role of the teacher are critical factors for fostering an environment in which all students have the tools and encouragement required to become computational thinkers, and underpins the entirety of this section. Opportunities to explore and play with computational tools, student-directed learning, and cultural relevance cannot exist in the classroom without teacher support, and so it falls to them to create the appropriate instructional context in which to build students' CT skills. Teachers should approach CT instruction with cultural humility and openness to student input in order to build student agency and investment in identifying and solving problems with personal relevance.[3] Recognizing and viewing differences among students' interests as an asset rather than a barrier also helps foster an environment in which iterative and open-ended inquiry-based play with computational tools is supported.[4] Teachers can also support a classroom culture of creativity and persistence by removing focus from "right" and "wrong" answers, contextualizing failure as an informative part of the iterative process,[5] and supporting connections between CT skills across the curriculum.

Just as important are students' individual STEM identities. A lack of relatable role models, low expectations from teachers and administrators, and the perceived absence of connections between STEM, computing, and students' community contexts all function as barriers to engagement for children of color, girls, and other minority students.[6] However, by drawing on culturally responsive computing practices and explicitly inviting students to explore personally relevant issues across subjects through the lens of CT, students become powerfully aware of connections between their communities, life experiences, and the possibilities of computational problem solving. Opportunities to work on real-world, self-determined and open-ended projects, as well as an environment that provides encouragement, exposure to diverse role models, and supports positive STEM self-concept, are crucial instructional contexts for building computational thinking skills.

Identify Concepts and Specific Ideas: In order to successfully integrate computational thinking into the K-12 curriculum we must first map the key concepts to the developmental levels of our audience at each grade span. This begins with our making sense of the jumble of concepts sometimes grouped under the single heading of "computer science." Starting from the CSTA K-12 Computer Science Standards[7] we identify four broad categories: computers as technology, coding as language, CT as problem solving process, and life in a digital society. We must be careful in defining computational thinking since many efforts to define standards around this topic have been part of larger efforts to enumerate computer science in general. That said, we recognize competence in CT will depend on familiarity with these adjacent concepts as well[8]. We also want to emphasize the importance of self-advocacy, collaboration, and perseverance[9] in the practice of CT, as well as a general adherence to the principles of growth mindset[10] (favoring process over artifact). **We present the following progression for K-12 CT education:**

	Progression for CT Education
Grades K-2	As children at this age are more concrete thinkers, we would focus on physical, unplugged examples at first. These would be bridged to plugged-in examples as students are able. This would introduce new and familiar concepts and give opportunities to practice new vocabulary. Key practices would be algorithm design (sequences of steps and the language used to give instructions), data collection and analysis (deciding when to use quantitative vs. qualitative data, simple graphing)), and abstraction (recognizing patterns). Activities would involve active play and exploration, with students building skills through their curiosity and connecting their discoveries to math, language arts, and science content.
Grades 3-5	Having now built a foundational understanding of CT terminology and practices, students would be given more opportunities to apply these concepts in new settings and using new technology. Students can be introduced to a visual programming language through the use of a tool such as Scratch, which would allow them to apply concepts such as algorithm design, data, and abstraction to a coding environment.
Grades 6-8	At these ages we can also pivot from prescriptive explorations to self-driven projects or models that represent real-world problems. Key practices from earlier grades would continue with added complexity, with the addition of modularization (using part of one solution for more than one problem), and debugging (testing solutions and working through problems). Familiarity with a programming language such as Scratch can be expanded through the use of a text-based language and more integration with hardware, robotics, or automation.

	These explorations could be increasingly framed against examples of careers that use CT skills, using such moments to promote positive STEM identity for underrepresented groups in STEM.
Grades 9-12	In these grade levels, we envision students applying CT across disciplines, modeling real-world problems, and simulating complex systems. Here we would see the problem solving aspects of CT come into focus. Career connections are explored in more depth, with more attention paid to getting students ready for computing careers in STEM or other disciplines.

Examine Research on Student Learning: Educational research has identified a complex web of misconceptions and systemic challenges that act as barriers to effective and equitable education. CT as a discipline is particularly susceptible to misconceptions around what intelligence means, who is capable, and who takes part. Fortunately, CT also offers us unique opportunities to challenge some of these misconceptions. A core misconception about the nature of intelligence is the assumption that computers are intelligent like humans – students being exposed to computers as tools for the first time are very likely to have "attributed an intelligence to the computer such that it could interpret what they wished for the computer to do and carry it out."[11] Errors stemming from this inaccurate mental model of the "hidden information processes" inside the computer are highly covert and resistant to change, unlike more cut-and-dry errors such as incorrect syntax while coding.[12] A clear and early emphasis on differentiating human thought processes from a computer's functions can help address this misconception despite challenges posed by everyday vocabulary around computers and "smart" devices. Students are often surprised by how much effort is required to tell a computer how to carry out a task exactly as intended. This fact can inspire a discussion about the particular strengths of humans versus machines, and subsequently help students cultivate a more accurate mental model of the limitations of computers. Another broad misconception that impacts students' ability to learn computational thinking skills is the belief that one's problem solving abilities are fixed, and some people are inherently good at it while others are not. Holding this fixed intelligence theory "raises students' concerns about how smart they are, it creates anxiety about challenges, and it makes failures into a measure of their fixed intelligence. It can therefore create disorganized, defensive, and helpless behavior."[13] In CT contexts, this mindset can lead to such specific misconceptions as assuming that there is little value in coming up with incorrect solutions, that encountering a bug in code means the entire code doesn't work and the student has failed, and that the first solution to a problem is always the best or final one.[14] Because computational thinking is best developed through opportunities to play, iterate, and guided inquiry, students who display such "helpless" responses to failure will face greater challenges than students who display mastery-oriented responses to failure, in which intelligence is seen as a malleable quality that can be improved and failure does not indict the whole individual.

Emphasizing growth strategies and mindsets is a conversation that reaches far beyond CT. An overall emphasis across all subjects on basing personal value on effort rather than inherent ability and re-framing failure as a core part of learning for all students is critical. Specific classroom strategies while engaged in CT lessons such as pair programming, giving guided questioning and tips, reflecting after work time to emphasize a wide variety of approaches and solutions, and remixing others' work can help dispel misconceptions about there being only one answer or that the first solution is always best.

Stereotypes around "who codes," viewing computing as incompatible with social issues and making a positive difference in the world, and a lack of diverse role models in computing and STEM contribute to students feeling that they cannot be good at or are not interested in computational thinking.[15] A lack of exposure to technology for students from low-income families can also contribute to these beliefs.[16] In their groundbreaking study of computer science education opportunities at three different California High Schools, Jane Margolis and her team discovered that access to technology in itself did not ensure that students had access to quality computer science courses.[17] Margolis and her team observed that deeply held stereotypes about who is innately skilled at "computers" played an important role in how administrators chose and marketed classes to students, masked under the guise of "student choice." While student choice seemed like a democratizing force, it actually created a self-perpetuating loop for students of color who did not identify with or express interest in the field of Computer Science and thus were not offered opportunities in it. To counteract these cycles, a proactive emphasis on integrating CT throughout all subjects, providing a diverse range of culturally relevant and student-directed learning opportunities, and framing CT as a tool that can be used across different real-world and community applications is critical. Culturally situated lessons can "reduce identity conflict, in which students feel like their personal or cultural identity is incompatible with participation or academic success in a subject"[18] (CSTA), including identities around race, ethnicity, gender, and ability. In addition, being cognizant of students' ability or inability to access computing tools outside of the classroom can inform strategies to integrate CT across subjects and learning spaces.

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Build Computational Literacy, question 22

Demand for Computational Thinking (CT) education in Minnesota is steadily growing as economic and educational factors demonstrate an increasing need for high-quality and equitable learning opportunities. Due to its extensive CT experience and impact across the state, the [redacted] plays a unique role in Minnesota CT education. Currently, CT education in Minnesota schools is extremely limited and decidedly inequitable. A small number of early adopter teachers engage their students in creative computational experiences, but most teachers lack the training and resources to teach CT effectively. As a result, there is a digital use "divide" between most learners who use technology predominantly for passive content consumption, and the relatively few who use technology in active, creative ways to fully support their learning.[1] This digital use divide more significantly impacts students of color and low-income students, who may be the least likely groups to experience transformative CT and Computer Science education, even with the requisite technology resources.[2] The current absence of state and national support and standards contributes to these inequities. Opportunities are especially lacking in elementary and middle schools.[3] However, the Minnesota Department of Education is gradually implementing a plan for "CS in All," integrating Computer Science expectations across standards for all content areas as they come up for revision. These efforts can currently be seen in the new Arts standards (and are especially strong in the Media Arts sections) and the most recent, Commissioner-approved draft of new Science standards, particularly in Practice 5: Using Mathematics and Computational Thinking. CT is also thoroughly integrated in the new Science standards' strands and substrands, for example in "analyzing and interpreting data" and "developing and using models." The Commissioner of Education is recommending that the year of full implementation be 2023-24, the same year that the Minnesota Comprehensive Assessment would begin to assess the new standards.[4]

The [redacted] has an extensive history of innovative technology education. From its founding, the Learning Technologies Center focused on its mission to support informal science learning through creative and meaningful applications of digital technologies.[5] [redacted] summer camps have included technology classes for many years, including the long-running *Design a Computer Game* which began with Logo and currently utilizes Scratch. Technology summer camps are offered for ages 6-16. Since 2012, the Museum's *Play, Tinker, Make, Engineer* program (previously known as *"Activate"*) has brought making experiences into [redacted] public spaces in a flexible, volunteer-led model. Often, these activities include CT concepts and technology tools. Furthermore, [redacted] is widely recognized for its effective and innovative teacher training and ability to partner with teachers, schools, and districts to increase their capacity for high-quality STEM teaching. In 2014-15, the *Bits-2-Bites* project provided STEM exposure for 31 high school students organized into two crews. Both of the *Bits-2-Bites* Crews consist almost exclusively of girls, youth of color, and youth from low-income households, all groups under-represented in STEM academics and careers. The youth experienced sequential introduction of computational tools with the short term goal of learning to use and apply them to create projects that explore and promote equitable access to healthy food in their communities and the longer-term goal of building their computational thinking skills. The youth also met with STEM undergraduate students, researchers, and other professionals to broaden their awareness of STEM careers and career paths, particularly in the areas of food science and computer programing.[6] In 2015, the National Science Foundation funded a project led by [redacted] called [redacted] The [redacted] project set out to research a model that would: 1) Support emerging teachers to be comfortable and confident with bringing CT experiences into their classrooms; 2) Reach and inspire diverse, female high school youth to develop their comfort with CT and expose them to the teaching profession and STEM career possibilities; 3) Engage young learners in summer camp and school based computational learning experiences; and 4) Build and strengthen partnerships with internal museum departments and two of the most diverse higher education institutions in the [redacted]. The [redacted] approach included a scaffolded experience, providing this all-female group of pre-service teachers and high school youth with a strong and shared learning community. Our researchers found that data revealed positive changes in teacher motivation, confidence, and self-efficacy, as well as growth and elevated value in community engagement, social justice, and equity within their teaching practices. Results from the high school youth revealed similar results and exposed that the youth recognized motivating concepts such as grit, self-advocacy, growth mindset, and a broadened understanding of technology, as well as strong leadership development in the area of community engagement and personal growth. Interviews with the youth showed their awareness of career opportunities and also revealed a motivation to get more girls engaged in CT experiences. Through [redacted], the museum developed a highly-effective computational thinking curriculum and elevated the technology education practices of its educators. The [redacted] project also supported the development of new technology-based summer camps, including girl-focused camp experiences.[7] Building on the strengths of the [redacted] project and curriculum implementation and teacher training successes of [redacted] project, the museum was awarded $3 million over 5 years from the Cargill Foundation in July 2018. [redacted] is designed to fully implement integrated computational thinking units in three elementary grades in both [redacted] and [redacted]. This significant investment in Minnesota STEM education will ensure we can produce effective and sustainable change in [redacted] and [redacted]. The project's partners share a vision for increasing equitable STEM student education and teacher training to ensure Minnesota students are prepared for college, careers, and full civic participation. We are building on our partnership and the successes of past projects to maximize the impact of our respective investments toward preparing students for STEM careers.[8] [redacted] will increase students' STEM interest, proficiency, and persistence; teachers' effectiveness in STEM; and districts' capacity to sustain STEM programming. With Cargill's continued support, [redacted] are collectively cultivating an increasingly diverse group of students who possess the skills and experiences to thrive academically and are inspired to pursue careers in STEM. [redacted] also continues to develop and provide CT programs for schools across the state. We currently offer two options for week-long classroom residencies, and are developing a CT family event, assembly, and additional teacher training offerings.

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[redacted]: STEM RFI Response

This response is submitted by a group of [redacted] representing the [redacted] program: [redacted] Along with hundreds of other student [redacted], we advocate for increased student voice and improved STEM innovation and education in our communities and the world. Regional [redacted] programs are integrated with local STEM Learning Ecosystems in order to leverage meaningful connections with a range of educational partners, science centers and museums, businesses, non-profits, and policymakers. The [redacted] program is currently in Arizona, Delaware, Florida, Georgia, Michigan, New York, Oregon, Pennsylvania, and Texas, with several other STEM Learning Ecosystems in the beginning stages of establishing programs. Internationally, the [redacted] program is in Kenya, Kuwait, and Mexico.

Future Opportunities in STEM Education; questions 1, 2, 8

Question 1:

Due to Covid-19, digital barriers such as students' limited access to the internet and certain devices do present themselves, causing some difficulty with connecting and networking with other students and STEM professionals which is crucial for implementing action plans. In our action plans, we identify gaps in local STEM education and devise a student-led strategy to address a specific area. We often focus on making STEM learning hands-on and interactive, or on engaging local STEM professionals to educate and inspire students.

To overcome these digital barriers, the [redacted] program has been utilizing a variety of connection methods such as email, Zoom, Remind 101, and Google Meets, which can be used on a wide range of devices. The difficulty of implementing action plans has been eased differently across regions. Before COVID, students would coordinate in-person STEM clubs, STEMonstrations, and STEM nights at schools or local venues such as libraries or community centers. In many regions including Texas, resources have been provided for students to instead implement online-adapted action plans.

In Arizona, the STEM Learning Ecosystem SciTech Institute, was selected by Iron Mountain to distribute 100 Chromebooks because they believe in the mission and core values of this nonprofit organization which manages the local [redacted] program. The Iron Mountain team appreciated the contact with students and preferred to know the devices were given directly to individuals who would benefit. Once the devices were confirmed, [redacted] were invited to identify students in their communities who would benefit from a new device, therefore directly impacting the learning environment for those identified.

It’s interesting to note that the [redacted] program has seen several benefits due to COVID-19, which is likely not the normal trend of responses from most organizations. Obstacles ranging from transportation to time conflicts with school can sometimes make it difficult for some students to get involved. During the pandemic, our organization has adapted by leveraging technology to hold Zoom for training and planning meetings. We’ve been able to hold many conversations with business professionals who now only need to schedule the meeting time itself, rather than allowing travel time.

Question 2:
The [redacted] have implemented several student-led educational programs that target learners like us. In virtual [redacted] calls, we have discussions with STEM professionals about their roles in a STEM ecosystem and their educational and career paths. These diverse professionals demonstrated how people from different backgrounds, of varying ethnicities and genders, have developed successful careers as marine biologists, pilots, astronauts, geologists, and more. These live sessions were recorded and made available as on-demand videos for those who could not participate in person. The student who developed the program did so with a goal of making connections among [redacted] during a time where social interactions may be difficult. Students have been able to gain interesting insights into a variety of professional paths and experiences, at the same time connecting with each other on the calls and encouraging their peers to maintain their passion for science and learning.

[redacted] created a [redacted] YouTube Channel to share science learning from their viewpoint. Monthly episodes include interviews with science professionals, demonstrations of hands-on science experiments and projects known as “STEMonstrations,” science-themed jokes, and student conversation and commentary. This show does not target a specific education system, but makes programs available to all. The ability to encompass everyone is what makes it so powerful for all kinds of students. We hope to see additional interventions that are targeted toward learners, including sessions for online networking, learning about [redacted] accomplishments, and introducing STEM opportunities that can be experienced in their own backyards!

Question 8:
Many regional STEM Learning Ecosystems are fortunate to support local learning through the [redacted] program, including a variety of options offered to continue connection and education despite COVID-19 restrictions. The [redacted] implemented [redacted] video calls through which [redacted] have the opportunity to meet STEM professionals and can explore STEM-related careers. Google Classrooms is an online

resource that the [redacted] program had already been using; therefore, online communication was still possible during quarantine. In an additional effort to stay connected, [redacted] were encouraged to participate in online challenges and activities including posting videos and/or photographs to Google Classrooms, making STEMonstration videos to post to Google Classrooms, and participating in Regional Cabinet Google Hangout calls. These platforms and adaptations ensured the stability of international connections.

However, quarantine made interaction with advisors and mentors difficult, therefore causing some students to feel disconnected from the program. In addition, many action plans were not able to be executed. Live meetings, celebrations, and other gatherings could not take place, and training with professionals was not possible.

Develop STEM Education Digital Resources; question 9

Question 9:

Based on discussions among the [redacted], we would like to see web resources like virtual field trips, online interactive STEMonstrations, or some form of speaker's bureau (similar to the [redacted] meetups) where we can interact with STEM professionals. In all three of these examples, we noticed that a key piece to implement is interactions and discovery that can leverage the full power of technology and its ability to connect people all over the world. One existing website we found was [redacted], in which they include modules of their course, provide virtual field trips of their previous projects, and even include outreach opportunities to get in contact with a business professional (but still could be developed to be more useful and student-friendly).

Increase Diversity, Equity, and Inclusion in STEM; question 12

Question 12:

Our organization has actively encouraged our sites and administrators to choose students of each gender for stronger and more diverse ideas to build our program. In addition to these methods, we have implemented a new diversity, equity, and inclusion committee to ensure that all voices are heard and form a foundation for the future of our organization. We hope to specifically target all forms of underrepresented minorities with this organization, and encourage individuality among race, gender, etc.

We have evaluated the success of these interventions by surveying our students. Looking specifically at the gender statistics, our ratio was 54% female and 46% male [redacted], which happened naturally. As a program begins at a [redacted] site/school we encourage at least two [redacted] and one of each gender, but it is ultimately up to the [redacted] site/school to decide during an election or selection process. Currently, not all regions are registered but our ratio of the 446 [redacted] is 62% female and 37% male with 1% non-binary.

Engage Students Where Disciplines Converge; questions 13, 14

Question 13:

The [redacted] program merges STEM-based learning with communication. As [redacted], we reach out to professionals, STEM experts, and other [redacted] to formulate action plans. [redacted] learn professionalism, such as how to be polite and be actively engaged in a conversation. Communication is a crucial life skill that [redacted] learn throughout their experience in the program. Proper use of technology is a crucial part of communication among [redacted] delegations to achieve global collaboration. Finally, [redacted] learn how to problem solve in real-world situations. Throughout the course of our action plans, [redacted] plan creatively, implement programs and ideas, and use problem-solving to overcome any unforeseen obstacles that come our way, such as adapting to the COVID-19 pandemic; in which in-person experiences suddenly had to shift to virtual formats.

Question 14:

Before quarantine, communication involved scheduling meetings, arranging interviews, and other in-person forms of outreach. During quarantine, however, communication was limited primarily to online methods for connection. Virtual outreach platforms include email, telephone, Google Classrooms, and Zoom (and other video call platforms). Distancing requirements forced Leadership Training Institutes to become virtual. This denied new [redacted] the same experiences they would have had if they were in-person. For example, [redacted] learned skills such as speaking in front of a crowd, in-person interviews, and introductions, but the value of those lessons was diminished because the [redacted] could not physically practice carrying out the life skill highlighted in the demonstration.

Develop and Enrich Strategic Partnerships; question 18

Question 18:

The [redacted] believe that the most successful learning program depends on the strong connections among the participants. Our partners commit to mentorship and resources for the students that help to build strong ecosystems for the future. Federal agencies can similarly expand their partnerships by understanding the needs of the private and non-profit sectors and building towards what is required of the future workforce. To name a few, our partnerships with Boeing, American Express, DIA, and NASA all worked to not only benefit the organization but provide the proper resources to ensure that the students could develop their passion for STEM and understand potential career paths.

Build Computational Literacy; questions 20, 23

Question 20:

By leveraging a strong core of computational literacy for our students, we develop powerful collaborations and a strong sense of community among our [redacted]. An ability for a student to interact through the resources that are provided is a key piece of our curriculum, and it ensures that there is a foundation of equity for those who aren't able to consistently reach in-person meetings, especially in our current climate. Since the [redacted] program had already maintained a strong foundation integrating computational literacy into our instruction before the necessity for remote learning, we didn't have many challenges due to COVID-19. The only thing we had to ensure was that there was technology equity. We already had a structure to address that among our students, and we also went further by providing Chromebooks for those who needed them.

Question 23:

The main basis for the connections among [redacted] depends on our utilization of G-Suite. Due to its broad range of tools like hangouts for conversations with other [redacted] a classroom for assignments and posts, and Gmail for making connections with business professionals, it helps us to not require any other resources that we need for our remote teaching.

Community Use and Implementation of the Federal STEM Education Strategic Plan; question 24

Question 24:

The four program goals of the [redacted] are to:

- Create a global network of diverse STEM leaders.
- Foster communication and collaboration among [redacted].
- Enrich STEM culture and career awareness.
- Amplify student voice in STEM conversations in the community.

These closely mirror those in the Federal STEM Education Strategic Plan, including diversity and preparation for the STEM workforce. The [redacted] program works in and builds around the formally-organized STEM Learning Ecosystems, including partnerships with the Alamo STEM Ecosystems of San Antonio, Texas; Arizona SciTech Ecosystem; Great Lakes Bay Regional Alliance in Michigan; North Louisiana STEM Alliance; Northeast Florida Regional STEM2 Hub; Northshore STEM Coalition in Louisiana; seven areas included in Oregon's Statewide Regional STEM Hub Network; and the Western NY STEM Hub.

Working within these ecosystems fosters networking between students and STEM/Business professionals. Our program was already integrated into the organization of STEM Learning Ecosystems before the Federal Strategy was developed, and we have continued leveraging the community relationships that the Federal Plan has highlighted as effective.

Submitted by [redacted]
We welcome the opportunity to further discuss via Zoom or other virtual platform if possible.
Contact [redacted]
(b) (6) [redacted]
(b) (6) [redacted]

[redacted]

October 19, 2020

Cindy Hasselbring
Senior Policy Advisor and Assistant Director, STEM Education
White House Office of Science and Technology Policy
Eisenhower Executive Office Building
1650 Pennsylvania Avenue
Washington, DC 20504

Dear Dr. Hasselbring,

On behalf of the [redacted] I want to thank you for the opportunity to provide comments on the Request for Information (RFI) on STEM Education.

[redacted] is the major national scientific association of 25,000 faculty, researchers, graduate students, and other distinguished professionals dedicated to advancing knowledge about education, encouraging scholarly inquiry related to education, and promoting the use of research to improve education and serve the public good. Many of our members are engaged in STEM education research at all levels of education, and such research is a major priority in our association's programming. Our members work in a range of settings—from universities and other academic institutions to research institutes, federal and state agencies, school systems, testing companies, and nonprofit organizations—to conduct research across all areas of education and learning from early childhood through the workforce.

[redacted] as a professional scientific organization is also itself engaged in STEM education. Not only do we work with well over 140 graduate schools of education engaged in training STEM scientists, but also [redacted] leads in capacity building programs that train education research scientists pursuing doctoral degrees and provides opportunities for, in particular, early career education scientists in the workforce.

We will address the following questions in this response:

- Future Opportunities in STEM Education – Questions 4 and 6
- Develop STEM Education Digital Resources – Overall Response to Questions 9-11
- Increase Diversity, Equity, and Inclusion In STEM – Question 12
- Engage Students Where Disciplines Converge – Overall Response
- Building Computational Literacy – Question 22
- Community Use and Implementation of the Federal STEM Education Strategic Plan – Question 24

In addition to responding to these specific questions, we would like to express our appreciation for how federal agencies supporting education research have responded to address the impact of COVID-19 on STEM teaching and learning. With support from the Coronavirus Aid, Relief, and Economic Security Act, the Education and Human Resources (EHR) Directorate has funded research to understand how the pandemic has affected STEM education across all levels. In addition, the Institute of Education Sciences (IES) worked with Small Business Innovation Research grantees to produce Guides to Education Technologies, including for math and science and engineering. These activities and evidence-based strategies are aligned with the Federal STEM Education Strategic Plan.

Future Opportunities in STEM Education, question 4

We address the first question here from a systems-level perspective. The shift from in-person to distance learning in March has exacerbated persistent, systemic inequities in access to education, particularly for low-income students and traditionally marginalized populations. The lack of access to computers, internet, and space to be able to participate in distance learning are issues that students across all levels of education continue to face in the 2020-21 school year. Undergraduate and graduate students have also experienced impacts to their research experiences, including delays in completing degree requirements and limited access to mentoring and opportunities in the field. Students, educators, and researchers in the STEM pipeline have also faced the underlying effects of systemic racism that have been compounded by COVID-19.

In the short term, education research can spawn innovations in remote learning. In the longer range, federal agencies can continue to play a vital role in supporting STEM education research and professional development that can attend to learning loss, understand the ways that mitigation strategies have influenced educational and socioemotional development, and continue to address systemic racism in STEM education and the workforce.

Future Opportunities in STEM Education, question 6

We are very pleased that the National Center for Education Statistics (NCES) is adding questions on the impact of the pandemic on several surveys, including the High School and Beyond Longitudinal Study of 2020 and the National Postsecondary Student Aid Study of 2020. We also appreciate that the National Center for Science and Engineering Statistics (NCSES) has added questions on the Survey of Earned Doctorates to gather information on how the pandemic has affected degree completion, employment, and post-graduate opportunities. Data from these surveys will be very useful for future examination of research questions on the pandemic's impact on the STEM education research and workforce pipeline.

[redacted] is currently involved in several initiatives that include data on the impact of the pandemic on STEM education graduate students and the workforce; we highlight two here. First, with NSF funding, [redacted] and the Inter-university Consortium for Political and

Social Research have just launched the Partnership for Expanding Education Research in STEM Data Hub (PEERS "Hub"). The Hub aims to advance discovery through data, connect researchers across arenas of inquiry to work together on research topics in STEM education and learning, provide opportunities to share and access data from research studies, and foster diverse methodologies in STEM education research. We plan for the Hub to include data and resources on the impact that the COVID-19 pandemic has had in STEM education across all levels and on the scientific workforce.

In addition, [redacted] and the Spencer Foundation are currently conducting a major study of the impact of COVID-19 on doctoral students and early career education researchers. This study will provide information on how the pandemic has affected their research, collaborations, receiving mentorship, and their career trajectories.

Develop STEM Education Digital Resources, overall response to questions 9-11

In considering the development of a web resource for educators, parents, and students, we would encourage leveraging federal agency websites that have compiled and curated resources and curriculum. We recommend that any resource built be easily accessible by multiple audiences. Some examples that could be integrated in a broader federal website include:

- Institute of Education Sciences (IES):
  - What Works Clearinghouse – Science Interventions
  - What Works Clearinghouse – Practice guides
  - IES SBIR Grants and Related Resources
  - Evidence-based Resources from the Regional Educational Laboratories
- National Science Foundation
  - Center for the Advancement of Informal STEM Education
  - Community for Advancing Discovery Research in Education
  - STEM Learning and Research (STELAR) Center

Any web portal that would include the above repositories and resources from the non-profit and private sector should be organized for teachers, students, and parents, among others with interest in STEM resources. In addition, these resources should be organized by grade (e.g., K-3, 3-8, 9-12/high school, postsecondary) to make it easy to find developmentally-appropriate materials. The Federal STEM Education Strategic Plan highlighted the What Works Clearinghouse as an example, and we agree that this would be a good model for an integrated web portal to leverage promising and evidence-based strategies in STEM education across federal agencies.

Increase Diversity, Equity, and Inclusion in STEM, question 12

[redacted] strongly encourages federal research agencies and OSTP to increase the numbers of traditionally underrepresented and marginalized populations in STEM education. Within federal agencies, we strongly support initiatives that aim to develop interest in STEM education and careers such as the NSF INCLUDES program, and through grants from the EHR Directorate to Historically Black Colleges and Universities, Hispanic Serving Institutions, Tribal Colleges and Universities, and other minority serving institutions to support traditionally underserved students in STEM education. These investments at NSF, along with pre-doctoral and post-doctoral training grants supported by IES, have been an important catalyst for cultivating interest and supporting attainment in STEM and broadening participation in the STEM education research pipeline.

As an organization, [redacted] has had a longstanding commitment to increasing diversity and inclusion in the STEM education research pipeline. One prominent example is the [redacted] program that has supported doctoral students of color (e.g., African Americans, Alaskan Natives, American Indians, Asian Americans, Hispanics or Latinos, and Native Hawaiian or Pacific Islanders) in completing their degrees and dissertations. In addition, the [redacted] Grants Program (Advancing Core STEM Research through Scientific Studies and Capacity Building with Large-Scale Data Resources) has also supported research that has used NCES and NSF data as well as other federally supported data to understand STEM education trajectories across the lifespan. This program has been intentional in reaching out to and providing funding support for education researchers of color.

[redacted] is engaged in several efforts to continue to address the dual pandemics of COVID-19 and systemic racism. Through the Education Research Service Projects initiative, [redacted] is supporting pro bono research to help educational institutions and non-profits to address issues they face. Several of our divisions (large and small) are using their own funds for small grants to graduate students and early career scientists on COVID-19 and systemic racism. Our scientific journals have calls for proposals to submit manuscripts for three special issues on these topics. [redacted] is also collaborating with the Society of Research on Adolescence and the Society for Research in Child Development to feature our respective publication initiatives.

In addition to this work, federal agencies can play a role not only in ensuring racial and ethnic inclusion, but also gender inclusion. One way that federal agencies can be sure that LGBTQ+ populations are represented in science is through including questions on sexual orientation and gender identity on surveys such as the Survey of Earned Doctorates. [redacted] along with the American Association for the Advancement of Science and active scientists in the community have been at the forefront of pressing for change.

Engage Students Where Disciplines Converge (general response)

As a field, education research has long been involved in drawing across all scientific disciplines to conduct research in STEM disciplines and develop evidence-based practices. In recent years, [redacted] has worked with organizations and researchers in the physical, biological, and mathematical sciences on discipline-based education research (DBER). The [redacted] initiative has, for example, a special emphasis on the DBER research community and DBER data. NSF has been a vital source for supporting grants in DBER and related efforts, and we would urge OSTP to consider similar funding mechanisms at other federal agencies.

We also appreciate the attention of the current Federal STEM Education Strategic Plan to incorporating the arts and humanities as part of a transdisciplinary convergence model. Consistent with a framework that embraces all science, as federal agencies continue to implement this plan, we urge them to be attentive to the inclusion of education research and the social and behavioral sciences more broadly as essential parts of STEM education and research. Also, in further implementing the Federal STEM Education Strategic Plan, we recommend ensuring that the training of graduate and doctoral students and further professional development of STEM education researchers are included in discussions of developing STEM education programs.

Building Computational Literacy – Question 22

The federal government's priorities in the Strategic Plan are aligned with ongoing efforts in STEM education research to provide professional development and encourage ethical data use and data sharing consonant with confidentiality and privacy protections. The NSF Education Core Research program has been a critical source for supporting the development of resources and collaborative efforts, including the PEERS Data Hub mentioned previously, to educate researchers on data sharing, using big data in STEM education research, and draw upon innovative analytic and computational methods. Since its inception in1990, the [redacted] Grants Program has been at the forefront of supporting and building capacity to use advanced computational methods.

Community Use and Implementation of the Federal STEM Education Strategic Plan, question 24

Our response here focuses on two of the Federal STEM Education Strategic Plan pathways: (1) Develop and Enrich Strategic Partnerships, and (2) Operate with Transparency and Accountability.

Develop and Enrich Strategic Partnerships

Education researchers have been and continue to remain key partners with a number of stakeholders to improve STEM education outcomes and to highlight promising practices for the field. A few recent examples are provided below:

- [redacted] partnered with NCES on a webinar in June 2020 to showcase scientifically productive ways for education researchers to collaborate with state education agencies to address research questions of interest to state policymakers. Initiatives such as Mentor Matters in Michigan and the Wisconsin Evaluation Collaborative Network incorporate these partnerships and involve data supported through grants from the Statewide Longitudinal Data Systems program at NCES.
- With results published in [redacted], a group of educational researchers interviewed public health officials, state and district policymakers, and leaders of national education organizations, resulting in [redacted] informing how education researchers can apply their expertise during the

COVID-19 pandemic. Recommendations include synthesizing and translating research, organizing and developing timely professional development (PD) opportunities, and evaluating new practices.

Operate with Transparency and Accountability

We wish to comment on one significant item suggested for agencies to include as part of their implementation plans in reporting indicators: “A definition of STEM education programs, investments, and activities that will be used to collect annual inventory data.” The 2019 progress report on the implementation of the Federal STEM Education Strategic Plan included the following note in guiding agencies on their inventories of STEM programs: “While various definitions of ‘STEM’ exist, for the purposes of this inventory, STEM includes physical and natural sciences, technology, engineering, mathematics, and computer science disciplines, topics, or issues (including environmental science, environmental stewardship, artificial intelligence, quantum information sciences, and cybersecurity).”

We strongly object to a definition of STEM for federal agencies that excludes STEM topics in education research as well as the social, behavioral, and economic sciences overall. We urge OSTP to update this definition to include education science (beyond education technology) and the social and behavioral sciences as STEM for the purposes of identifying “STEM education programs, investments, and activities.” Explicit attention to these fields will ensure that these sciences are included and represented in data on STEM education programs reported by federal agencies. As an example, while the FY 2019 inventory listed several NSF programs within the EHR Directorate that align with the goals of the strategic plan, the current, narrow definition of STEM education did not include investments in STEM education made by the NSF Social, Behavioral, and Economic Sciences Directorate and limited what was classified as STEM education within IES.

Thank you once again for the opportunity to provide input on this Request for Information on STEM Education. We appreciate the work that OSTP and NSF have undertaken in leading efforts to implement the Federal STEM Education Strategic Plan and look forward to continuing to work with you on these issues and in the next iteration of the strategic plan. Please do not hesitate to contact me if [redacted] can be helpful.

Sincerely,

[redacted]

Category: Future Opportunities in STEM

(b) (6) [redacted]

Question # 4: What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

1. <u>Student engagement</u>

Social presence in class is very important for learning. Students attend remote class via an online platform such as Zoom, WebEx or Google classroom. However, not all logged students actively participate in the learning community. While this happens in face-to-face classes too, the instructor's inability to see all the students while teaching makes it more challenging with online classes. They can see a few whose cameras are turned on. The others remain incognito. A teacher assesses student engagement by watching for students' facial expressions, body language, participation, and curiosity. Student engagement is used as an assessment tool for learning. Jennifer A Fredricks, author of "Eight Myths of student learning" (1) describes that students need to be engaged on three levels: **emotionally** where they are emotionally attached to their school, their teacher and the subject, **behaviorally** shown by their attentiveness and participation, and **cognitively** as demonstrated by their ability to perform well in the class. In a regular classroom a disengaged or otherwise preoccupied student can be easily identified by the teacher and the student's attention could be quickly brought back to focus. However, in a digital world some students are visible with their cameras on and the others are sitting behind a hidden camera. Because it is easy to focus on a person interacting with the faculty, many times students who do not turn on their cameras are forgotten in an out-of-sight out-of-mind manner. These students' cameras are off partially because they do not want to turn on their cameras, but a great majority do not have a computer with a camera or do not have a private study room. Either they are embarrassed to share their living environments with others or they feel it is an encroachment on their privacy.

Solutions: Regarding student involvement, faculty are now adopting new methods to engage students such as in-class assignments, polling during classes, encouraging students to ask questions privately through chat, participating by raising hands through Zoom, showing a thumbs-up if they have understood, asking students to draw the concept taught to them using a paper and pencil and submitting a cell phone picture of it via blackboard, dividing students into small breakout rooms to discuss a problem and then have them brainstorm it in class, having students write and post the five important points that the instructor said will be on test, and so on. Grades have been shifted to put as much emphasis on participation as on assignments and test grades. Students have been advised to take advantage of the free Chromebooks, iPads, and hotspots loaned by the school. Our college also has online library resources, online tutoring services that can be accessed remotely, and a study room. We are currently assessing the success of our solutions by comparing the number of participating students, analyzing their polls and in-class assignments, assessing retention and, of course, their overall class grades. Class retention and grades will be compared with the same courses taught by the same instructor face-to-face in the previous years.

Gaps: Students who refuse to attend classes are the most difficult to engage. When they do not respond to emails and fail to attend classes, and there is no way to contact them, then there is no way we can reach out and assist them. Even though the college is making every effort to help students, not all of them take advantage of the resources. When they do realize that they can get help from available resources, the burden gets too challenging to make up the missing work. As discussed separately below, students' living conditions, work schedules, and current life conditions play a major role in how much and how well they engage in their courses.

2. **<u>Laboratory</u>**

Labs are an integral part of science education as hands-on experiments done in a lab can reinforce concepts learnt in lecture. With the recent necessity for teaching from a distance due to the COVID-19 pandemic, undergraduate science faculty have been compelled to teach lecture and laboratory content through remote platforms. It is very difficult to engage and involve students in Zoom sessions even if they are taught synchronously. They lose interest if they just have to watch videos or listen to their instructors talk about the labs (2). Finally, with the continuation of the pandemic, many more semesters can be taught online and there will be an increasing expectation that future online lab courses meet the same standards as in-person labs.

Solutions: A reasonable solution to this problem could be innovative simple investigative labs that can be performed by students safely at home with common household materials and purchased kits from vendors. Alternatives to this are online virtual labs that mimic certain laboratory activities. Such simulations can be purchased from vendors like Labster or obtained from textbook publishers whose book is already used by the school. Such simulations can also be downloaded from the internet at no cost.

Gaps: The major inequity here is that some students have the ability and the intention to purchase lab kits while others do not, even though they are not very expensive. Some students have room at home to perform those experiments while others say they do not have enough space. Simulation software such as Labster is possible only if the college purchases licenses for the students as they are very expensive and unaffordable by students. Some simulations are very limited and not up to expected quality.

3. <u>The lack of a home environment that is conducive to learning</u>

To be effective, online learning requires, at a minimum, a quiet place to work. In a distraction-free setting, students can participate in online lab sessions, engage in group work, and analyze data in a thoughtful way—all of which are essential parts of lab-based science classes. However, many students lack a quiet place to work and study.

Many students live with multiple family members. As a result, it is difficult for students to find a quiet place to concentrate on STEM coursework. This problem is particularly acute for those who have childcare and eldercare responsibilities. Beyond the basic requirements of shopping, cooking, and cleaning, parents of very young children cannot rely on daycare or pre-school and need to watch their children round-the-clock. It is not uncommon for minor children to appear on-screen while a mother or father is attending an online class.

For parents with school-age children, schedules often conflict and there is less access to a family computer or wi-fi. Simply put, it is exceedingly difficult for many STEM students and their minor children to attend Zoom classes at the same time. These parents also have the burden of assisting their children with their own remote learning.

The COVID-19 pandemic has had a disproportionate impact on the health and safety of economically challenged and minority households (3). Many students live in homes where one or more close family members have been directly affected by the virus. And for STEM students who live in multi-generational households, elderly relatives often have additional medical needs. These family obligations have taken an especially harsh toll on female students who were already severely under-represented in the STEM field.

Solutions: Institutions might offer outreach for students in need of assistance (4). Financial aid for child/elder care might be extended to alleviate home care responsibilities. Courses could be restructured to limit the time needed for synchronous participation so that students can arrange their own time schedules for asynchronous work. As mentioned earlier, our institution has implemented safe spaces for students to use for independent study without the fear of contracting the virus.

Gaps: These diverse environments create disparity in a student's ability to succeed in a STEM class. Although resources are offered, many students do not reach out to ask for assistance.

4. <u>Economic hardship and the digital divide</u>

The pandemic has had a devastating impact on our neediest STEM students. Many have lost their jobs and are undergoing tremendous pressure. And for those fortunate to still have jobs, work schedules have been disrupted, making it nearly impossible to attend regularly scheduled classes. Students in the health care and service fields, have been working longer hours under great pressure and they have had to drop classes.

Economic hardship directly impacts many student accesses to technology (5). Computers with sufficient memory and adequate internet service are essential requirements for all STEM courses. A student of limited means, who lacks access to a reliable computer or internet service, is unable to thrive in a digital learning environment. If a basic piece of equipment, such as a camera or microphone, is not working, a financially burdened student cannot get it easily repaired.
This financial pressure on STEM students prevents them from obtaining tutoring assistance. It also prevents talented students from taking advantage of research and other extracurricular opportunities where they can develop basic skills. To succeed in the STEM field students often need to go beyond the basic curriculum. A student who is struggling to pay for necessities or is caring for children or parents cannot conduct independent research or volunteer at a health care facility (6).

Solutions: Students at our institution are able to borrow the technology required for the coursework. Institutional tech support services are also available to students. [redacted] was recently awarded the Conexiónes Title V project grant from the US Department of Education. Plans are currently underway to use this grant to narrow the gaps in inequities among our student population.

Gaps: Economic insecurities during these unstable times arise without warning and put a student at a sudden disadvantage for success in an online class. Technology skills vary with different age groups and at different academic levels.

5. Inequity in test taking

This situation that some students find easier to cheat online creates a pressure and encourages all the other students to cheat as well. Some students have the correct software and the means to purchase subscriptions to test training programs available online. Some of them can even hire a tutor at the time of the test to solve their test questions. A good number of them do not have that option. This causes many problems. First, it raises the class average creating an illusion that topics are mastered, while misleading the professor. The second problem is the professor makes a harder test putting the honest students at a disadvantage. Finally, it creates an idea that cheating is possible and difficult to be detected. This discourages students from participating or engaging in class activities and has the potential to impact their learning. With so many resources available during an online test and no one to proctor, the temptation to take advantage of these resources is difficult to resist. Moreover, peer pressure might also be a contributing factor.

Solution. So far, we have not had an effective solution for this problem. Some tactics that have worked in a limited way are restricting the time available to take the test, changing the wording of questions whose answers are available online, asking critical thinking open-ended questions, decreasing the weight of overall grades on tests and increasing the weight on participation. In smaller classes, another alternative is to assess learning in colloquium or oral exams/quizzes. Frequent individual or group colloquiums could have a positive impact on learning. Some software such as Respondus Lockdown and ProctorU are available to minimize cheating.

Gaps. Many students are aware that finding answers on internet during tests constitutes cheating. However, they believe this is an easy way to get better grades. Academic pressure in this learning environment causes our students to resort to these methods. What they do not realize is that they are putting themselves at a disadvantage for their future. Counseling students to improve their self esteem and confidence might teach them not to follow this practice.

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Response to RFI on STEM Education, 85 FR 55323, 09/04/202

The reply to the questions is from my, [redacted]

1. What COVID-19 related digital barriers (*e.g.,* access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

   [redacted] Program had all of the following: access to broadband or computers, digital learning platforms, online educational resources COVID-19 Digital barriers. While all of the above mentioned have been partially resolved in the case of access to broadband [redacted] has just recently, early September, forwarded Wi-Fi hotspots to the students. The barriers that remain is obtaining the correct information, specifically students self- identifying as well as having enough hot spots for students. Access to Wi-Fi is the most difficult to resolve. In the case of access to computers this barrier has been almost fully resolved. Students were sent laptops and tablets via courier service. In the case of digital learning platforms, this too has been partially resolved as a consequence of having an online tutorial for zoom, blackboard and google meet.

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers / faculty / instructors (*e.g.,* virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (*e.g.,* pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

   New educational programs that we would like to consider for [redacted] students is to offer a summer bridge program for incoming freshmen that will focus specifically on the needs of underrepresented students considering STEM fields. We envision the program being hybrid whereby students will have the flexibility of engaging in both pre-recorded sessions as well as virtual meeting with a mentor/faculty member.

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

   A positive experience using remote learning technologies in recent months has been noticing students who were withdrawn and timid are using remote learning technologies to flourish by taking it upon themselves to reach out to one another and form support / study groups. EAB Navigate Study Buddy feature has been helpful in allowing STEM students connect with one another. In order to enhance this experience instructors and students need to receive adequate training. Awareness coupled with training will allow for the institutionalization of STEM support groups. This will likely allow underrepresented students new opportunities in STEM education.

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

   The greatest challenges that have emerged related to inequities in STEM with the shift to online education and training has been that SEEK students did not have the technology in place nor the resources at home (stable internet) to engage in online learning. In the case of the former, lack of technology, most of the students were granted laptop or tablet during the [redacted] pause period in early April. However, getting students technology proved to be much more cumbersome as a consequence of students not being able to commute coupled with shoddy courier service. In the case of stable internet service this proved to be much more complicated and we only recently obtained Wi-Fi hotspots for the [redacted] STEM students. First, we needed to identify the problem, this we did by sending Student Surveys whereby students would self-identify their need for technology and Wi-Fi. However, some STEM students failed to identify within a timely basis and this led to the gaps in our ability to deliver the need for technology and resources needed to access STEM education services. The Wi-Fi issue lingered on through the end of the Spring 2020 semester. Hotspots were finally obtained and sent to students in August / September 2020. We measured our solution's success by gauging how many students were still reporting technology and resource needs during Spring 2020 and then gauging the number of students needed both during the Fall 2020 semester. This number has drastically dropped from 68 to 1 – as of early October 2020.

5. What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.,* utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

   Currently the areas of professional learning that would be most beneficial to educators providing remote instruction would be small group collaboration since this has the likely effect of allowing students to learn from one another and support each other. However, during the initial phase of the pandemic, instructors should have received training in creating rigorous alternative assessments for those without access to technology/broadband).

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

   The data/information that is of the most important to collect about STEM education during the disruption of educational systems because of COVID-19 revolved around inquiring if students had the technology and resources coupled with the ability to log on to the various online platforms (Blackboard, Zoom, Google meet). We are currently collecting and analyzing data regarding pre- and post- pandemic grades for STEM students. We are also surveying students for possible mental health issues, family life including household size, sharing of space and resources at home as well as experience food insecurities.

7. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

The [redacted] Program took the following actions in order to support learning in response to COVID-19, including: having an assign Counselor check up on students, providing mental health workshops, providing resources (including food bank information), having extended hours for STEM consultants and Tutors. These actions were extremely helpful since students provided thank you emails. Budgetary constraints were barriers that definitely limited our capacity to undertake additional actions. We could have serviced more students if we had the additional resources (people) and could have serviced students later in the evening since our students were serving as in-home teachers to their siblings.

Develop STEM Education Digital Resources

8. What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

https://stemeducation.nd.edu and [redacted]

10. Please describe your primary audience (*e.g.,* I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience. Start Printed Page 55325

The [redacted] Program primarily works with first-generation, low-income college students; I specifically work overseeing the [redacted] Program.

11. How would you like to see resources categorized (*e.g.,* subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.
Would like to see STEM resources primarily categorized by Subject. There are limited number of post-secondary education websites, besides the Notre Dame website. that I would consider a model website.

Engage Students Where Disciplines Converge

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (*e.g.,* a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (*e.g.,* more engaging for students, school / administration promotes transdisciplinary learning) and how does it benefit your students' learning?

[redacted], uses transdisciplinary learning, this is done by ensuring that students are well rounded and take courses in the Humanities as illustrated by the Pathway requirements. All students must take courses outside their major in order to complete the baccalaureate requirements.

14. How has your ability to teach transdisciplinary concepts to your students changed in recent months because of the shift to remote teaching and learning? What teaching modalities have you employed to deliver transdisciplinary instruction virtually?

My ability to teach transdisciplinary concepts to STEM students changed in recent months because of the shift to remote teaching and learning by seeking to break down the silos that exist within academia to this end the student assignments have incorporated collaboration across different fields. Proving that subjects that appear incompatible can and do comingle. By using hybrid teaching modality have been able to virtually deliver a synthesis of subjects considered incongruent. Such is the case with rehabilitation whereby we can pull strands from biology and interactive music when considering the range of motion undertaken from a recovering patient who had a stroke.

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way? What specific delivery mechanism work well for you (*e.g.,* online course, webinar, in-person workshop)? What technology tools would be helpful for you when using a transdisciplinary approach?

Offering faculty development that acknowledges that the better way to teach STEM must come from a transdisciplinary approach one that will allow students to see that what they are learning in one course fits with what they are learning in another. Furthermore, allowing students to notice that their learning will actually turn into solutions to problems. The delivery mechanism favored is hybrid online course (includes face to face meetings and asynchronous assignments.

Develop and Enrich Strategic Partnerships

18. What factors drive successful work-based learning programs?

Mentorships and internships drive successful work-based learning programs

What elements encourage or discourage students, schools, or industries from participating? The number one element that discourages students from participating is the lack of financial resources available to students – unpaid or low-paid internships. In the case of schools, the issue includes start-up costs associated with following students coupled with lack of faculty buy-in and relieve time.

How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities?

Federal agencies can expand partnerships with the private and non-profit sectors and educational institutions, to train the workforce needed for jobs of the future through work-based learning opportunities, by coming together to first know what are the skills and jobs of the future. The federal agencies must adequately invest in offering well paid internships and mentorships to the mentors, instructors and students. Furthermore, institutions must be willing and able to provide relief time to faculty engaged in work-based learning opportunities.

If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization adjusted in response?

Due to the pandemic, [redacted] has had to provide work-based learning opportunities online.

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success?

Characteristics of a successful STEM learning ecosystem must include underrepresented faculty and students. Furthermore, the STEM learning ecosystem must provide financial incentives to all involved.

What is the role of the private sector in a successful STEM learning ecosystem?

The private sector must be able to assist with offering human resources as well as financial support in order to deliver a successful STEM learning ecosystem. Furthermore, private must be able to share lesson learned with the STEM community – similar to a "What Works Clearinghouse."

What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

Since the pandemic began, the [redacted] ecosystem is being supported by the Center for Teaching and Learning (CTL) and by an HSI-STEM US Department of Education funded project. CTL and HSI-STEM have offered a plethora of online courses in order to make sure that faculty and staff are properly trained in virtual learning.

Build Computational Literacy

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

The benefits associated with integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources include the synthesizing effect and the symbiotic relationship. Furthermore, as alluded to in Question #14, integrating computational literacy within a STEM curriculum will foster more integrated or transdisciplinary approach to teaching STEM.

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.

We agree that every American must have the opportunity to master basic STEM concepts, including computational thinking, and to become digitally literate. At the high school level students must be able to obtain a level of proficiency in Biology, Chemistry and Environmental Sciences – in line with the [redacted]. In the case of Technology high school students must have completed an Introduction to Computer class and in the case of Engineering foundational Physics should be completed by all students and students scoring at the proficiency level. While in the case of Math high school students must have scored at the proficiency level in both Algebra and Geometry.

Community Use and Implementation of the Federal Stem Education Strategic Plan

24. Please describe how your organization has used the Federal STEM Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?

Fully aware that the percentage of underrepresented students in STEM fields is less than stellar. In line with the Federal STEM Education Strategic Plan we are working on a campaign to Increase Diversity, Equity, and Inclusion in STEM. We will do this by going into high schools with a large percentage of underrepresented students and recruiting from these schools. We will also offer a summer bridge program that focuses on STEM fields. We must increase the percentage of [redacted] students (low-income / first-generation) going into STEM fields. Currently the [redacted] has only 5% in STEM related fields.

[redacted]

[redacted] provides leadership in higher education reform, specifically in biology, with a focus on current trends, emerging issues, and effective pedagogical approaches. We offer transformative professional development experiences for faculty from all types of higher education institutions across the country, and have been doing so for almost 35 years. [redacted] translates discipline based education research into actionable practices in the classroom in challenging areas such as quantitative skills. We promote authentic, relevant scientific experiences for all students.

Future Opportunities in STEM Education (Questions 4, 5, 6, 8)
This response focuses on delivering professional development and supporting communities for faculty in higher education.

The greatest inequities we discovered were limited access to good internet service. Faculty everywhere struggled with this but especially faculty in rural areas. We made as many experiences as possible available asynchronously as well as synchronously, but this does not solve the basic accessibility problem.

This disruption to the usual educational practices provides an opportunity to reconsider the purpose, delivery and assessment of education in person and online. Professional development for faculty teaching online should focus on good pedagogical practices, such as backward design, making content relevant, and teaching critical thinking and application skills rather than focusing on memorization. A universal design for learning approach and open pedagogical practices would help faculty support students regardless of their circumstances. These approaches would help faculty design more effective teaching strategies and overcome barriers presented by technology and access issues.

We need to know who leaves higher education during this pandemic, and moving forward who does not show up in higher education. Students in STEM who were already underrepresented due to various systemic barriers are likely to face even greater challenges participating in the near future. Faculty who are teaching in underresourced institutions will find it more difficult to participate in professional development due to lack of funding and time at exactly the moment when education needs to improve to retain more students.

[redacted] moved its traditional in person meeting to an online version. The new model consisted of a two week online experience with workshops introducing resources and practices, sharing projects and ideas in poster sessions, and talks from leaders in the field. Following the two week event, facilitated working groups formed to allow participants to collaborate with peers and push their ideas forward. We had strong application pressure for this event, and continued participation through the fall semester. We will retain this model post-COVID as it provides several benefits, including greater access for faculty with limited professional development funding and year round teaching schedules. The success of this project depended on high levels of staff involvement. As with all programming in education, strong funding is always required to support staffing and participation.

Develop STEM Education Digital Resources (Questions: 9, 10)
Responding as a [redacted], which emphasizes open education resources and engages participants in the OER lifecycle.

The idea of a central educational repository has some value, but previous work in this area (eg the National Science Digital Library) has demonstrated some of the challenges with one stop repositories. In our work with faculty in higher education we have fount that rather than focusing on pulling together all the available materials, supporting the community of users to learn how to use a smaller range of materials and explore how to use pedagogies effectively is more productive than producing collections. This is because teaching is so contextual. Instructors need to have the know how and capacity to modify resources to fit their need.

Increase Diversity, Equity, and Inclusion in STEM (Question 12)

We have found Universal Design for Learning to be a useful framework for implementing inclusive professional development experiences. We also reach out through the community to reach an ever broader audience including community college faculty, persons with disabilities, and the Deaf/Hard of Hearing community. Online community engaging professional development experiences have proven very effective in broadening participation. We have been offering semester long professional development experiences online, with no registration fees, and have had excellent completion rates.

Engage Students Where Disciplines Converge (Questions 13,14)

Biology is an inherently interdisciplinary practice and easily incorporates new practices and ideas from other disciplines. Our work with faculty encourages engaging students with socially relevant topics that include biology, quantitative skills, and data literacy. Practices such as case based learning, problem based learning, and place based learning are all methods that allow combinations of disciplines to come together for student learning and problem solving.

Computational Literacy (Question 20, 22)

Computational literacy is a key component of modern quantitative and data literacy skills. It is unrealistic to think that students would be successful in STEM without experience with all these skills. Incorporating computational literacy in the existing curriculum is largely a matter of presentation and emphasizing computational approaches and concepts within existing curricular activities. Faculty need time and professional development opportunities to reconsider their presentation and hone new computational skills. Several existing projects do this very well including Oceans of Data and Data Carpentries.

Provided By
[redacted]

Questions Addressed in this Response

Future Opportunities in STEM: 1, 2, 3, 4, 5, 6
Develop STEM Education Digital Resources: 9, 10, 11
Increase Diversity, Equity, and Inclusion in STEM: 12
Develop and Enrich Strategic Partnerships: 19

Future Opportunities in STEM

Question 1

The much-touted 'promise' of 'distance learning' failed the nation's students, educators, and families. The limitations of 'pivoting' education—especially from the perspective of STEM education—from a deeply interpersonal, social experience with materials provided by a school to a video call became evident. Worse, many students disconnected from school altogether; in Texas, 12% of students were not 'fully engaged' in learning in spring 2020. When assessed through the lens of adversity or race, the disparities increase: 16% economically disadvantaged students were not 'fully engaged'. 14% of Latino students, and 17% of African-American students, also were not 'fully engaged' in learning during the spring. That is why [redacted] redoubled its efforts to continue to provide meaningful and engaging STEM education programs during this time. Realizing this quagmire, [redacted] leveraged one of its core assets, culture and engagement, as part of its spring pilot of [redacted].

In the spring pilot, [redacted] reached 280 of our [redacted] girls with weekly programs. Our team used that time to experiment, test and refine leading STEM activities and experiences through the virtual plane. Even more so than formal education, [redacted] work is interpersonally intensive. The impact that we have been able to make is in no small part owing to the connections that girls in our programs make with their STEM CREW (college students, and, occasionally, alumnae who lead our programs), and with each other. That sticky factor is not unique to [redacted], but it is one of our core elements, and we rely on that aspect of our work to make learning more personal and meaningful for girls.

Learning, however, to adapt to a new medium for educating and inspiring is not simply a matter of channeling through a screen: it also requires deep thinking about the nature of how to build sticky and meaningful educational interactions despite the screen. By addressing these practical challenges, we worked to find at least one answer to this question: how might we make, not just a step, but a seismic change, in order to continue providing high quality STEM education for girls during a pandemic? How might we overcome the likelihood that children might not experience a single hands-on science activity in the spring, summer, or fall of 2020?

And, in the process of answering this question, we are also asking: how might this new paradigm to see if it might be applied to create new opportunities for [redacted], to potentially respond to overwhelming demand for our programs in places where we may have heretofore thought impossible? [redacted] waitlist exceeds 80 school districts in Texas and 23 states, and the modest scale-up that [redacted] has been able to accomplish has not been able to meet the demand for its work. What if…by learning this, we might be able to create a new program that serves girls regardless of their location?

That was the challenge in spring 2020 as [redacted] began to plan for Summer Camp. Having developed five new camp programs for in-person learning (they will be implemented in summer 2021, if safety permits), [redacted] developed two entirely new camp programs that reached 972 girls across 33 'weeks' of camp in June and July of 2020. Several key elements of these camp programs were necessarily new. One in particular was highlighting the importance of structured socio-emotional learning (SEL) as a way to foster engagement and promote connection, both between the camper and the STEM CREW but also between campers generally. SEL strategies are an important aspect of [redacted] programs, but they have not often been highlighted as a core element of our work. As [redacted] scaled in Houston and North Texas, reaching diverse and high-need girls who were participating in both [redacted] and [redacted], our program team began to recognize that SEL strategies were an important way to encourage focus and engagement in our day-long summer camp programs. We began to incorporate SEL activities at Summer Camp in 2016, and formalized them in 2017. Now, SEL strategies are formalized into our program delivery model, and stretched across both [redacted] and [redacted]. In 2016, we piloted '[redacted]' as a way to understand and empathize with girls' varied challenges at home, but also to establish a soft 'reset' before beginning the say's STEM activities. '[redacted]' also creates an opportunity to set an intention and purpose for the day, and a conceptual space for shared behavior expectations and accountability. The strategy involves a "Weather Check" in which girls can share something that is on their mind, weighing them down, or lifting them up. Next, a day-specific theme is introduced (e.g., 'Be Brave Monday,' 'Tranquil Tuesday,' 'Team Up Wednesday,' 'Got Grit Thursday,' 'Friendly Friday,') in which girls discuss how they are going to employ the theme of the day throughout their day of camp. Then, to close out the '[redacted]' activity, a brief goal setting activity takes place, so that girls can establish an intention for the day. An "I Need

Some Recognition"activity closes out each day, during which girls reflect on the work that they have accomplished, and acknowledge help and support given and received throughout the day. While these activities require no budget, it's a vital investment of time to meet girls where they are. These SEL strategies were folded in to Summer Camp at Home. '[redacted]' became [redacted]', and 'I Need Some Recognition' became 'Moment of Recognition'. Each day, these SEL strategies were employed as a form of routine and structure. Routine and structure, especially in these uncertain times and for at-risk children, are an important mental health support.

Another new program element was the creation of a library of videos that girls could access at any time, in order to supplement their learning. These videos were designed to be standalone, quick 'snacks' to support the synchronous learning opportunities.

Yet another new element was with regard to program materials. It was impossible to make assumptions about what materials might be available to girls, at their homes. We also did not want to increase barriers to participation, or cause additional stress, by asking that parents source materials to be used in the program. That is why [redacted] sourced every single material that would be required in order for girls to meaningfully participate in Summer Camp at Home, and the Camp Box that girls received (either through a 'pickup party' or mailed directly to her home) included those materials organized such that for each activity, a specially marked envelope with the activity's name included each and every item that would be needed for the lesson. A book, called *The Most Magnificent Thing* (about the engineering design process and grit), was also included in the Camp Box. In addition, general office materials to support activities throughout the week (e.g., markers, pencil, and tape), stickers, and a camp t-shirt, were provided.

Because technology is a central part of Summer Camp, the Camp Box also included a technology robotics device called an Ozobot, which was each girl's to keep. Upon registration, we also inquired if a girl had access to a device that could connect to the internet (PC/laptop, tablet, or mobile device), and whether she had access to the internet. Those girls reporting that no device or internet access was available received a device and/or a hotspot. All Camp Boxes also included a journal/book that [redacted] developed and printed expressly for this program. Girls used the journal/book as a pedagogical scaffold on which to go through the series of activities throughout the week. SEL activities such as [redacted] and 'Moment of Recognition' begin and conclude each section of the book. Another journal specific to programming the Ozobot was also included. The journal was designed so that even if a girl was not able to join the daily video calls, she could still participate in Summer Camp at Home.

With this fundamental basis—SEL and STEM supplies and materials—[redacted] was implemented. As we do each year, [redacted] prepares and trains a cadre of pre- and in-service teachers, called the STEM CREW, to lead our programs. This summer's training and support was far more intensive, and called for additional training to ensure that girls would have a meaningful and engaging experience despite the screen. This approach is an important new discovery and continued in Question 5.

Question 2
We believe that both formal and informal, in and out of school learning can be enhanced by our discoveries and innovations. [redacted] addresses OST learning but also supports teacher preparation because the program team that leads our programs in the field are also college-age aspirant teachers.

Question 3
We believe that there are a range of successes, chiefly Zoom, to facilitate remote learning. But it's not effective on its own. [redacted] uses a combination of Zoom, its own websites (password protected to keep girls safe), and evaluation tools such as Padlet, Mentimeter, and Zoom polls to implement effective programs. But those programs would not be possible without our team ensuring that every girl receives a box of ALL materials required to have a successful program. So while there are virtual tools, the analog tools are still vital.

Question 4
Materials. We cannot assume that we know what families have at home. That is why [redacted] team ensured that every girl in Summer Camp at Home and After School at Home receives all materials needed to have success, and connectedness, in our programs.

Question 5
Educators ought to be provided additional supports in order to manage the virtual space. They are asked to do many stretch things with their current skills and capacities. One thing that [redacted] has learned is that for every online program, it requires a lot more people to be able to facilitate the conversation. It is very hard to teach and monitor the chat box simultaneously (so to speak). In our programs--Summer Camp at Home and After School at Home--we have added additional personnel in order to monitor the chat box, quickly address questions, and gauge and drive student engagement. When one is teaching a group of online learners, one ought to look at the camera on one's device, but that is not the same place where students are raising

hands, tuning out, or turning off their cameras. In order to bridge that communication gap, it is vital to have extra people—teacher's aide or student volunteer—who know how to efficiently manage Zoom to support the educator providing the lesson.

Question 6
One of the most important pieces of data to collect ([redacted] is not able to collect this, but we believe it is important to be collected and comprehended) is to understand whether students had access to hands-on STEM activities in spring and fall 2020. Whether owing to the format of distance learning, or over concern about sharing classroom materials, we surmise that many students, particularly elementary age students, will not have participated in ANY hands-on STEM activities in spring, summer, or fall 2020. This lack of engagement could be have an adverse impact on whether students are able to succeed in STEM.

Develop STEM Education Digital Resources
Question 9
To engage the user, we believe that the most effective way to currently reach wide audiences is through social media like video demonstrations of STEM activities that can be done with pedestrian materials at home. It might be meaningful if the STEM activities could also be aligned to particular grade levels for learning, but any material chiefly needs to be presented in an engaging manner. Generally speaking, a student is not going to self-select to go to a website and look up STEM activities for fourth and fifth graders. A website needs to be engaging and inviting for the fourth or fifth grader to want to pursue these activities, and it also should be something that the student can drive on their own. If the student is accessing the website of their own volition, and the parent does not need to be involved, that means that more learning is actually taking place. If materials are merely printed out and provided to a student, that doesn't constitute engaged or any other kind of learning.

The key issue with any type of virtual learning—[redacted] has learned this over the last eight months in particular—is that none of these web-based materials necessarily constitute engagement. Engagement has to be measured in a different way. [redacted] has been using a variety of data tools in order to collect different types of data points that demonstrate knowledge and skills acquisition; we have historically done pre-and post- surveys for our programs, for example. During the pandemic, we have prepared a new suite of evaluation tools. While we do not want the student to experience survey fatigue, but we do want to know is whether students are learning something and if they are engaged in the work in a meaningful way. We have devised a range of strategies as a way to understand whether or not learning is taking place.

Question 10

[redacted] serves girls K-16, with a particular focus on 4th-8th grade. [redacted] mission is to increase girls' interest and engagement in STEM through innovative, nationally recognized informal STEM education programs. We are focused on serving girls of diverse ethnicities—80+% of [redacted] girls are of a nonwhite ethnicity—girls who live in low-income environments—75+% of [redacted] girls receive free or reduced lunch—and/or are considered at-risk.

Question 11

We are interested in seeing resources categorized in the most human-centric way. Organizing by federal agency doesn't make sense. By topic, it makes more sense. Any virtual resources websites need to be organized and curated in a way that is meaningful and engaging for the user. Very few websites are like this; we at [redacted] try to provide, through our STEM at Home website and engaging suite of activities that are really designed to engage the user and that is the sole purpose of the website we want to engage the user in hands-on STEM. The initial approach to the website should be, when you are first encountering it, is a question: Who are you? I'm a student / I'm a teacher / I'm a parent because then that choice will send you down to the correct resources, oriented in a way that is meaningful for the user, in order to find the resource in question. Asking the question from a design perspective about who the user is, is very important and cannot be overlooked.

Increase Diversity, Equity, and Inclusion in STEM

Question 12

[redacted] reaches girls,100% of whom are underserved in STEM. Additionally, 80+% of [redacted] girls are of a nonwhite ethnicity and 60+% are high-need. We work with Title 1 schools and community-based organizations to recruit a richly diverse group of girls to participate in our program.

Develop and Enrich Strategic Partnerships

Question 19

[redacted] is engaged in the Austin area ecosystem, which was part of the first cohort. Other than information sharing, their value is very limited. Change The Equation was a far more effective and important organization. We are glad that its STEMWorks still lives on at WestEd (https://stemworks.wested.org/) and Vital Signs also live on at ECS (https://vitalsigns.ecs.org/).

Category: Future Opportunities in STEM

[redacted]

We are community college STEM educators and we are responding to
Category: Future Opportunities in STEM

Question # 4: What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

1. <u>Student engagement</u>

Social presence in class is very important for learning. Students attend remote class via an online platform such as Zoom, WebEx or Google classroom. However, not all logged students actively participate in the learning community. While this happens in face-to-face classes too, the instructor's inability to see all the students while teaching makes it more challenging with online classes. They can see a few whose cameras are turned on. The others remain incognito. A teacher assesses student engagement by watching for students' facial expressions, body language, participation, and curiosity. Student engagement is used as an assessment tool for learning. Jennifer A Fredricks, author of "Eight Myths of student learning" (1) describes that students need to be engaged on three levels: **emotionally** where they are emotionally attached to their school, their teacher and the subject, **behaviorally** shown by their attentiveness and participation, and **cognitively** as demonstrated by their ability to perform well in the class. In a regular classroom a disengaged or otherwise preoccupied student can be easily identified by the teacher and the student's attention could be quickly brought back to focus. However, in a digital world some students are visible with their cameras on and the others are sitting behind a hidden camera. Because it is easy to focus on a person interacting with the faculty, many times students who do not turn on their cameras are forgotten in an out-of-sight out-of-mind manner. These students' cameras are off partially because they do not want to turn on their cameras, but a great majority do not have a computer with a camera or do not have a private study room. Either they are embarrassed to share their living environments with others or they feel it is an encroachment on their privacy.

Solutions: Regarding student involvement, faculty are now adopting new methods to engage students such as in-class assignments, polling during classes, encouraging students to ask questions privately through chat, participating by raising hands through Zoom, showing a thumbs-up if they have understood, asking students to draw the concept taught to them using a paper and pencil and submitting a cell phone picture of it via blackboard, dividing students into small breakout rooms to discuss a problem and then have them brainstorm it in class, having students write and post the five important points that the instructor said will be on test, and so on. Grades have been shifted to put as much emphasis on participation as on assignments and test grades. Students have been advised to take advantage of the free Chromebooks, iPads, and hotspots loaned by the school. Our college also has online library resources, online tutoring services that can be accessed remotely, and a study room. We are currently assessing the success of our solutions by comparing the number of participating students, analyzing their polls and in-class assignments, assessing retention and, of course, their overall class grades. Class retention and grades will be compared with the same courses taught by the same instructor face-to-face in the previous years.

Gaps: Students who refuse to attend classes are the most difficult to engage. When they do not respond to emails and fail to attend classes, and there is no way to contact them, then there is no way we can reach out and assist them. Even though the college is making every effort to help students, not all of them take advantage of the resources. When they do realize that they can get help from available resources, the burden gets too challenging to make up the missing work. As discussed separately below, students' living conditions, work schedules, and current life conditions play a major role in how much and how well they engage in their courses.

2. Laboratory

Labs are an integral part of science education as hands-on experiments done in a lab can reinforce concepts learnt in lecture. With the recent necessity for teaching from a distance due to the COVID-19 pandemic, undergraduate science faculty have been compelled to teach lecture and laboratory content through remote platforms. It is very difficult to engage and involve students in Zoom sessions even if they are taught synchronously. They lose interest if they just have to watch videos or listen to their instructors talk about the labs (2). Finally, with the continuation of the pandemic, many more semesters can be taught online and there will be an increasing expectation that future online lab courses meet the same standards as in-person labs.

Solutions: A reasonable solution to this problem could be innovative simple investigative labs that can be performed by students safely at home with common household materials and purchased kits from vendors. Alternatives to this are online virtual labs that mimic certain laboratory activities. Such simulations can be purchased from vendors like Labster or obtained from textbook publishers whose book is already used by the school. Such simulations can also be downloaded from the internet at no cost.

Gaps: The major inequity here is that some students have the ability and the intention to purchase lab kits while others do not, even though they are not very expensive. Some students have room at home to perform those experiments while others say they do not have enough space. Simulation software such as Labster is possible only if the college purchases licenses for the students as they are very expensive and unaffordable by students. Some simulations are very limited and not up to expected quality.

3. <u>The lack of a home environment that is conducive to learning</u>

To be effective, online learning requires, at a minimum, a quiet place to work. In a distraction-free setting, students can participate in online lab sessions, engage in group work, and analyze data in a thoughtful way—all of which are essential parts of lab-based science classes. However, many students lack a quiet place to work and study.

Many students live with multiple family members. As a result, it is difficult for students to find a quiet place to concentrate on STEM coursework. This problem is particularly acute for those who have childcare and eldercare responsibilities. Beyond the basic requirements of shopping, cooking, and cleaning, parents of very young children cannot rely on daycare or pre-school and need to watch their children round-the-clock. It is not uncommon for minor children to appear on-screen while a mother or father is attending an online class.

For parents with school-age children, schedules often conflict and there is less access to a family computer or wi-fi. Simply put, it is exceedingly difficult for many STEM students and their minor children to attend Zoom classes at the same time. These parents also have the burden of assisting their children with their own remote learning.

The COVID-19 pandemic has had a disproportionate impact on the health and safety of economically challenged and minority households (3). Many students live in homes where one or more close family members have been directly affected by the virus. And for STEM students who live in multi-generational households, elderly relatives often have additional medical needs. These family obligations have taken an especially harsh toll on female students who were already severely under-represented in the STEM field.

Solutions: Institutions might offer outreach for students in need of assistance (4). Financial aid for child/elder care might be extended to alleviate home care responsibilities. Courses could be restructured to limit the time needed for synchronous participation so that students can arrange their own time schedules for asynchronous work. As mentioned earlier, our institution has implemented safe spaces for students to use for independent study without the fear of contracting the virus.

Gaps: These diverse environments create disparity in a student's ability to succeed in a STEM class. Although resources are offered, many students do not reach out to ask for assistance.

4. <u>Economic hardship and the digital divide</u>

The pandemic has had a devastating impact on our neediest STEM students. Many have lost their jobs and are undergoing tremendous pressure. And for those fortunate to still have jobs, work schedules have been disrupted, making it nearly impossible to attend regularly scheduled classes. Students in the health care and service fields, have been working longer hours under great pressure and they have had to drop classes.

Economic hardship directly impacts many student accesses to technology (5). Computers with sufficient memory and adequate internet service are essential requirements for all STEM courses. A student of limited means, who lacks access to a reliable computer or internet service, is unable to thrive in a digital learning environment. If a basic piece of equipment, such as a camera or microphone, is not working, a financially burdened student cannot get it easily repaired.

This financial pressure on STEM students prevents them from obtaining tutoring assistance. It also prevents talented students from taking advantage of research and other extracurricular opportunities where they can develop basic skills. To succeed in the STEM field students often need to go beyond the basic curriculum. A student who is struggling to pay for necessities or is caring for children or parents cannot conduct independent research or volunteer at a health care facility (6).

Solutions: Students at our institution are able to borrow the technology required for the coursework. Institutional tech support services are also available to students. [redacted] was recently awarded the Conexiónes Title V project grant from the US Department of Education. Plans are currently underway to use this grant to narrow the gaps in inequities among our student population.

Gaps: Economic insecurities during these unstable times arise without warning and put a student at a sudden disadvantage for success in an online class. Technology skills vary with different age groups and at different academic levels.

5. <u>Inequity in test taking</u>

This situation that some students find easier to cheat online creates a pressure and encourages all the other students to cheat as well. Some students have the correct software and the means to purchase subscriptions to test training programs available online. Some of them can even hire a tutor at the time of the test to solve their test questions. A good number of them do not have that option. This causes many problems. First, it raises the class average creating an illusion that topics are mastered, while misleading the professor. The second problem is the professor makes a harder test putting the honest students at a disadvantage. Finally, it creates an idea that cheating is possible and difficult to be detected. This discourages students from participating or engaging in class activities and has the potential to impact their learning. With so many resources available during an online test and no one to proctor, the temptation to take advantage of these resources is difficult to resist. Moreover, peer pressure might also be a contributing factor.

Solution. So far, we have not had an effective solution for this problem. Some tactics that have worked in a limited way are restricting the time available to take the test, changing the wording of questions whose answers are available online, asking critical thinking open-ended questions, decreasing the weight of overall grades on tests and increasing the weight on participation. In smaller classes, another alternative is to assess learning in colloquium or oral exams/quizzes. Frequent individual or group colloquiums could have a positive impact on learning. Some software such as Respondus Lockdown and ProctorU are available to minimize cheating.

Gaps. Many students are aware that finding answers on internet during tests constitutes cheating. However, they believe this is an easy way to get better grades. Academic pressure in this learning environment causes our students to resort to these methods. What they do not realize is that they are putting themselves at a disadvantage for their future. Counseling students to improve their self esteem and confidence might teach them not to follow this practice.

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Notice of Request for Information on STEM Education

The following RFI on STEM Education is submitted on behalf of [redacted], a [redacted] This cumulative submission addresses all sections laid out in the RFI from a multi-sector lens. [redacted] is managed by [redacted]

Future Opportunities in STEM Education

In response to the COVID-19 pandemic, education systems (including preK-12, postsecondary, adult, and informal) were required to make a sudden shift to remote or asynchronous teaching and learning, and this may continue in the near term. Please provide insights to the questions below based on current experiences. For each response below please indicate the education system (preK-12, postsecondary, adult, and informal) that covers your response and whether you are addressing school systems, schools, teachers/faculty/instructors, learners, other, or more than one category.

1. What COVID-19 related digital barriers (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

Access to Broadband

Many schools that make up southeast Minnesota's [redacted] program and much of [redacted] eleven county region are in rural communities with limited resources to strong and consistent broadband. A recommendation from Educaitonsuperhighway.org, suggests that schools and communities should house the recommended bandwidth of 1 MB per student to support 21st century learning. In Minnesota, 46% of schools do not meet that recommendation. Southeast Minnesota is above the state average with 56% of our schools not at the recommended levels of bandwidth per student. The same is a concern for student households. In many cases households typically have multiple students and potentially parents working from home all on the same connection. In addition, nearly all of our communities still have equity

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issues for students who do not have the means to pay for or get to safe locations that offer access to the internet. Access to the infrastructure needed to engage in remote learning during this pandemic is the key linchpin that needs to be addressed before any other major barriers can be addressed.

Schools and communities are working together to find short and long term equitable solutions to get students the internet they need to be connected to school. Some of these potential strategies include buying hot spots for students, paying for internet for students, etc. Other questions arise from potential solutions. Schools are concerned about who would be responsible for filtering content if they purchased internet for the household. Schools are also concerned about the number of people accessing the broadband to make sure it has enough speed.

This challenge is not easy to overcome as it is very costly. Unfortunately if there isn't support from the federal or state government, our local communities' tax base cannot afford to pay for the infrastructure needed to get access to these rural areas.

1:1 Device Usage

The paradigm shift in education increased the push for K-12 schools to move to a 1:1 device to student ratio. While most schools in southeast Minnesota were well on their way to this, the pandemic has pushed our schools to complete this initiative. Now completed, the conversation has shifted from deployment of the devices to long term sustainability plans for these devices and hot spots centered around cost and equitable processes for developing the rotation and systems for replacement. Schools are struggling to stretch budgets that were previously approved by their boards last winter to accommodate for the unforeseen purchases for hardware and software to accommodate hybrid or distance learning models. Our schools are not optimistic of long term sustainable resources for funding to replace devices long term.

Operating Systems Issues

Even if schools, communities, and homes have proper access to the internet, educators, students, and parents are quickly learning that not all devices like Apple iPads and applications like the Google Suite are working in tandem with one another. Almost all schools in southeast Minnesota are using Google Enterprise or the Google suite of applications to facilitate their daily instruction. These barriers are not fully resolved. Unfortunately for schools who are trying to complete their 1:1 initiative are committed to using one kind of device. It would be very costly to switch to a new device for all students. Unfortunately the upgrades that need to be done have to be done by the

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developers of the software platforms. Schools have little control over the outcome of this issue.

Reduce the Number & Consistency of Applications

Student and parent feedback from the first round of distance learning in the spring of 2020 informed schools that the first round of the new paradigm of education was clunky and confusing. Parents quickly requested that school districts refine their strategy of deploying these tools for classroom use. Parents in particular were asking for a consistent use of a single learning management system and applications between grades. In addition, parents were also requesting the use of single sign on platforms. Many schools have opted to use platforms like Clever to accomplish this. Adults and students were struggling to keep login credentials straight. In addition adults felt pressured for time trying to balance work and schooling for these students. Efficiencies that could speed up the process, provide a better user journey, and reduce the stress on adults and youth was top priority for our schools in the fall of 2020.

Application Limitations, Innovations, and Costs

In the previous in-person paradigm of education, many free or low cost applications like Google Hangouts were barely used for educator-student interactions. When the shift in the paradigm transitioned to distance learning we saw software platforms and web based systems were not ready to accommodate large numbers of people at one time. Many applications were built with capped participation allowances (i.e. 16 seats for video conference room) which made it nearly impossible for educators to effectively create community and hold live conversations with multiple students. Some developers of applications addressed this. For example Google Enterprise now allows educators increased participation allowances per video conference room. In addition, some of these applications like Google now have increased security and student engagement analytics that can be shared back to the schools. We are seeing some larger companies innovate their offerings to accommodate the changing paradigm shift in education.

These shifts come at a cost. A cost not originally budgeted for in a school budget. The bigger question still remains, how will schools and communities continue to pay for their overhead and traditional costs and manage the long term sustainability of more technology?

Increased Need for Educator Training

Educators were thrust into a completely new paradigm of education last spring. With little to no time to plan. Many educators who have been teaching for many years did not

[redacted]

possess the skills or have the time needed to be successful in a more digital paradigm. Schools were very intentional in the fall to provide educators additional support and time to learn about the platforms to be used in the classroom. Once educators were able to dedicate time to practice their learnings, the use of technology to teach did get easier.

In addition, many schools are starting to use their Peer Learning Community (PLC) time to do book studies around resources like Douglas B. Fisher, John Hattie, and Nancy Frey's "The Distance Learning Playbook" book. Some of our schools are purchasing these books and related resources for new or all staff to engage in additional learning for highly effective strategies in various learning environments.

Cheating

Many educators and communities are worried about student cheating as much of the information is at their fingertips through the use of a quick Google search. While this problem is still not completely solved, many developers like Google Enterprise will start to incorporate authenticity checks across the internet and students in the fall of 2020. Our schools are starting conversations around different types of assessment that are more project and competency based to try to mitigate this issue.

Applications that Replace Hands On Learning

While our educators are feeling overwhelmed with free resources filling up their email inboxes, they are struggling to find the time to vet which resources are the most beneficial to engage students in hands-on learning through the use of digital platforms. Studies show that hands-on-learning is the best learning to connect the relevancy of the content in the context of the world. Many platforms that offer support to distance learning haven't evolved in this area. The few platforms that do offer this support are costly or require special hardware to utilize, making them hard to use in an equitable and safe way during a pandemic.

Once Free Resources Not Sustainable

Many companies wanted to help K-16 education in the early phases of the pandemic. To this end, many online companies opened up their resources for free. Then companies flooded email inboxes of educators and administration with these free resources. Educators found it hard to sift through the material. In addition educators felt there wasn't enough time in the day to vet all the material. In partnership with [redacted] a free resources library was housed on their website to help sift through the resources and organize them in a way that made the content areas easy to decipher.

[redacted]

A larger looming question still remains with these resources. At some point there will be a cost for them. While they are free now, it is going to be very expensive for schools to use all the resources they have available today. K-12 schools are trying to figure out strategies to determine the best resources available to utilize in the most cost effective way.

Staff Bandwidth Minimal

Many of the great programs, resources, and tools available require a significant amount of bandwidth from educators and potentially community partners to learn and implement. Unfortunately at this time educators and community partner staff time are stretched and do not have the bandwidth to support all the changes. Community partners and local employers who also participate in some of these innovative programs are also finding themselves fatigued trying to stay afloat of all the changes to their organizations or downsizing physically reducing the workforce who potentially would support some of these changes.

Stakeholders: School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (e.g., virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (e.g., pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

Single Sign On

Any resources such as single sign on, automatic updating, and other features that save time and energy are valuable to educators, students, and parents. Respondents from schools surveys have requested that a streamlined approach for applications and web based systems to reduce the number of user names and passwords to remember, create the least complicated way of remote instruction for students and adults who are navigating a new learning system, and provide continuity between grades for efficiency. When this is the case, single sign on options can help support quicker connections for students to do their schooling.

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GoGuardian

K-12 schools are now using GoGuardian, a powerful all-in-one suite to manage 1:1 technology. This tool provides filtering, classroom management, and school mental health tools into a single suite. GoGuardian's suite of tools helps you maximize the learning potential of your 1:1 school technology program.

- Filtering & Monitoring - Filter and monitor any device and any OS with K-12's most powerful content filter.
- Classroom Management - Eliminate distractions and connect with students by using K-12's leading classroom management software. Educators can take over screens, push content to students, and much more.
- Student Mental Health - Proactively identify students at risk of suicide and self-harm, with an option of 24/7 escalation.

[redacted] - Increased Emphasis on Virtual Experiential Learning

Thanks to one time state grant funding and increased emphasis on experiential learning for students, schools in southeast Minnesota were starting to provide experiential learning to deepen students' learning, relationships, and partnerships in the community. The pandemic has halted these conversations making stakeholders involved reevaluate the value of these partnerships and innovate the delivery model and frequency of those experiences. [redacted] is piloting an online platform called [redacted]

[redacted] is a technology platform which brings life to learning and careers to the classroom. [redacted] seeks to connect educators and their students with professionals and companies in their community to enable educators to make their teaching more real and relevant and to allow students to learn about future careers on a direct and personal basis with professionals in the local community.

[redacted] not only connects educators, students and local professionals but also provides a wealth of video and written resources to allow participants to excel in the process of either volunteering or hosting volunteers. These resources ensure that both professionals and educators provide high quality and rewarding pathways for students to participate in real life experiences in the community such as company site visits, informational interviews, projects, mentoring and even internships and employment.

How [redacted] Works

Educators and their schools and professionals and their companies create profiles on [redacted] detailing what career fields, courses, skills they can either provide to

[redacted]

schools or need. Participants, including students, can then search on the platform for company or school experiences that align with their particular interests. Volunteers participate as guest instructors, site visit hosts, teacher externship hosts, internship providers and career information interviewers. Professionals can select from over 200 curated lessons specifically designed for volunteers to deliver in the classroom. They can also create their own lessons, site visit experiences and company pages.

For Educators, [redacted] makes it easy to find community resources such as expert presenters, site visit hosts, mentors, advisors and project providers.

For Companies, [redacted] allows them to access their future talent pipeline, share the benefits of working in their field and make a difference in their local community.

For Professionals, [redacted] makes it easy to impact and positively alter the trajectory of students' lives by sharing their expertise and career experiences.

For students, [redacted] equips them with the skills, experiences and knowledge to explore, learn and connect to future careers by accessing local companies and professionals directly.

Finally, [redacted] provides detailed feedback and evaluation mechanisms from educators, professionals, and students to allow companies and their volunteers to measure the impact of the time they spend volunteering with schools and their students. Companies see Net Promoter Score and Likert scale data on change in interest in working for their company and the value gained from the experiences as well as written feedback. Students also receive feedback from professionals in the community on their informational interviews, job shadows and work experiences to allow them to build a personal portfolio to show their personal and career focused growth.

What Does [redacted] Seek to Achieve?

[redacted]'s mission is three-fold:

- To make it easy and quick for a teacher to find high quality community-based learning experiences for their students which makes learning more real, relevant and exciting.
- To empower volunteers to play their part in building our future workforce and their future pipeline by sharing their expertise with students in a guided and pedagogically effective manner.

[redacted]

- To enable students to learn about future potential careers and the link between their academic learning and the workplace and thus become a part of a strong talent pipeline for local companies.

[redacted] *Features*

On [redacted], Educators can:

- Create a personal profile to share with volunteers
- Review over 200+ guest instructor lesson plans available, seeing a lesson summary, learning outcomes and educational standards addressed by each lesson
- Select into their library lessons which they would like guest instructors to teach in their classroom
- Search by individual's name, company and keyword to find guest events related to specific academic topics that they teach or which activities such as a site visit, that they are willing to participate in
- Sign up their students for site visits, informational interviews, mini internships and apprenticeships with companies
- Access extensive help resources, both video and written, that will help them successfully utilize community resources in their teaching
- View company profiles to learn about available opportunities for their students' careers, what businesses that company is in and see videos and other materials on that company
- See the profiles of guest instructors able to teach specific lessons
- Use the platform's inmail system to connect with, invite to class and chat with volunteer professionals
- Create their own lessons for guest instructors to teach
- Suggest a topic they would like a guest instructor to come in for
- Access instructional videos and materials on how to use volunteer professionals most effectively in their teaching.
- Give feedback to professionals who have volunteered in their classrooms

On [redacted]*, community volunteers can:*

- Create a personal profile to share with other volunteers and educators which also states the differing roles they wish to volunteer in
- Search for and Select schools they are willing to volunteer at
- Create a profile for their company where teachers and students can learn more about career opportunities and the nature of the work at that company as well as see other company employee profiles and how they wish to volunteer
- Access extensive help resources, both video and written, that will help them succeed as guest instructors, site visit hosts project providers and mentors

[redacted]

- Review over 200+ guest instructor lesson plans available, seeing a lesson summary, learning outcomes and educational standards addressed by each lesson
- Select into their library lessons which they would like to guest instruct on and create their own personalized lesson plan on the general lesson
- Search for teachers and schools by individual's name, company and keyword to find schools where they can volunteer at
- See the profiles of other guest instructors able to teach specific lessons
- Use the platform's inmail system to connect with educators teaching in academic fields related to their profession
- Create their own lessons for those in their field of expertise to teach, upload related documents and share them with the [redacted] community
- Create experiences for teachers and students at their place of work such as site visits, career fairs and informational interviews
- Suggest a topic they would like to guest instruct on
- Receive feedback on their volunteering from both educators and students

On [redacted], students can:

- Access an extensive library of videos across all 16 federal career clusters that allow them to learn about potential future careers
- Access a variety of videos to help them excel in their career exploration efforts in their local communities
- Search for and find vetted professionals and companies that they can meet with to learn about potential future career paths and develop work place skills
- Sign upon for career-based experiences at local companies such as site visits, job shadows, informational interviews (both virtual and face to face)
- Receive feedback from local companies on their informational interviews and job shadows.
- Provide feedback to local companies, educators and professionals on their career exploration experiences.

[redacted]s Response to the COVID-19 challenge

The [redacted] platform continues to enhance connection between local companies and schools at a time when face to face interaction has not been possible. FutureForward™ has added the capacity for companies to create virtual site visits and virtual informational meetings where educators and students can use video conferencing technology to connect with professionals within career fields of interest to them. [redacted] has also added features for professionals and companies to add videos to their profiles describing their work and skills which students and educators can view to learn about specific career fields and professions. Students and educators can

[redacted]

search the extensive video database by career cluster, interests and, for educators, school course relevance. These advances have enabled the [redacted] platform to continue to fulfil its missions of connecting classrooms to the community at a time when face to face communication has been severely curtailed.

International Carpenters Union Curriculum

International Carpenters Union's Nick Willie has taken their courses **and resources** (woods, welding, construction) and put their curriculum in an online environment. This program offers the course and credential for students interested in pursuing a credential in carpentry.

Unfortunately schools run into barriers to supply students in a hybrid or distance learning environment with the tools needed to complete the projects. Schools are working with local companies to find short term partnership options to provide these to students as swag. The success of this relies on our employers remaining solvent through the pandemic in order to provide such resources and must be revaluated each semester for their continued involvement. This poses an equity issue in our smaller rural communities who might not have a large employer to help with these programs. Also a layer of sanitation comes into the conversation as we talk through the processes for getting physical tools out to youth.

Stakeholders: School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

Increased & Dedicated Funding for Broadband & Devices

Schools are spending unbudgeted money and are deficit spending to make a much needed transition in education based on a combination of national, state, and local mandates and suggestions. These changes have led to increased costs in technology, staffing, and transportation. While our schools and communities are excited about the innovation and the professional growth of our educators, staff, parents, and students, the sustainability factor is unknown. It was very expensive to get the remaining districts of our region to get to a 1:1 device to student ratio. The devices won't last forever and at some point will need to be replaced. The instruction doesn't happen without building the infrastructure (broadband, technology, etc.). Traditional budgets for educator

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professional development are not sufficient to cover every educator in a school district to receive the proper training in the new tools or upgrades to these tools that they are being asked to use.

Funding & Incentives for Software Developers to Create Tools with Interoperable Learning Records, Single Sign On & Precision Learning Systems

Our schools are starting to request interoperable learning systems today more tahn ever with the increased use of applications and software tools. Technology Directors have urged software developers to embed these in their tools because staff does not have time to update all the systems each day when there are changes that need to be made. It would be much more efficient for their limited time to have the network of software platforms speak to one another and automatically update with student records, student changes, educator changes, etc. Applications and software that require manual updating are less of a priority for schools, even if the content is good, because there is a barrier concerning staff time that can be dedicated to making the updates.

To that same notion, requests from parents and students for a single sign on is increasing in significance. Many applications allow for single sign on, however not all do. As the number of different applications and software platforms grow in usage it will be important more than ever to create an easy way for parents, guardians, and youth to quickly access content for learning. We live in a world of usernames and passwords, if a parent or guardian cannot log in that could mean that a young student would not be given the opportunity to engage in class that day. Allowing the use of one username and password provide efficiency for busy parents and students and allows for easier management and likely increased participation in school.

Incentives for more companies to incorporate precision learning systems that would help to better support the individualized needs of the students in areas where they need the most support while freeing up time for our educators. Our schools aren't even aware of all of the programs and software available in this category, nor do most educators know these terms.

Dedicated Funding for Virtual Online Learning Platforms & Cooperative Positions

Minnesota service cooperatives have received a one time funding stream of $1.5 million over two years to enable the Future Ready CTE grant funds from the state of Minnesota. The funds were designed to provide equitable support to rural school districts to support career connected learning to prepare students to be engaged community members in the future workforce. These funds were able to help deploy new innovative positions called Career Navigators to support collaboration amongst multiple school districts through a cooperative position where the employee is shared between districts with the

[redacted]

employer of record as the service cooperative. Career Navigator helps to locate grants to support career exploration and STEM skill set development, develop career pathways, address the teacher shortage and provide support to educators seeking to get credentialed in CTE or work-based learning, and develop strategic partnerships with community partners in post-secondary and industry to accomplish career connected learning. In just over a year, six staff have efficiently helped support over twenty six school districts obtaining thousands of dollars in grants, created healthcare pathways in Certified Nursing Assistant which is vital to our local economy, and engaged over 220 professionals in the eleven counties to engage in hands on and virtual learning opportunities for our students.The Career Navigators are now taking their work to new levels strategizing the best way to obtain parent engagement in these conversations. This funding is in jeopardy of not continuing into the future.

The Federal Government could help to financially support innovative approaches to education that emphasize collaboration, efficiency, and online resources to aid schools and educational service agencies in the new education paradigm. Our schools and educational service agencies have had very positive experiences with local employers, resources, and community partners to support the new delivery of education. Specific funding to help support software development, license fees, and operational costs for staff to connect siloed systems is needed. .

In addition, the Federal Government could work with the technology companies and providers of these resources and training opportunities to negotiate education rates and/or provide tax write offs for these companies to keep cost effective for schools. Education is being asked to do a lot right now. If companies want schools to produce students to be ready for their work environments upon graduation, they could be incentivized to support schools for the greater good rather than viewing schools as a revenue stream.

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

Access to Bandwidth

See question one.

[redacted]

Bandwidth of Educators

Education is being forced to be nimble. Many times our educators are teaching through multi-modal delivery models. The bandwidth it takes for our educators to teach two different pods of students (one in person and one distance learning) makes it more time consuming and thus harder to individualize learning for each student.

Mental Health

In addition to systems changes, southeast Minnesota communities learned that mental health goes hand in hand with the changing delivery model of education. Last spring, mental health hotlines opened up for education and community partners to cope with youth dealing with isolation, unsafe home environments, etc. Due to mental health issues of others in our students' homes, these hotlines also transitioned to accommodate and encourage youth to reach out in discrete ways. The new smart phone application was created in addition to a traditional phone line to accommodate booking appointments or reaching out to mental health experts for those who had safety issues at home.The pandemic shined a light on equity and safety issues for our students where their home may not be conducive to education, students are taking care of other siblings, mental health issues of the adults in the home impact the health and safety of our students, and poverty. Educators have always viewed the delivery model of education to include the whole child, but are paying attention to it even more as we enter this new paradigm of education.

Role of Standards in Education

Education is still struggling how to incorporate the standards into the new delivery of education in an engaging and hands on way.

Hands on Activities Lost

With limited experience teaching through a digital platform, many educators are struggling to incorporate hands on STEM learning with their students. Educators are trying to balance realistic expectations around materials that students and their families would need to supply themselves with the resources they have available. Logistics models and sanitation issues cause problems for materials that would usually be used in the classroom and shared amongst multiple classrooms. Many of these piece of equipment are costly and not realistic to share through a lending library service to students. Lending libraries and mobile labs, once a staple in the past, are also being rethought for a delivery model that can be accommodated under the new guidance and sanitation instructions to prevent the spread of covid-19.

[redacted]

Childcare Cost Support

Parents and guardians are still working or working from home. Many students are providing childcare for their families because their family cannot afford childcare. Many students are being forced to make a choice to watch their siblings or attend school. Many times older students are also serving as educators to their siblings in their own homes for online learning. The balance that schools have kept between synchronous and asynchronous learning is an equity conversation for students who have to help their sibling complete their work. This is putting a lot of extra pressure on students. This coupled with the fact that we have a shortage of childcare workers creates a unique opportunity. Can the Federal Government help make childcare careers a more stable base of income for people who want to go into it?

Stakeholders: School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

5. What areas of professional learning would be most beneficial to educators providing remote instruction (e.g., utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

Making Assessment Non-Googleable

Curriculum Directors are having conversations centered around making assessments non-Googleable. Google Enterprise has the authenticity feature now, but we are still struggling with the concept of making assessments and learning meaningful with an exciting experience. Our educators are now thinking in the context of moving away from the literal and having kids apply their learning to their life.

While our educators recognize the importance of relevant hands on learning, our communities and school districts need training on best practices for deploying a new variety of assessments that give students choice and how they assess that mastery. Another conversation being posted is how our education system for STEM can incorporate grading for learning and what are the different ways that students can demonstrate mastery putting a focus on kids using their interests and passions to demonstrate what has been taught. All of this is a major mind shift for the educational paradigm.

[redacted]

How to Virtually Teach to the Standards & Help Youth Apply Learning to Community

When the pandemic first hit, many school districts didn't have much time to plan. Thus much of the delivery of education was through physical worksheets or digitized worksheets. While it is one form of delivering education, it may not be the best way. Our school and educators are now thinking through how the standards can be taught in a more engaging way so that youth can see how the learning applies to their life within their home or community. Add to this that our schools were making huge strides in the classroom for approaches to target personalized learning and now to rethink this in a digital space.

How to Simultaneously Teaching Virtually and In-Person

With many schools in a hybrid learning model, many of our teachers are having to teach curriculum in two different modes with three different plans. The first two modes are in person and online. Teachers in addition have to plan for three environmental scenarios and execute strategies to support students in all three settings (distance, hybrid, and in person). While many schools started out in person, teachers had to prepare curriculum for distance learning situations for students who had to quartneen. For schools who were in a hybrid situation, teachers had to plan to teach two groups of students at 50% capacity on certain days in person while teaching online for the other 50% of students essentially doubling the amount of work per week for classroom educators. In this situation educators also had to plan for a 100% completel remote option for students who would have to quarantine essentially delivering three different modes of education. Teachers are exhausted and historically not used to the amount of work it is taking while the learning curve is still taking place. The more time that is spent on preparing for the different modes of teaching is cutting into their time to research and plan for hands on experiential learning. Until we help our school systems deliver efficient education for their staff, curriculum and pre-work for delivery will suffer due to human capacity.

Direction on Best Practice in Instructional Expectations, Delivery, and Staff Support

Requests from our school systems and educators relate to best practices for instructional expectations with technology and equity. In particular additional support is needed in the following areas:

- The proper balance of synchronous and asynchronous delivery of education.
- Timing and content strategy for independent, group, and 1:1 student support.
- Frequency recommendations virtual meeting frequency for students.
- Best learning management systems, interconnected learning management systems and precision learning systems to use.
- Relieving staff stress and fatigue.
- School administration training on how to set staff expectations for the year.

[redacted]

Stakeholders: School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

Community Bandwidth Rates

Remote internet access is a barrier. Nationally we have to better understand what areas of the country need improved infrastructure. Without it, and quickly, our students in rural communities without access to an equitable internet cannot even participate in school as it requires the internet to view assignments, instructions, tests, videos, websites, and virtual chats. Especially with flu season quickly approaching. Our schools are currently experiencing attendance issues. In order to diagnose the cause of these, our students should be given the equal rights to have the same opportunity to receive an education regardless of location or wealth as other students. Once we can address getting all students equitable access to the right speed of internet bandwidth, our schools can then start to work through subsequent barriers that might exist. (See question one for more information on southeast Minnesota statistics.)

Hard to Measure Impact

Because this new paradigm in education is so new, our communities are having a hard time establishing an adequate baseline. The newness of the pandemic hasn't provided our communities the opportunity to know all the problems of a new delivery model of STEM education or validate which solutions are providing the most positive or negative consequences to the system and people in it.

Stakeholders: School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

[redacted]

7. What experience does your school system have with interoperable learning records or precision learning systems? If used, please share any barriers, solutions, or other information relevant to their effectiveness particularly related to digital barriers and the impact or effectiveness related to distance education. How were these concepts used or modified in response to COVID?

   Southeast Minnesota has little experience with interoperable learning records or precision learning systems. In fact, when asked, many K-12 education staff had not heard of these terms before. There poses an opportunity for education around common language, technology awareness, and extra support for training in this space.

   ### Interoperable Learning Records

   Having a record that documents achievements and captures competencies aligned with employers needs benefits students who are not considering the traditional four year college path. Due to the pandemic, more students are opting out of this path for online programs, two year degree options, or moving straight into their career. Continuing education, competency-based education, and career and technical education programs provide a broad range of educational experiences—many happening on a not-for-credit basis—that are difficult to document on a traditional transcript.

   Many schools can see the benefits to using such technology and wouldn't be surprised to see an uptick in it's usage in the near future due to their shift in a digital learning environment. For example, many of these digital platforms already have badging and credentialing built into them. Many students are currently forgoing formal college education until the pandemic passes. Many students will choose to pay for expensive programs just to do it online from home, and will be looking for ways to show which skills/training/competencies they have in the job market.

   The biggest barrier of ILR is the open standards. It does not do students or employers any good if there are multiple different ILR systems, schools need to choose one to use., and when an alumnus goes out to use it, the organization they are trying to present it to only accepts an ILR wallet from a different system.

   One example that is being used in a local school district is Master Transcript Online (MTC). The traditional transcript reinforces outdated modes of education, constrains innovation, limits learning to single subjects, and impedes the pursuit of educational equity and excellence. It sorts and sifts students through a narrow measures such as grades GPAs, reducing each complex and unique individual to a simple number. The MTC Mastery Transcript® is a dramatic alternative to the status quo. It supports each student in learning for today's world, in exploring and pursuing varied pathways to

[redacted]

futures that compel them, and in being recognized for acquiring and mastering skills both inside and outside of school. The MTC theory of action draws upon three critical levers for change:

- Build a Mastery Transcript® that authentically and holistically captures student learning, progress, and interests.
- Create a networked innovation space where High Schools can use the Mastery Transcript to catalyze and support redesign..
- Engage Higher Education institutions who will adopt the Mastery Transcript as a catalyst for rethinking admissions and mobilize their peers to do the same.

Precision Learning Systems

Southeast Minnesota's post-secondary partners and higher education partners are much more versed in Precision Learning Systems than K-12 due to current credentials using similar tools to test out for nursing and education degrees. Education in the K-12 space has seen resources come through the classroom, but they are often very expensive. With the pandemic putting added stress on time for teachers, they are hesitant to start new things. However, many could be open to the idea if it would help to individualize learning and make it more efficient for them to better understand and be connected to their students. Being remote makes it hard to get to know and connect with the students.

Stakeholders: School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

8. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

Partnered with our local internet providers to work on short term and potential long term solutions to get equitable internet access to students. While this was great and helped to develop strong partnerships in communities, it is not necessarily systinable. Unfortunately, that still remains an issue due to spotty coverage. The region needs increased internet bandwidth and coverage.

Hands on activities in the Ag and industrial tech suffered. We have gone to asynchronous opportunities in some of these areas where students can have hands on opportunities.

School systems;Schools;Teachers/faculty/instructors

[redacted]

Status: Not complete

Develop STEM Education Digital Resources

The Federal Government is seeking information on web-based STEM educational resources and opportunities for preK-12 teachers, post-secondary faculty, educational institutions, informal educators, parents, and students.

9. What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

Our educators are really struggling to find interactive and engaging ways to teach their students. Educators would like to see more gamified learning sources available that meet the Minnesota standards. A current list of free resources is available at [redacted]

[redacted] (also mentioned in question two) is the regional tool that is being used to connect professionals with educators and students for career connected experiential learning.

Learning management systems used in southeast Minnesota include SeeSaw, Schoology, and Google Enterprise to house curriculum.

Other schools are using Build Your Own Curriculum to house and sequence curriculum. This software also allows for open source sharing between school districts across the United State who have opted into this feature.

ExploreLearning® is a Charlottesville, VA based company that develops online solutions to improve student learning in math and science. This website offers over 400 Gizmos aligned to your math and science curriculum in grades 3-12.

School systems;Schools;Teachers/faculty/instructors

Status: Not complete

[redacted]

10. Please describe your primary audience (e.g., I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.

    School systems;Schools;Teachers/faculty/instructors

    Status: Not complete

11. How would you like to see resources categorized (e.g., subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.

    Resources should be categorized either by primary, upper elementary, middle school, and high school then topic or by topic then grade level.

    School systems;Schools;Teachers/faculty/instructors;Learners

    Status: Not complete

Increase Diversity, Equity, and Inclusion in STEM

STEM education practices and policies at all levels should embody the values of inclusion and equity. All Americans deserve access to high-quality STEM education, regardless of geography, race, gender, ethnicity, socioeconomic status, veteran status, parental education attainment, disability status, learning challenges, and other social identities. For each response below, please indicate the education system or career experience for which you are responding.

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

    Our schools work through our counselor, teachers, and administrators to help recruit and retain underrepresented and underserved youth in STEM education.

    Schools also partner with STEM ecosystems like [redacted] to increase their networks of peers to idea share for recruitment and retention strategies. [redacted] supports STEM excellence in K-12 schools through workforce development and

[redacted]

professional development support. Net promoter scores are collected at professional development events to gauge the value of the peer to peer ideas sharing and learning.

In addition 26 schools in southeast Minnesota are partnering with [redacted] to hire cooperative positions, called Career Navigators, to work one on one with individual educators to determine how to increase underrepresented student populations in experiential and career connected learning in STEM. Some of these populations include students with behavior disabilities, girls in CTE classrooms, and alternative learning students. The Career Navigators also partner with community partners like the workforce centers to help support individual youth who qualify for work Success comes in the form of grants, new initiatives launched, the addition of new community partners incorporated in the work, the number of relationships developed and uploaded in [redacted], the number of students, educator, and employer engagement in [redacted].

Schools also partner with Project FINE. Empowering Youth programs help youth from refugee and immigrant families develop the skills needed to prosper and realize their full potential. Youth from refugee and immigrant families face different challenges than their parents. They often acquire language skills more quickly, but also face the challenge of being immersed in American culture and have to find a balance between their traditional culture and that of their peers. As a result of this programming, youth gain knowledge of the educational system and receive support to help them pursue their goals.

Schools and community partners work collaboratively with employers like Mayo Clinic on Project Search connecting and preparing ring young people with significant disabilities for success in competitive integrated employment in the healthcare sector. If successful, students are employed at the end of this project.

2015-2018 Project SEARCH Outcome Summary:

	2014-15	2015-16	2016-17	2017-18
# Enrolled	2370	2876	3232	3733
# Completed	2205	2643	3026	3511
% Completed	92.7%	92%	93.6%	94%
# Employed	1697	2016	2420	2357
% Employed (All Jobs)	N/A	N/A	80%	77.3%
% Employed (Meet PS Criteria)	75.5%	75.5%	70.2%	67.1%

*Based on outcome reporting by 93% to 98% of Project SEARCH program sites.

Integrated Science Education Outreach (InSciEd Out) is a collaborative partnership committed to rebuilding pre-K through 12 science education for Pre-K—12 students, and providing opportunities for in-service teachers to grow themselves as scientists, engineers, and educators. Our mission is to engage students and empower teachers through research-based experiential learning rooted in real science and connected to the local communities to close the achievement gap.

[redacted]

One thing that southeast Minnesota made very clear, communities have to continue supporting the whole child during the pandemic. If basic needs of our students and their families are not being met (.e. access to food and shelter) they will not engage with school as their priorities for basic survival will be at the forefront of their minds. It is very important that support is given to our schools to continue to provide meal options for students beyond January 1, 2021 to ensure that these basic needs of youth are being met.

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

Engage Students Where Disciplines Converge

Real world STEM problems require students to ask and answer questions across traditional disciplinary boundaries. This type of transdisciplinary learning, or convergence, is encouraged to produce STEM-literate talent capable of integrating knowledge to produce innovative solutions. Toward this objective, the Federal STEM Education Strategic Plan aims to (1) enable STEM educators through upskilling, resourcing, and providing a forum to share best practices; (2) support the dissemination of transdisciplinary education best practices and programs, and (3) expand support for STEM learners to study transdisciplinary problems.

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

School administration encourages trans disciplinary learning during PLC planning and when developing learning goals.

Schools are working on ways to integrate local employers and multiple classes together to provide authentic lessons for classes in CTE. Some schools are even starting to incorporate student run businesses as classes in CTE classrooms like manufacturing that generate actual revenue generating products for the community.

School systems;Schools;Teachers/faculty/instructors

Status: Not complete

14. How has your ability to teach transdisciplinary concepts to your students changed in recent months because of the shift to remote teaching and learning? What teaching modalities have you employed to deliver transdisciplinary instruction virtually?

    Southeast Minnesota schools state that it has been very hard to offer transdisciplinary learning while shifting to remote teaching and learning. While the transition has increased collaboration of the teachers this year, it completely halted hands on experiential learning opportunities with our local employers. While it has been challenging, community partners like our Perkins coordinators, economic development agencies, chambers of commerces, workforce centers and educational service cooperatives have been very supportive to help employers connect virtually to our staff and students.

    School systems;Schools;Teachers/faculty/instructors;Learners

    Status: Not complete

15. What training have you/your organization received in any of these approaches for teaching STEM education: transdisciplinary, integrated, convergence, or engineering design, etc.? Please describe the training, if any (including university coursework or professional development), that helped you/your organization prepare to teach STEM using an integrated or transdisciplinary approach. Why was that specific training helpful, and if not, what could be done differently?

    Fall Educator Forum

    On November 4, 2020 [redacted] will be hosting the [redacted] where local educators, community partners, and post-secondary incisions will come together to share pedagogy support, age appropriate resources and tools for educators to use in the delivery of remove learning, and foster conversations around these topic if equity with Minnesota STEM ecosystem. This event that typically takes place twice a year is one of the most beneficial and efficient training that allows area educators a space to network with colleagues across the state, share ideas and best practices, learn new activities, resources, and skills they can implement in the virtual or in-person classroom the very next day.

[redacted]

Distance Learning Course

[redacted] is currently offering a free [redacted] to support school leaders and teachers. The course offers equitable models for distance learning at the district or school level, as well as best practice instructional resources for teachers. Also included are planning guides, and the latest guidance and planning resources from MDE, MREA, CASEL, and others. Resources will continue to be added as more guidance and resources are made available. This training also includes training on tools that can be used to provide relevant and engaging learning for students.

Design Thinking

In 2017, IBM offered design thinking training to education members of [redacted] on an engineering design process that helps organizations to empathize and follow a process that can help school districts and community design effective and value based education. This training was very helpful when a real world situation was used as the example for the group to focus on.

Educators acknowledge that more professional development is needed, but there is just a lack of time and capacity for educators. In addition our schools budgets stretched with schools around the nation deficit spending this year to accommodate for all the changes to staffing, transportation, and technology.

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way? What specific delivery mechanism works well for you (e.g., online course, webinar, in-person workshop)? What technology tools would be helpful for you when using a transdisciplinary approach?

Educators are requesting live webinars that can be recorded during covid. If educators can join in person, it is more engaging. However educators are stretched so thin right now the training needs to be delivered through an on demand system as well. This can most easily be accommodated through recording live sessions and posting them publicly. When the pandemic ends or a vaccine is available, our educators are requesting to go back to in person training as they are much more engaging.

[redacted]

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

17. If you are a student, what specific delivery mechanism works well for you (e.g., online course, webinar, in-person workshop)? What technology tools would be helpful for you to enhance your learning and engagement to deliver transdisciplinary education to your students?

    School systems;Schools;Teachers/faculty/instructors;Learners

    Status: Not complete

Develop and Enrich Strategic Partnerships

The Federal Government seeks perspectives to build STEM learning ecosystems through cross-sector strategic partnerships that promote work-based learning programs aimed at reskilling and upskilling. For the following questions, a STEM education partnership is a group of multi-sector partners united by a common vision of creating accessible, inclusive STEM learning opportunities that increase STEM literacy, expose learners to multiple STEM career pathways, and prepare Americans for jobs of the future.

18. What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

    Employers need to understand expectations and their responsibilities for their organization and the others involved. Employers have previously been hesitant because they weren't sure what they are liable or responsible for.

    Employers and colleges also find paperwork for such opportunities in the K-12 setting to be complex. Through the partnership and collaborative work completed with our local two year colleges, we learned the post-secondary model of education allows for one state contract that simplifies their paperwork to participate. The federal government can

[redacted]

help reduce the processes and hoops our K-12 education partners need completed in order to participate in such programs and allow such great opportunities to students.

Other barriers are industry specific that center around a person's age to be allowed to do the work. Examples of this include allowing those who are 18 years or older to be on the floor at a manufacturing facility. Many high schools students are interested in the trades, computer science, and manufacturing sector. However employers will not hire or take on students for experiential learning under the age of 18. In addition, typically students start career exploration and experiential learning as young as seventh grade with career planning taking place in tenth or eleventh grade. This presents a huge barrier to catch kids when they are in their career exploration classes making decisions about their future if they haven’t had a chance to be exposed to work in these fields. Many students do not turn 18 until their senior year of high school which limits the window of experiential learning and making plans for continued education or applying for a job in one of these careers less likely due to the timing. The federal government can help reduce age barriers for career exploration and employment

Due to the pandemic, schools have limited the amounts of in person experiential learning that students can participate in. Most schools are still offering work based learning for credit, but have slowed or stopped internships, job shadows, site visits and tours, and allowing guest instructors into the classroom.

Underrepresented populations of students like special education and students enrolled in alternative learning settings really rely on work based learning programs to engage their students. If schools don’t embrace new models of virtual experiential learning and STEM ecosystems don’t engage with meaningful and fun experiences students will tune out. Southeast Minnesota’s STEM ecosystem is excited about the pilot and potential of Future*Forward*™ to keep momentum in this area and soft launch our local employers into more engagement with their educational communities.

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

[redacted]

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

Success Factors: Engaged Community & Thought Leaders

[redacted] is the largest STEM learning ecosystem in southeast Minnesota. Twice a year this learning system hosts Educator Forums where educators and industry professionals come together to share best practices, innovations, and facilitate discussions to enhance STEM learning for our ecosystem members. [redacted] has transitioned our forums to move to a virtual format to accommodate for the Covid-19 pandemic. Also the cost for putting on these events virtually has lessened, so the event costs have been reduced to try to allow more people to attend.

[redacted] believes that industry is instrumental in the STEM learning ecosystem conversation as they can communicate to K-12 and postsecondary the needs of employers and the knowledge, skills, and competencies graduates need to have in order to be successful for career and college. Due to the stress on our educators, the [redacted] ecosystem has leaned on our employer and community partners to focus on work that lessens burdens and provides direct support for educators during this challenging time. Also working collaboratively with these partners to share and pool resources to engage in outside the box thinking also helps to provide innovative solutions to our STEM ecosystems.

Success Factors: Equity & Inclusion | Self Identification in Science for Elementary Students

Changing the way we help students self identify and associate themselves in and with STEM education at early ages is where we try to focus on systems change. In elementary classrooms, our schools are starting to see a shift with pretest results given to early elementary school students. When asked to draw what a scientist looks like students initially draw a stereotypical older man with crazy hair and glasses. After watching videos and doing activities that focus on gender, race, and other factors, students start to transition their scientists to looking more like themselves.

Success Factors: Engagement in Digital Learning Resources Supported by Industries that Fuel Local Economy

[redacted] helps to connect students to career videos, professionals, and experiences that deepen the learning for career exploration, soft skill development, specific to their interest and local economy. Through the use of informational interviews,

[redacted]

site visits, and recruiting videos students are able to learn, even in remote situations, information regarding specific careers, the employers in the region that offer these careers, and specific people from business and industry they can reach out to. In addition to individual employers, post-secondary partners and other hubs that house specific career videos are housed in [redacted]. Content from the Minnesota State Center of Excellence, Khan Academy, and local employers are included. These opportunities give access to professionals in industry who are readily available to support the learning in our community.

Biggest challenge in this space now is how to engage students in the same level of engagement for lessons and activities that were previously taught well in person. Our schools do not have the systems or equipment to lend to students to do them at home. You can't give them the equipment to do it from home, so how do you do it from home?

Success Factors: Innovative Cooperative Shared Positions to Accomplish Regional Goals

Through needs analysis and years of conversations, collaboratives like [redacted] learned about best practices centered around cooperative shared positions who are employed by and support collaborative work identified by community stakeholders to better connect the future workforce in pipeline development opportunities, called Career Navigators.

This position performs professional work developing career-connected learning opportunities for a consortium of small rural school districts. This includes supporting educators and students to identify career opportunities in industries that provide promise for future job demand, sustainable wages, and potential for industry-recognized credentials that align to their interests and passions of students including, but not limited to, career clusters like STEM and CTE. Career-connected learning includes experiences that engage employers from multiple sectors and raise student awareness (such as career fairs and classroom presentations), work-based learning opportunities (such as site visits and job shadowing), and career pathway development (including dual credit options, and internships/apprenticeships).

This position seeks an innovative, visionary, collaborative, and creative thinker that is a self-starter with strong initiative and influencing skills. This position will be an important contributor to providing leadership and support to teachers, administrators, industry partners, and colleges in developing and maintaining experiential and/or work-based learning and career pathway programs, experiences, and exploration.

[redacted]

[redacted] hosts and supervises this position, and work is performed under the guidance of the schools within the region. These positions will also collaborate with other partners at local chambers of commerce, economic development agencies (CEDA and RAEDI), federal Perkins consortia (Riverland, Rochester/ZED, South Central, and Southeast).

Major Duties and Responsibilities:

- Program Development & Coordination: Maintain and grow best practice knowledge of career-connected learning and pathway development. Promote the career-connected learning and pathway opportunities within the district, consortium, and local communities. Develop or enhance existing career exploration curriculum, including integrating concepts into elementary and middle schools. Liaison with Southeast Perkins Consortium leaders to maximize resources and align work, including support for job-alike networks for CTE teachers. Identify authentic work-based learning experiences both within the classroom and in the community. Explore innovative inter-district collaborative opportunities, identify potential barriers, facilitate problem-solving, and recommend potential internal systemic changes to support fresh, innovative ideas.
- Relationship & Partnership Development: Establish and maintain effective working relationships and partnerships with multiple stakeholders including administration, teachers, learning teams, counselors, workforce development experts, and employers. As needed to support partners (e.g. Workforce Development, Inc. Employer Outreach Specialists), serve as a liaison to industry representatives to develop and promote partnership opportunities in career-connected learning experiences and pathways. Work with administrators and department leaders to develop concurrent enrollment agreements with community colleges and other institutions of higher learning. Represent schools/districts in interactions with parents, community, staff, and students. Grow and manage regional portal that connects education and industry.
- Event Planning: Work in cooperation with colleges and school administrators in planning events for college and career readiness, such as student/parent information nights and job fairs.
- Regional Networking: Participate in regional Career-Connected Learning Network at [redacted]. Provide regional information on the labor market and in demand careers of the region. Provide regional support for educators and employers to connect them with available resources for professional development/training on work-based learning.
- Continuous Improvement: Develop and maintain metrics to measure success and growth. Collaborate on the development of recruitment and marketing collateral.

[redacted]

Success Factors: Advisory Committees

Using best practices from the federal Perkins program, the CTE advisory committee process at post-secondary has served as a model to replicate when it comes to industry and higher education input in the K-12 space. Advisory committees look at the curriculum, instruction, and assessment. The advisory provides career connected experiential opportunities. These employers are often the link to share what relevant industry standards and credentials are recognized.

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

Build Computational Literacy

The Federal Government seeks information on building computational literacy in STEM education. In the Federal Strategy for STEM Education, computational literacy includes digital literacy, cybersafety, cyberethics, cybersecurity, data science, data security, intellectual property (IP), computational thinking, artificial intelligence, quantum information science, and digital platforms for teaching and learning. Considering this definition, please answer the questions below:

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

Schools in southeast Minnesota are talking about the mindshift taking place as it relates to computer science. Computer science needs to be embedded into all classrooms and staff as it surrounds us on a daily basis and is going to be the key to future economic stability and security for our nation. With the way our world works, one computer class is no longer adequate. The Minnesota Department of Education is also starting to embrace this mentality and is embedding computer science standards into the new standards each year as individual content areas are updated to help our educators understand the role it plays in the big picture of education. Most recently science and ELA standards now integrate computer science into individual standards.

Benefit: Furthering Education

Modern education requires the use of computer software, devices, the internet, etc. In person and online remote learning depend on computer science practice. Especially now during covid, e-learning platforms and applications are giving students tools to problem

[redacted]

solve and study. The ability to take classes online is a benefit removing barriers like location, finances, and abilities to offer equitable access to students for their right to learn. These are important matters for students to remember as they are constantly impacted by it on a daily basis. It is helping to increase efficiencies for educators to deliver relevant curriculum.

Benefit: Expanding Communication

The world is much smaller now because of computer science. Connection to friends, families, colleagues, and potential employers is at our fingertips thanks to social media, face timing and video conferencing, and other daily innovations. Computer science has made it easier for educators and students groups to congregate in a virtual space enabling peer learning communities, instant contact to other people to gain additional knowledge, idea sharing, and problem solving. Computer science has also shifted the entire paradigm for delivery of education and work removing proximity barriers and increasing efficiencies. Thanks to applications that now allow us to cost effectively share documents and photos with people instantly to be able to work and learn remotely.

Benefit: Sparking Interest for Students to Solve Real World Problems

Computer science has enabled a strong movement in students to be aware of and address big issues facing our global economy and planet such as climate change, global business and enterprise, and national security. Teaching students computer science helps the human race to predict human behavior via social media and augmented intelligence, predict weather patterns for environmental catastrophes, and most recently track and predict pandemic outbreak patterns. Almost every aspect of society, from family-owned businesses needing digital protection to homeless shelters needing a way to streamline their volunteer base—relies on the innovations spurred by computer science professionals.

Challenges: Lack of Computer Science Literacy in Adult Population

The adult population is behind on kills in computer science literacy. This hinders the delivery of computer science education to students. While the pandemic has pushed the educational system lightyears forward in the understanding and appreciation of computer science, there is still a long way to go. STEM ecosystems are charged with empowering our adult learning to expand their skills and comfort teaching computer science and embracing it in their lives as well.

Challenges: Distance Learning Schools Within Schools

While a great option for students and families who wish to participate 100% in a remote learning environment, the 6-7% of students and families that opt for these options are posing extra challenges to educational systems and staff who are teaching in multiple

[redacted]

modes. This multimodal approach to education delivery has highlighted the that systems strategies and professional development should be focused in computer science advancement and support. Our educational systems are also being particular to make sure that the right staff and resources are in places that can provide genuine value to educators, families, and students.

Challenges: Balancing Quality with Quick Implementation

Schools are taking a good look at their priorities. Schools are overwhelmed with tools and information and constantly feel like they are putting out the closest fire to their feet. Southeast Minnesota gives our schools a lot of credit as they had to build a completely new paradigm of education, vet and get the tools they needed, quickly deliver education, and innovate based on constant community feedback. They have had to balance quick implementation with relliancy to adjust in a moment's notice with little to no preparation.

Challenges: Humans Dealing with Other Humans

Above all else, southeast Minnesota schools and communities constantly remembered that the shift in education due to the pandemic was as simple as humans dealing with other humans. We have to think innovatively on how we address the barriers of time for educators to get the needed resources to help them through this new paradigm shift. Southeast Minnesota's [redacted] ecosystem started to iterate ideas to support this work; some potential solutions posed included ideas like J term online learning options for one day courses to brush up on skills for the second semester.

Challenges:Substitute Shortage

School systems pointed out that substitutes are going to be a significant issue in the near future. Instead of working with unions and school boards to change policies to only allow staff to use sick leave and PTO, schools are trying to make alternative changes to the delivery of education to allow for flexible learning days. These flexible learning days to allow teachers to tape lessons while students are in common spaces with a paraprofessional. This will significantly reduce the dependence on substitutes.

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.

School systems;Schools;Teachers/faculty/instructors;Learners

[redacted]

Status: Not complete

22. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.

CS for All MN

Minnesota has joined 23 other states in seeking to increase the number and diversity of K-16 students with access to computer science through the Expanding Computing Education Pathways Alliance (ECEP). The goals of this grant include:

- Writing a landscape report for the state of computer science in MN
- Convening a summit to draft a state plan & timeline for increasing access to K-16 CS education in MN
- Creating pathways & partnerships to drive state-level CS education

CS for All MN - Southeast

This subset of stakeholders from the southeast region of Minnesota, mainly made up of [redacted] school districts and community partners will take next steps on the landscape survey report from CS for All MN.

Girls Who Code

Aim to close the gender gap in engineering and computer programming. Girls Who Code Accomplishes this by providing after school programming, summer camps, and closing college loops.

Code Savvy

Code Savvy strives to make kids and teens more code-savvy through creative educational programs and services. We incubate and support community-based programs that bring technology and know-how to local kids and educators, all the while championing gender and ethnic diversity. Code Savvy is dedicated to ensuring the next generation of computer science professionals represents the billions of users of tomorrow's innovative technologies.

Code.org

Code.org® is a nonprofit dedicated to expanding access to computer science in schools and increasing participation by young women and students from other underrepresented groups. Our vision is that every student in every school has the opportunity to learn computer science as part of their core K-12 education. The leading provider of K-12

[redacted]

computer science curriculum in the largest school districts in the United States, Code.org also created the annual Hour of Code campaign, which has engaged more than 15% of all students in the world. Code.org is supported by generous donors including Microsoft, Facebook, Amazon, the Infosys Foundation, Google and many more.

Coding/Robotics Clubs & Other Efforts

Many of southeast Minneota schools offer before or after school programs mentioned above or their own form of Robotics and Coding clubs. Other movements like Comp Lit ABC's, Hour of Code, Day of Code, and Pi Day are being adopted across the nation. Most of our regions focus on computer science at the club level. Schools recognize a need to better embed computer science into our other content areas.

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

23. What technologies and resources do you currently use (e.g., apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

- G Suite/Enterprise - All (K-12)
- Seesaw - Early elementary (K-2)
- Schoology - Upper Elementary (3-5)
- Zoom
- FutureForward™
- Kahn Academy
- My Open Math

Community Use and Implementation of the Federal Stem Education Strategic Plan

The Federal Government seeks information on community utilization of the Federal STEM Education Strategic Plan.

[redacted]

24. Please describe how your organization has used the Federal STEM Education Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?

[redacted] uses the Federal STEM Education Strategic Plan as its main strategic planning document. We have cross compared our regional goals with the goals of the federal plan and realized they are incredibly aligned. While the Federal STEM Educaiton Strategic Plan is much more comprehensive, [redacted] has prioritized some of the components of this plan based on work already taking place in our state and communities and areas of the highest identified need. While all pieces of this plan are important, there is a big lift in our part of the country to get caught up to other parts of the country.

[redacted] even went as far to cross walk the Federal STEM Education Strategic Plan to the Federal Perkins Plan goals and guiding document to identify areas of overlap and discrepancy. [redacted] has used this plan to compare other initiative plans to identify common missions to work in collaboration with other organizations and found discrepancies and differences to point out where separation of work or responsibility should lie in the collaboration of these multisector endeavors.

As you will see from this report, all questions were answered as not complete. Currently our education systems and STEM ecosystems are experiencing high levels of systems change and a significant lack of funding to accomplish the many goals set out by the Federal Washington STEM Plan. [redacted] STEM ecosystem firmly believes in the Federal plan, but more funding needs to be made available in order to achieve any of it.

School systems;Schools;Teachers/faculty/instructors;Learners

Status: Not complete

NSF, Request for Information on STEM Education

Response from the [redacted]

Submitter: [redacted]

This wholistic response addresses the following parts and questions of the RFI:

- **Future Opportunities in STEM Education, Questions 2 and 6**
- **Develop STEM Education Digital Resources, Questions 9, 10, 11**
- **Engage Students Where Disciplines Converge, Question 13**
- **Develop and Enrich Strategic Partnerships, Questions 18 and 19**

In response to the pandemic's impact on education, the [redacted] (referred to as "the Group") was formed and completed three main activities: (1) stakeholder outreach, (2) identification and organization of [redacted] educational content for online learning, and (3) synthesis of information.

(1) Stakeholder outreach provided the avenue to gather information through conversations with [redacted] staff, K-12 science educators, and other federal agencies. The Group ascertained that although primary school educators have a higher demand for online learning modules, middle school science programs are the best group to target to spark student interest in STEM. Another key takeaway was that secondary educators most need online resources for two categories in the physical science core curriculum, namely Matter and Its Interactions, and Energy. Conversations with PhET (Physics Education Technology)[1] and other federal agencies including NASA, USGS, EPA, and NOAA, revealed that remote education could be enhanced by further developing secondary school interactive online activities such as

- Scientist demonstrations that students can follow along with at home
- Interviews with a scientist, similar to CIRES (Cooperative Institute for Research in Environmental Sciences at the University of Colorado Boulder)[2]
- Connections to career paths
- Virtual lab tours
- Utilizing existing simulations (e.g., PhET) in conjunction with [redacted] educational content

Through the second activity, (2) identification and organization of [redacted] educational content for online learning, the Group found that [redacted] has a rich collection of content for secondary learners, and can address the educator needs stated above specifically with

[1] https://phet.colorado.edu
[2] https://cires.colorado.edu/

the following topics: Chemical Reactions, Structure and Properties of Matter, Conservation of Energy and Energy Transfer, and Relationship between Energy and Forces.

As a result of the final stage, (3) synthesis of information, the Group suggests that the effort to engage students where disciplines converge could be uniquely met with a collaborative registry of educational content curated from [redacted] and other federal agencies. This educational content has the potential to provide an ideal collection of online supplemental materials and applications for use in secondary STEM programs. For ease of access, the resources in the registry would be best categorized using NGSS and Common Core State Standards in Mathematics, and should also be searchable by content band, topic as named in the standards, resource type and grade level. An excellent example of this search framework is the CLEAN Collection.[3] [redacted] has participated in the development of interagency data structures that satisfy a similar need across federal research agencies (and beyond), exemplified by the [redacted].

[3] https://cleanet.org/clean/educational_resources/collection/index.html
[redacted]

On behalf of [redacted], we thank you for the opportunity to provide public comments related to the implementation of the Federal STEM Education Strategic Plan, *Charting a Course For Success: America's Strategy for STEM Education proposed priorities for the U.S.* [85 FR 55323].[1] Requests for clarification or additional information may be directed to [redacted]

Who We Are

[redacted]. We are innovators committed to transforming education and closing the experience gap for all learners to raise the next generation of critical thinkers and problem solvers. Founded in 1998 by three University of California researchers, our vision is united behind a simple yet innovative idea: let's teach math the way children learn—visually and experientially.

[redacted]

[redacted] – our PreK-8 visual instructional program – leverages the brain's innate spatial-temporal reasoning ability. The program's unique approach is highly effective for all children, regardless of socioeconomic, linguistic, or cultural background.

Following, we present our comments on these questions outlined in the NSF *Federal Register* notice dated September 4, 2020:

Category	Question(s)
Future Opportunities in STEM Education	1, 2
Increase Diversity, Equity, and Inclusion in STEM	12
Engage Students Where Disciplines Converge	13
Develop and Enrich Strategic Partnerships	19

[1] https://www.federalregister.gov/documents/2020/09/04/2020-19681
[redacted]

[redacted]

Question 1:

What COVID-19 related digital barriers (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

Access is the primary challenge in regard to distance learning, and with good reason. Over the past several years, progress has been made with regard to the "digital divide," the gap between students who have access to technology and those who do not. But while many schools have increased access to technology and better internet connectivity, many students do not have that same access at home. School closures have meant a step backward when it comes to the digital divides. For underserved students and rural communities, the impact is even greater.

Access to devices and digital tools alone is not enough. The kind of learning experiences that students are having with technology varies widely. The DOE's Office of Educational Technology defined the digital use divide[4] as separating "students who use technology in ways that transform their learning from those who use the tools to complete the same activities but now with an electronic device (e.g., digital worksheets, online multiple-choice tests)."[5] Multiple studies[6] and reports[7] have provided evidence of the digital use divide between underprivileged students in poorer districts, and students in more affluent ones. This is another reason why facilitating learning during the COVID-19 situation is not a one-solution problem.

To address the access/learning issue, [redacted] provided free access to ST Math—not only for schools, but also for parents who were suddenly homeschooling their children. From March 14 - June 30, 2020, [redacted] provided access to 5,725 additional schools and more than 1.8M new students. [redacted] for families is free through the remainder of 2020, and we have provided access to 32,914 households in the last 4 months.

In addition, [redacted] focused on providing support and developing resources for families to facilitate meaningful math learning at home, including:

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[4] https://tech.ed.gov/files/2017/01/NETP17.pdf
[5] https://tech.ed.gov/netp/introduction/#:~:text=Digital%20Use%20Divide
[6] https://doi.org/10.1016/j.compedu.2017.05.017
[7] https://clalliance.org/wp-content/uploads/2017/11/GIROreport_1031.pdf

- An Instructional Resources[8] page that features comprehensive PreK-5 ST Math Guidebooks for teachers and families.
- A series of tutorial videos and webinars[9] on using [redacted] and distance learning.
- Facebook groups for families and schools to connect with [redacted] staff and each other as they supported their students at home.
- A new video and blog series called [redacted] featuring video discussions, downloadable resources, and themed activities for families to do together.

Question 2:

What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education?

As stated in our previous answer, the challenges around remote learning go beyond ensuring access to digital materials for students. Many of the instructional tools that are being utilized in the classroom were not effective for all students to begin with, and are now almost entirely obsolete in a distance or hybrid learning model. We must stop framing learning environments separately, and instead seek out tools that can function anywhere in the student learning ecosystem. In order to get the most positive impact per educational week using digital resources, we must provide instructional tools that do the following:

1. Use tech to remove unnecessary barriers, making learning accessible to as many students as possible.
2. Allow students to self-pace through content.
3. Fully engage students, challenging them to generate productive struggle.
4. Go beyond practice of existing knowledge to provide students with robust opportunities to build conceptual understanding they don't already have.
5. Have an efficacy portfolio that demonstrates the research-based effectiveness of the program with a wide variety of students.
6. Personalize and differentiate learning to allow students to succeed on grade-level content, regardless of where they start.
7. Deliver program results with appropriate, lightweight levels of parent oversight.

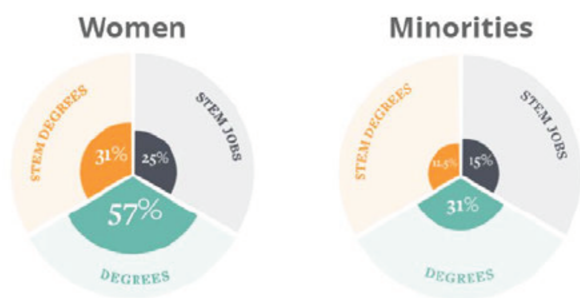
[redacted]

8. Offer training, support and community to parents and families.

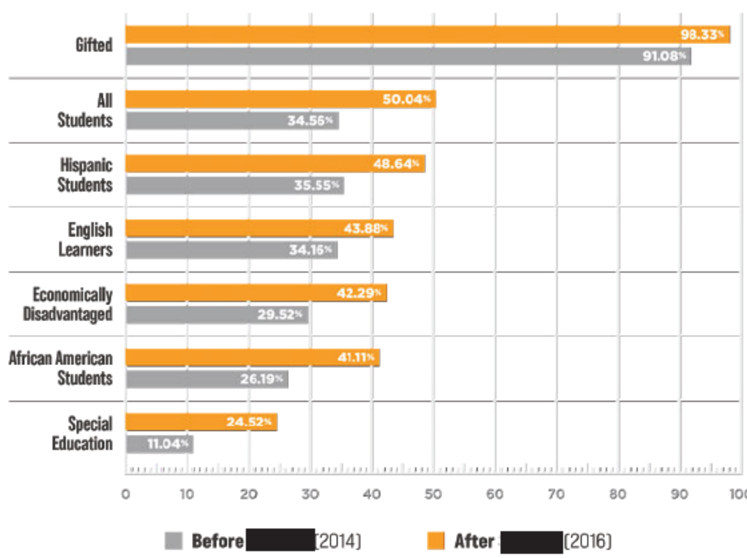
Question 12:

What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

Math is the foundation of STEM, and research has shown that early numeracy skills are a better predictor of later achievement than both reading and attention skills. Sadly, less than 50% of students in the U.S. are proficient in math by 4th grade, and by 12th grade that number drops to 25%.[11] A deeper look into those proficiency rates reveals that minority students are falling even further behind.



These gaps in math achievement are further evidence of the systemic challenges faced by students of color, which result in experience gaps and digital divides. The uneven path to the STEM workforce for many students has resulted in a lack of diversity in that workforce.[12]



Our approach to teaching and learning math is rooted in neuroscience, and the [redacted] program utilizes a variety of visual, spatial-temporal models to present math concepts in non-routine ways, and provide

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[11] https://www.nationsreportcard.gov/

[12] https://www.pewsocialtrends.org/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs

animated, informative feedback that adapts to a student's response.

[redacted] is proven effective for all students, regardless of socioeconomic, cultural or linguistic background. When students of all levels can problem solve without distractions, they see dramatic increases in achievement.

[redacted] success is demonstrated in both internal[13] and external[14] evaluations, and the program meets WWC quasi-experiment and ESSA Tier 2 requirements.[15]

Question 13:

How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach and how does it benefit your students' learning?

While STEM subjects seem tailor made for rich and varied learning experiences, those types of experiences are severely lacking when it comes to mathematics. Math is often taught in a way that focuses on calculations and rote memorization. As a result, many students have a poor relationship with math, only experiencing it in a very limited way.

This dissonance between the types of math experiences students could have, and the ones they currently have access to, is what we refer to as the "experience gap." So in our efforts to address the math crisis, we have to focus on the ways that we are teaching and learning math, providing rich new ways for students to experience the math that is all around them.

Our [redacted] program leverages the innate spatial-temporal reasoning ability that all students have. By engaging with a program like [redacted] in PreK-8, students are

[redacted]

continually exercising their spatial reasoning skills, better preparing them for future STEM coursework in areas like design and engineering.

Through our [redacted] we use storybook board games to combine math, history and literacy in a highly connected experience. Our [redacted] program provides students with real-life, hands-on experiences.

Question 19:

If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

We believe that strong public and private sector partnerships are crucial to impacting the math crisis in America and create change on a national level. We also believe that a student's learning ecosystem includes school, home, and community, and we work to support that entire ecosystem.

Sponsoring school districts by funding the implementation of effective instructional programs like [redacted] is one way the private sector can help students gain access to quality learning experiences. Many of our partners are very active in their local communities and are invested in their future workforce. Bringing [redacted] to their local schools is a way to see an immediate impact on the students they may be employing within the next several years. We work with partners and sponsored schools to capture the stories of how [redacted] is changing students' perception and proficiency in math. Those stories are told through our [redacted] series and our [redacted] series.

Supporting research and development of educational solutions is another way the private sector can work with educational nonprofits like [redacted] to support the STEM learning ecosystem. [redacted] continuously enhances our [redacted] and other program offerings to meet the changing needs of the students and teachers we serve.

[redacted]

[redacted]

Program Report

Introduction

[redacted] is a bold, interdisciplinary STEM program built especially for girls ages 13-16. The first offering of the [redacted] was held from July 13-31, 2020. In the spaces between school closures, summer learning loss, and online experiences, [redacted] arrived to fill the gaps for middle and high school girls that result in a vacuum for women in science. The [redacted] provided a high-quality, online curriculum during the Summer of 2020, consisting of three courses: The intersection of art and science, the strategies of women working with dangerous situations, and the challenges of conducting experiments on the human brain. Each week featured keynote speakers from cutting-edge fields, an opportunity for girls to learn from and interact with STE(A)M professionals. The first offering of [redacted] was organized through a first-of-its-kind collaboration between the World Science Foundation (WSF), National Girls Collaborative Project (NGCP), and The Hello Studios, leveraging shared resources to create a high-quality STEM-centered program.

Goals

Brite aims to chip away at gender inequality in STEM through intersectional program design and diverse participation. The central goals of the [redacted] were to:

- Foster STEM identity: a belief in self, image, and ability
- Foster STEM agency: decision-making about STEM
- Foster and engage girls in collaborative learning
- Build a community of girl learners and a support network among them
- Spark curiosity and creativity

To foster STEM identity and agency, the [redacted] was grounded in diverse participation, career pathways, and skill sets. Participants were racially and ethnicity diverse with 29% - 97% of girls served by selected programs from racial and ethnic minorities. A total of 14 scientist speakers participated, showcasing a myriad of unique pathways taken and skill sets built by female scientists: Out-of-the box thinking, creativity, and curiosity characterize these scientists. In this way, gender nor other social categories define or determine one's success or ability to pursue a career in STEM. Instead, the [redacted] community of girls saw first-hand and interacted with female scientists who have broken down barriers and created successful career pathways within STEM.

To build a community of girl learners and a support network among them, small group and community-wide learning, and sharing served as the cornerstone of engagement during [redacted]. Within each [redacted] group, girls brainstormed thought-provoking discussion prompts and generated questions for speaker scientists. As a [redacted] community, girls interacted with speaker scientists, through Q&A sessions and learning games, while also sharing their own projects and ideas with scientists.

To spark curiosity and creativity, girls were challenged to take action to think critically about topics ranging from volcanology to neurology, to create their own science-inspired art projects, and to design their own experiments.

Recruitment

An initial RFA to programs affiliated with NGCP networks was circulated in June 2020. NGCP received applications from 33 programs in 21 states. Eight programs were selected, each with 10 - 20 girls per site. The following programs were selected:

- Be-Ruth Foundation
- Girl Scouts of Eastern Missouri
- Girl Scouts of Historic Georgia, Inc.
- Girl Up
- Milwaukee School of Engineering
- Morrison Mentors
- SUNY Schenectady County Community College
- University of South Florida College of Marine Science

Selected programs were responsible for the recruitment of girls, permissions for participants, and the day-to-day operations and logistics of [redacted]. Each program received access to the online [redacted] Platform and an Educator Guide. Programs were geographically diverse, and included girl participants from 25 states, and four countries. Participants were racially and ethnicity diverse with 29% - 97% of girls served by selected programs from racial and ethnic minorities. Further, all programs reported between 33% - 89% of girls served receive free and/or reduced lunch.

Program Structure

The [redacted] was held online, through the [redacted], which girls accessed through a 1:1 device. The platform served as a launching pad for girls to participate in individual, small group, and community-wide activities. 70% of educators said they easily navigated the [redacted] platform and its weekly modules. The Educator Guide served as a useful supplement to guide girls through the day-to-day activities of [redacted], with 80% of educators saying they used the Educator Guide to facilitate their [redacted] group.

Each week of Brite constituted a course on the [redacted]. Daily programming spanned three hours, which included diverse synchronous and asynchronous activities to inspire curiosity, learning, and creativity. For example, each day began with a program group meeting involving an ice breaker activity and preparation for the live speaker sessions, [redacted]. After the [redacted], girls would learn about the related activity and then work independently to complete it. Throughout a course, girls completed five independent activities, one for each day, and engaged in group discussions, ice breakers, and reflections. The activity types are described more thoroughly in the section below. Upon completion of each course, girls received digital certificates. Of the 175 girls registered for [redacted], 57% of girls completed all three courses.

Group Activities

[redacted] convened multiple times each day via their Zoom Personal Meeting Room, accessed through the [redacted]. [redacted] activities ranged from collaborative art making, discussions on the ethics of brain experimentation, to creating visuals of the risks and rewards taken by female scientists. Within their groups, girls also engaged in conversation and brainstormed questions for scientist speakers.

(b) (6) [redacted]

Oceanography Camp for Girls on Zoom

Community Activities

Individual and group activities were augmented with community-wide live speaker sessions called [redacted] and [redacted], which featured speakers from diverse STE(A)M fields. Each week girls participated in three [redacted], 60-minute Zoom webinars featuring a scientist speaker and a robust Q&A. [redacted] provided an inside look at the multiple pathways taken by female scientists to reach their professional goals. Female scientists shared a snapshot of their daily lives, an opportunity for girls to put themselves in these scientists' shoes.

Each week culminated with [redacted]; a 90-minute celebratory event hosted by a female scientist. Scientists guided girls through an interactive discussion, and girls shared projects they worked on throughout the week, fostering a dynamic and collaborative learning environment for the [redacted] community. According to educators surveyed, building a community among participating girls was cited as the most enjoyable part of running [redacted]. The speaker sessions were cited as the second most enjoyable part of running [redacted].

Summary of Impacts

An external evaluation of the project was conducted by SJLR Solutions LLC. The findings are reflective of girls' responses to feedback questions embedded in the [redacted] (SJLR Solutions LLC, 2020). Six blog posts were uploaded to the National Girls Collaborative Project website, providing additional insights in the scope and dynamics of [redacted].

The five central projects goals can be summarized as: to foster girls' sense of STEM identity and STEM agency, engagement in collaborative learning, to build a community of girl learners and a support network among them, and to spark curiosity and creativity.

STEM Agency and Identity

Interdisciplinary STEAM programing centering upon interactive discussions with female role models and tailored activities, exposed girls to creative approaches to problem-solving, and introduced girls to innovative, intersectional career pathways. In this way, the [redacted] enabled girls to build confidence about their own capacities and provided a foundation for girls make decisions about the myriad of unique career options available to them, helping girls foster a sense of STEM agency and identity.

The external evaluation revealed evidence of increased STEM agency in girls, demonstrated through comments in feedback questions. Comments showcased girls' heightened awareness of choices available for pursuing STEM interests and careers paths, and comments also demonstrated increased interest in utilizing STEM to problem solve. Evidence of a STEM identity was demonstrated through comments focused on a characteristic or individual interest in the weekly theme or a particular activity, and girls shared "they felt recognized and validated regarding their STEM interest", and girls also stated they found peers with shared interests.

Girls shared similar insights into their STEM agency and identify with their [redacted] educators, and educators also observed girls' strengthened confidence in their capabilities and heightened interest in intersectional STEAM topics and careers. Girls emphasized how they learned about new and exciting careers. One girl from the Milwaukee School of Engineering's (MSOE) STEM Outreach Program said, "I liked the danger week speakers because they talked to us about careers in science that I didn't even know existed" (Massopust, 2020). Susan S. from SUNY said, "My favorite part was learning about the chemistry behind the Volcanoes. I am also fascinated by the formation of landscape due to the volcano eruptions" (Harris, 2020).

Sherika Adams, educator, from Morrison Mentors shared: "We enjoyed seeing the growth of the girls each week. Growth in regard to their mindset, and even attitudes. The girls participating in this program gained a sense of community and were able to be their unique selves while sharing their thoughts, interests and passion for STEM" (Adams, 2020).

Engagement in Collaborative Learning

The program encouraged collaborative learning across multiple levels: the Brite community of girls during [redacted] and [redacted], among [redacted] (individual programs), sharing of Flipgrid posts and views, and unique discussion posts to daily prompts (SJLR Solutions LLC, 2020).

Community-wide learning occurred during [redacted] and [redacted] as girls asked questions and interacted with female scientist speakers. Girls said, "[redacted] was fun and it was good to hear about everyone's projects" (SJLR Solutions LLC, 2020). "I really appreciate how interactive [redacted] is!" (SJLR Solutions LLC, 2020). Sarah Massopust, educator from MSOE, shared, "The best part about the guest speakers was they were LIVE! The girls were able to interact with them via Zoom, including coming on screen and asking them questions.

Girls were excited about seeing each other's work, both during [redacted] and through Flipgrid, sharing "...we can directly see who other girls are and see their process and thoughts [of the topic or activity]" . "I liked the whole thing and I really liked getting to see how everyone interpreted the risk and reward" (SJLR Solutions LLC, 2020).

Within [redacted], educators observed the workings of collaborative learning in remarkable ways:

Mary Fuller, educator from the Girls Scouts of Eastern Missouri (GSEMs) said:

One of the first times I saw this cooperative learning in action was the day we collaborated on a piece of artwork over Zoom – a campfire scene reminiscent of nights at Girl Scout Camp. I stepped back and let the girls lead the way – and they did. As the sessions continued, the girls began to warm up, both to me and to each other. They began to open up and speak up for discussions around the assigned topics and speakers – but also about what was going on in their lives and they things they enjoyed (Fuller, 2020).

Sherika Adams, educator from Morrison Mentors said*, "Although a few of the girls had a slight interest in STEM prior to the start of the program, they were unaware of how music, and art could enhance their feelings toward it. One of their favorite activities during the week was choreographing a group dance by using code"* (Adams, 2020).

Zoom, Flipgrid, chat spaces, and discussion boards enabled girls to learn from each other, and together with female role models. The multitude of examples of collaborative learning across the many plains of the Brite Program, underscores the transformative potential of digital collaboration among girls.

Building a Community and a Support Network

Through a combination of [redacted] activities and discussions, interactions with female role models, and opportunities for sharing and collaborative learning during [redacted] and [redacted] the [redacted] program built a community of future girl scientists and a support network. In responses to feedback questions, girls specifically referenced excitement for interacting with other girls with similar interests and emphasized the importance of supporting one another (SJLR Solutions LLC, 2020). "Building community among the girls" was most frequently referenced by educators as the "most fun element of the [redacted]" (SJLR Solutions LLC, 2020). Educators reported, "It was fun to see the girls work and share with, and support, each other" (SJLR Solutions LLC, 2020).

[redacted] offered a more personal setting to build relationships with peers, as groups met several times each day with consistent opportunities for collaborative projects, and discussion sessions to share reflections and insights. Educators witnessed the bonds girls formed in their [redacted]. Sarah Massopust from MSO said:

Reflecting on the past three weeks of [redacted]*, we feel like we've witnessed something truly special and unique in the world of virtual programs. We had an amazing group of about 20 girls who participated in the program and we watched each day as they became a tight knit group. We went from the first day where many girls were shy and unsure of themselves to a group that was creating themes for each day and laughing at inside jokes* (Massopust, 2020).

[redacted] and [redacted], provided an opportunity for girls to connect with the personal and professional journeys of female role models. Girls shared, "Being able to interact with people who have made achievements and worked hard" (SJLR Solutions LLC, 2020). Another girl said, "My favorite part of [redacted] was seeing al [sic] the girls projects and answering Amanda's Questions" (SJLR Solutions LLC, 2020).

While girls were physically not near each other, at multiple levels, in [redacted] and community-wide speaker sessions, girls built connections to each other and female role models.

In summary, educators communicated their joy and gratitude for participating in [redacted], centering upon the impacts of collaborative, role model-focused learning with high-quality activities, and numerous opportunities for sharing, support, and interaction.

The federal governor could assist in encouraging more programs like Brite by:

- Telling the stores of exemplary partnerships like this one
- Incentivizing collaborations with small amounts of seed funding and requiring significant dissemination
- Serving as a convenor to assist with bringing together diverse partners, e.g. public, private partnerships

Response to RFI on STEM Education

Authors: [redacted]

[redacted]

As STEM education researchers, teacher educators, and practitioners, we recognize the value of this important document. While we do not represent the voice of our university or a unit within, we believe our responses resonate with many in our STEM education researcher and teacher communities, be they in formal or informal contexts. Thank you for this opportunity to respond.

Future Opportunities in STEM Education	**questions 1-2, 6, 8**
Develop STEM education digital resources	**questions 9-10**
Increase diversity, equity, and inclusion in STEM	**question 12**
Engage students where disciplines converge	**questions 13, 15-16**
Develop and enrich strategic partnerships	**questions 18-19**
Build computational literacy	**questions 20-21**
Community use and implementation of the Federal STEM Education Strategic Plan	**question 24**

Q1. Many of our students face challenges accessing equipment to participate in virtual STEM learning given the transition to online modalities even for courses that traditionally required hours in the field (e.g., many geology field courses were transformed into virtual field courses). To combat this challenge [redacted] put together an extensive computer loaner program. This was spearheaded by the College of Arts, Sciences and Education (CASE) and later led by the [redacted] Libraries. In addition, [redacted] created specific fundraising opportunities (e.g., Ignite) for monies that go directly to students who are financially challenged due to the impacts of COVID-19. The [redacted], has continually stated his desire for no student to delay their education because of COVID-19. Challenges facing faculty over transitioning mid-semester (i.e., spring 2020) and beyond to online/virtual modalities are being addressed through multi-institutional collaborations that include the voices of our practitioners and instructors whose expertise lies in online education.

Q2. A challenge for K-12 STEM classrooms that has been exacerbated by home-based schooling and in-class restrictions, has been providing hands-on STEM experiences that address state and national standards for scientific skill development. There are several virtual opportunities available for K-12 teachers, such as the virtual programs offered through our education outreach team [redacted]. Services such as these offer opportunities for students to interact with experts, practice data collection and analysis, and develop computational literacy and science communication skills. Additionally, the affiliation with a local university introduces students to experts in their community and communicates identity-formative ideas about their potential to work in STEM—an opportunity that is especially important in Hispanic-majority communities like ours. However, as with similar programs, there is a cost associated with the service. In order for K-12 districts to take advantage of such opportunities, they require the necessary funding.

Q6. In our opinion, some of the most important data to collect relate to the mental health of our students and the affective domains related to changing how we live and work (e.g., sense of belonging, interest, motivation). Additionally, we must make sure to collect and analyze data with respect to how the pandemic-related shifts have affected our populations differently. The pandemic has affected every member of our community, but the intensity and nature of those effects are not uniformly distributed. Disaggregated data on student progress and teacher effectiveness will help us to observe the pockets of our population most in need of intervention and develop targeted strategies.

Q8. A challenge to secondary and postsecondary improvement in instructional practices, both during and prior to COVID-19 related impacts, is the lack of widespread adoption of teaching practices that are based on evidence of student learning that includes peer-learning approaches and other student-centric practices. When faculty believe that learning occurs when information is *transferred* from faculty to students, they focus on telling students the content they need to know (e.g., long lectures), which is not as effective as meaningfully engaging students with concepts. Helping faculty make positive shifts in their teaching practice is a social process. Interactions between faculty are not always possible at the moment. For example, our Department of Earth and Environment held casual Zoom meetings where faculty might have these conversations, but time is always limited and Zoom exhaustion is a challenge. Improving teaching practices without this social aspect of faculty work is a huge barrier. In the future, if more and more educators work remotely, it could significantly change how we think about improving teaching practices.

Q9. Publications of scientific research can serve as a tremendous resource for STEM classrooms because they provide real-world problems that motivate students and can serve as access-points to scientific literacy and national science standards, such as in understanding research questions, making sense of data, and critiquing scientific conclusions. However, scientific articles are difficult for students to read and cumbersome for educators to translate for students. Thus, educators would benefit from access to a web-based resource that provides these materials in an accessible format, alongside educator resources. The **Science in the Classroom** platform (https://www.scienceintheclassroom.org/research-papers/activities), developed and led by the American Association for the Advancement of Science (AAAS) with the support of a current member of our staff, Dr. Melissa McCartney, is an example of one such web resource, which features pared-down research articles, tools to highlight particular aspects of the article, educator resources (including standards-alignment) and supplementary activities.

Q10. We work with pre-service K-12 STEM teachers, i.e., current college students who are taking college courses towards teaching licensure. As developing teachers, these students must think about how to create classrooms that are equitable, conducive to learning, and mindful of state and national standards. Through integrative STEM curriculum, they can develop plans for problem-based lessons that are responsive to student and administrative needs. However, finding resources to incorporate in their lessons can be a challenge, as much of what is available is hard for teachers to access (due to publication costs), difficult to understand (due to academic writing), and challenging to translate into student activity. Resources such as **Science in the Classroom** remove some of the heaviest of these burdens.

Q12. As an HSI our institution carries out a slew of initiatives and activities to retain and advance the achievement of individuals from minoritized groups, the majority of which identify as Hispanic or Latino. A recent National Academy of Sciences Town Hall featured many of our strategies (you can find the recording here: [redacted] That said, our leaders aim to foster an inclusive culture that embraces the values and habits of our local communities. Many of our faculty also lead specific initiatives, some funded through the National Science Foundation, to support the success of our students. Below we highlight a few of these programs:

1. The NSF-funded **STEP Up** program supported by the American Physical Society and the American Association of Physics Teachers aims to close the gender equity gap in physics by engaging high school physics teachers to inspire female students to pursue careers in physics: https://engage.aps.org/stepup/home.
2. The **Talking Science** project is also an NSF-funded initiative that primarily focuses on family engagement research with Hispanic/Latino families to better understand home-related interactions that contribute to the development of children's identification with STEM: [redacted].
3. **Flit-Path** is funded through NSF's S-STEM program to provide scholarships and academic support to first-generation college students pursuing degrees in computer science and IT: https://flit-path.org.
4. **Scholarships for a Future Generation of Geoscience Professionals** is funded through NSF's S-STEM program to provide scholarships for students who have financial need and are from groups that have traditionally been underrepresented in STEM in the United States. It provides a cohort model for supporting students.
5. The **Learning Assistant (LA) Program** at [redacted] incorporates inclusive learning pedagogy training for all LAs. This training includes topics that promote equity in the classroom such as eliminating microaggressions, improving classroom climate, etc.

Q13. Faculty within the Department of Teaching and Learning work with both pre-service elementary and secondary (mathematics and science) teachers. In several of the methods courses taught by [redacted], instructional time is dedicated to introducing these novice educators to engineering education and integrated STEM instruction to prepare them for today's current teaching climate in science classrooms. Many of these educators did not experience this kind of instruction within their own K-12 experiences and often cite the class sessions focused on engineering integration and integrated STEM as their favorite due to the direct applications of scientific and mathematical conceptual knowledge in activities that are contextualized by complex, real-world problems. [redacted] have an NSF funded project [redacted] that aims to develop a valid and reliable observation protocol for integrated STEM instruction; the protocol helps pre-service and current teachers guide their own instruction, challenging them to think outside the box. This work has significant implications for the local school district as many of our education graduates end up working in Miami-Dade County Public Schools and Broward County Schools—the 4th and 6th largest school districts in the nation.

Q15. As noted in the response to Q13, [redacted] teach science methods courses with engineering education and STEM integration in mind. Their professional training at the University of Minnesota has prepared them to teach in this manner and their continued professional learning with other educators in the field through grant partnership and meetings at professional conferences allows them to grow. As such, they have shared their knowledge of engineering education and integrated STEM education not only with pre-service teachers as noted above, but with graduate students through coursework and internships on research projects. [redacted] have also worked with teachers in Miami-Dade County Public Schools as part of their funded NSF project, providing them with a foundational knowledge of integrated STEM education so that they are equipped to modify curricula for classroom use.

Q16. As teacher educators who are considered experts in the field of integrated STEM education, [redacted] have experience in providing professional development for in-service science teachers who are interested in integrated STEM education. In their work, they have focused on not just providing teachers with example activities to directly bring to their classrooms but emphasize that curriculum writing is an important component of creating change to instruction. As part of this, teachers are often expected to work with others. As a result, [redacted] incorporate elements of reflective practice into their work, assisting teachers as they implement integrated STEM into their classroom for the first time through a coaching model. This aspect can be done in person or virtually. Moreover, having access to resources such as time for course planning and supplies for classroom use are vital to their success.

Q18. [redacted] work on building STEM learning ecosystems has involved the contributions of industry partners, but questions about sustainable engagement and measurement of outcomes remain unaddressed. For example, the Adrienne Arsht Center for the Performing Arts leads a partnership with Miami Dade County Public Schools, [redacted], and over a dozen industry partners to engage middle school children in high-needs schools. The focus of this initiative—Kitty Hawk—is on aviation and aerospace science/engineering and career awareness. This includes field trips to Boeing and AirBus where children participate in hands-on activities and hear from engineers and scientists in the field. The project aims to generate excitement towards aerospace careers that may require either technical certification and/or postsecondary degrees. Despite the positive outcomes of this work, it is still unclear how to support sustained engagement beyond middle school that draws students further into these fields while presenting a clear career and workforce pathway. This type of work requires funding and other supports for infrastructure that facilitates children's engagement through middle and high school, and beyond. Moreover, support for longitudinal research is required to both evaluate the long-term impacts of the efforts, as well as identify effective programmatic factors to refine the program and allow for scalability. With regard to the pandemic, many of these efforts were halted throughout the remaining portions of the 2020 spring academic term. Nevertheless, institutions have begun to adapt and build on successful efforts to engage youth through virtual environments.

Q19. As part of our NSF-funded **Talking Science** research [redacted], [redacted] are exploring the capacity for parent-child interactions to facilitate STEM engagement and STEM identity development, particularly for Hispanic/Latino youths. Through this work, we have come to recognize that parents provide significant resources for engagement that are not available to many students in the K-12 STEM classroom. Particularly, as parents engage with their children on STEM-related topics, children see their parents as models of "STEM people" who share their identities (e.g., religious, ethnic)—an association that is especially important for children affiliated with communities that are underrepresented in STEM. Especially now that the COVID-19 pandemic has forced many schools online—and this children are learning in their own homes—drawing attention to this capacity of parents is important in the pursuit of equitable home-based learning. However, we also recognize that parents typically have varying levels of constraints due, for instance, to time, money, or sense of being welcomed in school spaces.

An additional implication of our work is the potential for out-of-school learning institutions to take on roles to facilitate relationships between parents and schools. For instance, museums that partner with community organizations (e.g., YMCA) and schools (e.g., teacher professional development, field trips) already exist as an intermediate between schools and communities. However, most out-of-school learning institutions have programs and content that are not relevant to students and/or do not encourage active participation. Given the above, we encourage more attention given to the home environment as a STEM learning setting in which caregivers, children, and other family members interact through STEM-related conversations and activities. Engaging children while failing to engage their families would hinder or limit sustained STEM engagement. In our opinion, additional attention and support should be given to programs and research focusing on family engagement, especially with regard to motivating minoritized children's positive identification with STEM.

Q20. Researchers have noted the overlap of *computational thinking* (CT) practices (such as problem representation, abstraction, decomposition, simulation, verification, and prediction) with scientific and mathematical practices, making a case for integrating CT into K-12 STEM curricula (Sengupta, Kinnebrew, Basu, Biswas, & Clark, 2013). Several scholars support the view that CT is highly compatible with STEM instruction and can be an effective practice in STEM classrooms, which are also focused on problem solving (e.g., Ellis et al., 2020; Kynigos, 2007; Weintrop et al., 2016; Wilensky & Reisman, 2006). The Next Generation Science Standards (NGSS) specifically describe CT as "strategies for organizing and searching data, creating sequences of steps called algorithms, and using and developing new simulations of natural and designed systems" (NGSS Lead States, 2013, Appendix F, p. 10). In science classrooms, technology tools and devices are primarily focused on practices related to data collection. For instance, virtual laboratories or simulations are used as a replacement for collecting data in a physical space. Similarly, sensors on mobile devices are increasingly utilized to gather data efficiently. In essence, these are examples of technologies that help learners engage in the same scientific practices used by scientists. While emergent technological tools can and should be used to reduce burdens on materials, time, and cognitive load, we advance the argument that the use of technologies in STEM education must move beyond tool-based approaches focused on data collection.

Q21. Kafai and Burke (2014) extended the discussion of CT in educational contexts, calling for CT to be reframed as *computational participation* (CP), emphasizing “the ability to solve problems with others, design systems for and with others, and draw on computer science concepts, practices, and perspectives (p. 6)” so that learners are able to meaningfully participate as critical thinkers, as well as producers, consumers, and distributors of technology. They argue that CP enables insight into sociological and cultural dimensions as learners move between the digital and physical world. CP, therefore, includes not just CT skills, but also utilizes CT skills toward specifically purposed, collaborative projects, such as using code to generate websites, programming to create interactive art projects and digital stories, and interacting through computational activities to build and sustain relationships.

We propose a view of computational literacy that includes both CT and CP. This view has the potential to support the integration of continually evolving technological tools, provide opportunities for STEM learners to move between digital and physical worlds, and construct knowledge of concepts and skills through collaborative STEM-related practices and collaborative interactions with individuals. We share examples of specific approaches (such as technology-mediated gaming and citizen science) in STEM learning that reveal the power of CP as an epistemological and pedagogical approach to integrating a wide range of technologies that promote STEM practices and learner behaviors. Learners’ interactions with technologies and others allow them to engage simultaneously in social and discipline-specific practices as members of a STEM community of practice, taking on critical roles as makers and innovators.

Q24. The Federal STEM Education Strategic Plan has shaped the framing of many of our faculty-led initiatives, both research-based and programmatic. Our faculty have to an extent aligned the design of student/teacher programs to the recommendations of the strategic plan, and in some ways have been doing so even prior to the publication of the plan given its foundation on evidence-based practices. The publication of this plan has provided a framework and language with which to structure these activities both for implementation and for pursuit of funding. With that said, there are aspects of the strategic plan that we believe could be leveraged or expanded upon in order to further ensure the success of K-12 students in STEM. Please see below:

Highlighting the Importance of Intersecting Pathways and Objectives

Many of the efforts we undertake to support the goals of the Federal strategy for STEM Education succeed because they address more than one Pathway and/or more than one Objective. For example, our relationship with the Adrienne Arsht Center for the Performing Arts focuses on developing a strategic partnership (Pathway 1) that supports our increasingly interconnected STEM ecosystem (Objective 1) by blending successful researcher and practitioner practices (Objective 3) that engage students (Pathway 2) through STEM-related transdisciplinary content (Objective 6). This example--based on the table found on pg. vii of the plan--illustrates how initiatives are enhanced by drawing on multiple pathways and recommendations of the strategic plan. Explicitly highlighting or describing approaches as accounting for multiple pathways and recommendations would support the development of initiatives more likely to achieve success.

(b) (6) [redacted] STEM RFI Response **October 2020**

Response from [redacted] Perspective: [redacted]

I will be responding to the following sections and questions:

Future Opportunities in STEM Education: Questions #3, 5, 6
Develop STEM Education Digital Resources: Questions #9, 10, 11
Engage Students Where Disciplines Converge: Question #14
Build Computational Literacy: Question #23
Community Use and Implementation: Question #24

Future Opportunities in STEM Education

#3. Teachers have risen to the challenge of providing remote learning activities to mirror the in-person learning of the past, and many of these experiences include teacher videos. In the spring of 2020, companies provided free services to help teachers. Teachers learned to record lessons using screen casting software and video conferencing software. Teachers made screencasts of their lessons and students could watch asynchronously in the spring. This year, teachers are recording using the same software to support absent students along with synchronous learning. One challenge continues to be writing fluently and seeing students' written work, especially in mathematics.

Now that lesson videos exist, I would like for schools to provide a common space to host them. These same resources could be used to help absent or struggling students for review, re-teaching or for future years. Downsides include that the recorded lessons may not be succinct and videos may include images of students.

#5. Professional learning around differentiation would positively impact equity. Teachers are working hard to keep their students safe and engaged, to write or adapt lessons, and to balance the needs of remote and in-person learners. To create learning opportunities that span the learning continuum is a challenge. To exacerbate the situation, remote learners may shift in their usual place on the continuum. For example, an average learner may not require additional support in the classroom but may need both technological and academic support when remote. Differentiation helps each student progress when ready, thereby helping learners at all levels.

#6. Important data would include scores and/or growth of remote versus in-person learners; however, this data would be enhanced by knowing what supports were available for each group. For example, what resources were provided for the remote learners? Did they have access to a lesson video? Did they have written notes? Were their resources available for translation as needed?

Other useful data would be the comparison of test scores across devices and learning management platforms to examine, and hopefully increase, the validity of scores. This is important in the lower grades for bridging gaps and in the upper grades because of the high-stakes nature of grade point averages. At a campus level, we need student and teacher input regarding “what worked well” and “suggestions for change” so that we can improve during the crisis but also build effective remote learning frameworks for the future.

Develop STEM Education Digital Resources

#9. I would like to see free plug-and-play math and science lessons by topic and grade level with no sign-in required. In math, for example, teachers could use short (2-5 minute) videos, completed example, and practice problems with a worked-out key. Having a real-life example would be a helpful as well. Right now, free programs often require districts to sign up for an entire program and for teachers to go through introductory training. In real life, teachers know what specific topics they need and often spend their own time and money looking for great lessons.

I would like to have cross-curricular lessons sorted by science topic and grade level. This would be helpful for extending and deepening the learning for students who are learning remotely and/or for earlier finishers at school who could use their time to deepen their learning across subject areas.

I would like to see plug-and-play Google tutorials for middle school students, especially Google Sheets for math and science. With the emphasis on Google Classroom and remote learning, I think the time is ripe for students to incorporate these skills. I have not found a good source for age-appropriate tutorials and not all teachers are comfortable teaching with spreadsheets. The math standards for Data Analysis across the middle school grades seem to be the opportune area to insert these skills. Video tutorials and short “try-it” exercises would help standardize experiences across grade levels and introduce students to analytics.

Lastly, I would like to see projects or activities that rely on everyday materials from home. For example, using toilet paper rolls to calculate surface area of cylinders or soup cans to calculate volume. If we expect students and teachers to use “math as a magnet,” then providing these lessons by math topic and grade would help. The simpler the better.

#10. I serve students in 5th through 8th grades and believe the above resources could even the playing field for students. When a student has a video explanation and a good example of what is expected, that student is more likely to persevere and be successful. If a student sees the real-world application, personal effort increases. In the same way, cross-curricular extension materials can help deepen the learning for students who have mastered the required content in a class.

#11. I need math and science resources categorized by topic as well as by grade or grade band. If I can find a project by topic, I can adapt to my grade level and students. Resources that can be accessed directly by the student, or linked by the teacher for easy use, would be preferable.

Engage Students Where Disciplines Converge

#14. Hands-on learning is a challenge due to safety and cleaning protocols. We have ordered class sets of items which we used to use in groups. For example, we previously needed 12 circuit boards to use in group settings but we now need 32 so that each child can have his or her own supplies. Even with the increased equipment, we have to spend extra time cleaning each set between classes.

Innovation is key during this time. We are using our Broadcast Journalism and Newspaper classes to connect the students to outside presenters. Our students interview community members about their careers or community projects and then use the information for their projects. For example, the twenty students in the Broadcast Journalism class interviewed our City Engineer and then edited the interview and showed the highlights to all 7th and 8th graders (1,000 students) in the Friday announcements.

Build Computational Literacy

#23. (Repeated from part of Question #9) I would like to see plug-and-play Google tutorials for middle school students, especially Google Sheets for math and science. With the emphasis on Google Classroom and remote learning, I think the time is ripe for students to incorporate these skills. I have not found a good source for age-appropriate tutorials and not all teachers are comfortable teaching with spreadsheets. The math standards for Data Analysis across the middle school grades seem to be the opportune area to insert these skills. Video tutorials and short "try-it" exercises would help standardize experiences across grade levels and introduce students to analytics.

Community Use and Implementation of the Federal Stem Education Strategic Plan

#24. Our district looked at various STEM programs in 2015 and the path we charted was similar to the Federal research. The main difference was the use of "Computational Literacy" where we focused on Student-Centered Design. We had many of the same goals but the term "computational literacy" is more inclusive of the band of skills.

[redacted]

[redacted] response to National Science Foundation Request for Information on STEM Education

[redacted]. Since 2012, we have collaborated with two- and four-year colleges, college access organizations, and employers to improve student outcomes. The positive impact of the [redacted] platform has been demonstrated in over 10 random control trials, and we have increased STEM student persistence by 10 percentage points.

We are responding to "Future Opportunities in STEM Education, question 2" and "Increase Diversity, Equity, and Inclusion in STEM, question 12." This response focuses on postsecondary education and addresses both learners as well as college administrators and student support staff.

Future Opportunities in STEM Education, question 2

Postsecondary STEM education would be enhanced by intelligent, mobile-based, and evidence-backed student support, especially during times of remote learning. When colleges were forced to restrict campus access due to the COVID-19 pandemic, STEM students lost more than just in-person instruction; they lost the face-to-face support of professors, advisors, tutors, and peers that we know keeps students engaged in school and in the STEM pathways that are critically important to their futures. This loss of in-person support has exacerbated an already vexing problem of students switching out of STEM majors and not continuing into fields needed for national economic growth and national defense. At the community college level, more than 20 percent of students major in a STEM discipline at some point (National Student Clearinghouse Research Center, 2017) but the majority do not earn a STEM degree: Approximately 35 percent graduate in a non-STEM major and another 35 percent fail to obtain any kind of postsecondary credential (Chen & Soldner, 2013). STEM attrition is similar at four-year institutions: 28 percent of baccalaureate students enter into STEM pathways, but nearly half depart before graduation. Amid the pandemic, we must find novel ways to continue tackling this problem given that 53 percent of manufacturing jobs are expected to go unfilled through 2028 because of a shortage of skilled workers (Deloitte and The Manufacturing Institute skills gap and future of work study, 2018).

[redacted] has developed an intelligent, automated system that reaches out to students via text messages ("nudges") to learn about their challenges, provide psychosocial support, connect students with campus staff and resources, and send reminders at pivotal moments like pre-registration, STEM career recruiting opportunities, and the FAFSA deadline. This system engages conversationally and forges an important bond between student and college, which is even more valuable while students cannot be on campus. Several studies have demonstrated the efficacy of this model for STEM students. For example, [redacted] partnered with a cohort of four community colleges in Ohio and Virginia that had developed middle-skill pathways to quickly-growing STEM careers in their regional economies (Soricone & Endel, 2019). The colleges needed to improve completion rates in these pathways, many of them in advanced manufacturing, robotics, mechatronics, and industrial technology. A random control trial demonstrated that these community college STEM students who were nudged for 7 weeks over the summer were 10 percentage points more likely to return for a second year of college compared to those who received business-as-usual support (O'Hara & Sparrow, 2019). In a non-randomized sample of university students taking online precalculus or

[redacted]

statistics, those who participated in nudging earned higher grades, were more likely to complete the course, and were more likely to pass the course (Carmean & Frankfort, 2013).

This nudging model, therefore, has proven highly effective in motivating STEM students to persist and excel. Moreover, students and colleges have found even more value in mobile support while both parties have felt disconnected from one another since the onset of the COVID-19 pandemic. College administrators and support staff, in particular, know the opportunities lost without in-person contact to build the relationships that keep students enrolled, and detect the hidden issues that lead students to withdraw. We view the promise for this technology to enhance remote STEM education occurring in three key areas: providing support for students forced into virtual learning environments, targeting support to underrepresented learners based on behavioral science, and diagnosing and correcting institutional barriers to STEM student success.

1. Providing support for students forced into virtual learning environments.

Students enrolled in Spring 2020 were forced to complete their coursework virtually, and this shift brought with it a palpable sense of frustration. Many students (and professors, for that matter) had never engaged in online education and required a whole new approach to learning, especially STEM students removed from beneficial hands-on instruction. Moreover, students struggled with finding a quiet and dedicated workspace at home, carving out time for study while stuck inside with family, and having adequate technology (e.g., up-to-date laptops, sufficient wi-fi) to fully participate in remote instruction. These issues remained in Summer and Fall 2020 when many students who wished to continue on their path to a STEM degree had no other option than online courses. [redacted] has supported thousands of online students and demonstrated through random control trials that students receiving nudges are more likely to finish their online classes and progress to the next course in the sequence. We have amplified our support for online students during the pandemic by developing a library of nudges with guidance for excelling in online education, fostering a sense of belonging with their college and peers while distanced from both, and maintaining emotional wellbeing during crises. Students expressed genuine gratitude for receiving this motivation and support during such a troubling time.

2. Targeting support to underrepresented STEM learners based on behavioral science.

College students face a number of psychosocial or meta-cognitive challenges that inhibit their ability to succeed, such as a lack of social belonging, a fixed mindset approach to education, and incongruence with their cultural values (Broda et al., 2018; Stephens, Fryberg, Markus, Johnson, & Covarrubias, 2012; Walton & Cohen, 2011). These barriers are heightened for STEM students, for whom the development of a positive STEM identity is pivotal for persistence and success, but which can be disrupted by stereotypes about who does and does not belong in STEM (Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011; Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013). These threats are greater still for students who belong to social groups traditionally excluded from STEM, such as women and Blacks (Riegle-Crumb, King, & Irizarry, 2019; Wang & Degol, 2017), but are also experienced by students who exhibit personality traits and personal values stereotypically viewed as incongruent with being a scientist (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011; Cundiff, Vescio, Loken, & Lo, 2013; Diekman, Steinberg, Brown, Belanger, & Clark, 2017).

[redacted]

Alleviating these threats is essential to students building a strong STEM identity, which will motivate them to persist in the STEM pipeline and enter into a STEM profession. Targeted nudges based on scientifically-validated interventions can do just that. For example, nudges that prompt students to self-reflect on the utility value of their STEM courses are derived from extensive research showing that these writing exercises improve STEM performance and persistence, especially among underrepresented students (Harackiewicz, Canning, Tibbetts, Priniski, & Hyde, 2016). Likewise, nudges that challenge STEM stereotypes that disproportionately deter some social groups from pursuing STEM are inspired by studies showing the importance for STEM persistence of congruence between one's personal values and those values perceived as important within STEM (Diekman, Clark, Johnston, Brown, & Steinberg, 2011).

3. Diagnosing and correcting institutional barriers to STEM student success.

During these times of restricted access to campus and remote instruction, administrators, faculty, and support staff are also disconnected from students. We have heard repeatedly from college partners how they know less about what is going on in their students' lives since the shift to remote learning, and feel more unsure about how to help them persist. This physical distance limits professors' and staff's opportunities to directly and indirectly learn about students' challenges that could force them to withdraw. Engaging with students in an easily accessible and comfortable medium, text messaging, creates a novel communications channel through which to identify students who are struggling. Students openly converse with the [redacted] platform and share problems ranging from financial shortfalls to academic barriers to mental health challenges. During the pandemic, for example, students indicated their need for better at-home technology, such as laptops and wi-fi hotspots, as well as their understandable frustration with the online learning environment.

[redacted] shares emerging themes and common issues with colleges so they can modify student-facing communications, supports, and procedures to better serve students' needs. For example, our partner colleges have changed how students enroll in college, revised how students apply for graduation, established food pantries, and distributed technology needs to students forced into remote instruction. Colleges with sufficient capacity have followed up with individual students to help them with their specific challenge while also reflecting on structural changes that could prevent other students from facing similar predicaments. Although the [redacted] support model connects only with students, the knowledge elicited allows us to make the institution a target of change, which may have the greatest potential to keep more students enrolled in college and persistent in STEM pathways.

<u>Increase Diversity, Equity, and Inclusion in STEM, question 12</u>

[redacted] uses its nudging support platform to increase the retention and achievement of students from various underrepresented groups in STEM, including women, Blacks, Latinos, and first-generation students. We do this by developing nudges from evidence-based interventions shown to disproportionately benefit underrepresented students. Examples of such nudges include:

- Nudges that persuade students that intelligence and skills are malleable through effort, known as a growth mindset (Dweck, 2006). Interventions that prompt college students to self-reflect

[redacted]

on areas of personal growth have improved grades and reduced equity gaps for both Black and Latino students (Aronson, Fried, & Good, 2002; Broda et al., 2018).
- Nudges that ask students to reflect on their most important personal values and how they relate to their education, known as a values affirmation exercise (Cohen & Sherman, 2014). Classroom interventions in which youth identify their values (e.g., friendship; family; creativity; athleticism) and write short essays on why those values are important to them improved long-term academic outcomes and reduced equity gaps among Black and Latino students (Cohen, Garcia, Purdie-Vaughns, Apfel, & Brzustoski, 2009; Sherman et al., 2013).
- Nudges that ask students to give advice to other students who are struggling. Giving advice to others can be empowering and motivating (Eskreis-Winkler, Fishbach, & Duckworth, 2018), and interventions that leverage this effect have improved academic fit and sustained enrollment for Black, Latino, and Native American college students (Murphy et al., 2020; Yeager et al., 2016).

Several psychosocial interventions of this style have also been shown to improve performance among underrepresented students specifically within STEM pathways. Examples of these include:
- Nudges that prompt students to consider the short- and long-term value of what they learn in STEM courses, known as utility value exercises (Harackiewicz & Priniski, 2018). Writing about utility value has reduced performance gaps within STEM college courses for first-generation and underrepresented minority students (Harackiewicz et al., 2016).
- Nudges that dispel erroneous stereotypes about who does not belong in STEM pathways and careers, known as goal congruence exercises (Diekman et al., 2017). Interventions that portray STEM careers as communal (e.g., offering opportunities to work with others and to help improve society) bolster students' opinions of STEM and their intention to pursue STEM careers, especially among women (Diekman et al., 2011; Steinberg & Diekman, 2018).
- Values affirmation exercises (described above) have also been shown to improve performance among women and first-generation students in introductory STEM courses (Harackiewicz et al., 2014; Miyake et al., 2010).

Our Behavioral Science team has leveraged the latest in psychosocial interventions in STEM to build a library of motivating and engaging nudges, and these are distributed to students by the [redacted] platform based on their demographic information and prior responses to the system. In this way, nudges are personalized to students based on who they are, what challenges they have expressed, and what we know scientifically about the best methods for intervening with those at risk of withdrawal from STEM.

Our main metric of success is student persistence in college, which we evaluate with both experimental and non-experimental methods. For example, in a random control trial conducted at an urban community college where the student body is 61% Hispanic and 33% Black, we observed a five percentage point increase in first-year persistence for students using [redacted]. In another sample of community college first-generation students, we observed a nine percentage point increase in first-semester persistence. When our engagements do not afford us the luxury of a random control trial, we employ matching analysis to approximate experimental and control groups based on baseline characteristics and whether students opted out of receiving [redacted] nudges. Using these methods, we continue to observe gains for underrepresented students on the order of 2 to 10 percentage points.

[redacted]

Submitted by:

[redacted]

I am a university administrator and represent the [redacted]. Responses are provided for all questions in all categories of the RFI with the exception of questions 17, 21, and 22.

Questions for Feedback

Provided below are categories from which the Government is seeking your input. Please respond to those questions within your (organization's) area of expertise or need. In your response, please identify the category(s) and question number(s) to which you are responding.

Future Opportunities in STEM Education

In response to the COVID-19 pandemic, education systems (including preK-12, postsecondary, adult, and informal) were required to make a sudden shift to remote or asynchronous teaching and learning, and this may continue in the near term. Please provide insights to the questions below based on current experiences. For each response below please indicate the education system (preK-12, postsecondary, adult, and informal) that covers your response and whether you are addressing school systems, schools, teachers/faculty/instructors, learners, other, or more than one category.

1. What COVID-19 related digital barriers (*e.g.,* access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

The most difficult COVID-19 related digital barriers have been access to broadband and technology. The digital divide is a much deeper problem but has been exacerbated as a result of COVID-19. The issue is not resolved and will require public and private entities to develop a plan for implementation supported by funding in order to bring broadband to every household.

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (*e.g.,* virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (*e.g.,* pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

For both K-12 teachers and students, the following activities would have a positive impact: virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, and micro credentialing.

3. What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies?

In all cases, the use of asynchronous and synchronous technologies have been instrumental in assisting teachers and students during COVID. The federal government could help to support the technology through funding that could be leveraged through contract pricing making the various technologies available for everyone.

4. What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success?

The greatest challenge was related to access. Second to access would be access to technology. (laptops) The access issue remains unresolved. To address some of the inequities during COVID, we implemented strategies to assist students in overcoming some of the challenges. The institution provided devices for students by allowing them to check out laptops, expanded the use of on and offline eLearning resources, developed course material that is more accessible via a mobile device, like a cell phone, and expanded access to the Internet by working with the community to identify businesses and agencies that provide free Wi-Fi.

5. What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.,* utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative assessments for those without access to technology/broadband)?

Professional learning would be most beneficial for educators that addresses meaningful collaboration and creating rigorous learning alternative for those without access to technology/broadband.

6. What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19? What data are you collecting currently related to the shift in education because of COVID-19?

Data about public access to broadband and actual cost to fully implement would be helpful for planning purposes. Formal comprehensive data is limited at this time.

7. What experience does your school system have with interoperable learning records or precision learning systems? If used, please share any barriers, solutions, or other information relevant to their effectiveness particularly related to digital barriers and the impact or effectiveness related to distance education. How were these concepts used or modified in response to COVID?

While precision teaching methods are utilized, they are limited to certain disciplines or courses.

8. What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful? What barriers prevented you from taking additional actions that may have been useful?

[redacted] *is in the process of being established. However, as an institution facilitating the STEM effort, all courses were transitioned to the online environment for the second half of the spring semester. Courses were offered through a variety of modalities which we have done for many years. New to us for Fall, 2020, was the HyFlex model in which half the class meets face to face one day per week while the other half accesses the class, synchronously online; for M/W/F classes, the schedule is the same, and Friday becomes a virtual day (either synchronous, asynchronous, or an online project) for all students. Many of the K-12 districts within* [redacted] *used a similar staggered approach to onsite vs online teaching.*

Develop STEM Education Digital Resources

The Federal Government is seeking information on web-based STEM educational resources and opportunities for preK-12 teachers, post-secondary faculty, educational institutions, informal educators, parents, and students.

9. What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized in a Federal website if such a site were developed?

It would be helpful to include resources that take advantage of virtual reality and artificial intelligence. The federal website should include a database of reputable resources that are rigorous and engaging and easy to locate using a complex database.

10. Please describe your primary audience (*e.g.,* I primarily work with 7th grade science students in a formal classroom setting) and how the STEM education resources you identified above would help you serve your audience.

The institution will provide oversight for the [redacted] *and the primary audience will be K-12 teachers and students.*

11. How would you like to see resources categorized (*e.g.,* subjects, topics, grade bands, Federal agency, other)? Do you have an example of another website that is categorized in this way? If so, please provide a link for reference.

All suggested categories would be beneficial.

Increase Diversity, Equity, and Inclusion in STEM

STEM education practices and policies at all levels should embody the values of inclusion and equity. All Americans deserve access to high-quality STEM education, regardless of geography, race, gender, ethnicity, socioeconomic status, veteran status, parental education attainment, disability status, learning challenges, and other social identities. For each response below, please indicate the education system or career experience for which you are responding.

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

The institution uses its inclusion and diversity division for its efforts. This is a relatively new division and interventions have not yet been measured. However, increasing recruitment, retention, and inclusion of individuals that are underrepresented and underserved is a priority.

Engage Students Where Disciplines Converge

Real world STEM problems require students to ask and answer questions across traditional disciplinary boundaries. This type of transdisciplinary learning, or convergence, is encouraged to produce STEM-literate talent capable of integrating knowledge to produce innovative solutions. Toward this objective, the Federal STEM Education Strategic Plan aims to (1) enable STEM educators through upskilling, resourcing, and providing a forum to share best practices; (2) support the dissemination of transdisciplinary education best practices and programs, and (3) expand support for STEM learners to study transdisciplinary problems.

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (*e.g.,* a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (*e.g.,* more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

In all applicable disciplines opportunities are presented for STEM interdisciplinary collaboration. This approach not only provides opportunities to engage students in STEM related activities, but it provides an opportunity for cross-discipline collaboration among departments and faculty.

14. How has your ability to teach transdisciplinary concepts to your students changed in recent months because of the shift to remote teaching and learning? What teaching modalities have you employed to deliver transdisciplinary instruction virtually?

The ability to delivery transdisciplinary concepts has not changed in recent months.

15. What training have you/your organization received in any of these approaches for teaching STEM education: Transdisciplinary, integrated, convergence, or engineering design, etc.? Please describe the training, if any (including university coursework or professional development), that helped you/your organization prepare to teach STEM using an integrated or transdisciplinary approach. Why was that specific training helpful, and if not, what could be done differently?

The institution provides opportunities for professional development onsite and online. There is continuous engagement between higher education and K-12 partners to further the advancement of STEM in the community.

16. If you are an educator or school system and interested in using a more integrated or transdisciplinary approach to teaching STEM, what professional development would help you teach in this way? What specific delivery mechanism work well for you (*e.g.,* online course, webinar, in-person workshop)? What technology tools would be helpful for you when using a transdisciplinary approach?

An online course or webinar would be beneficial. A series of webinars may be a more practical approach that focuses on a variety of topics.

17. If you are a student, what specific delivery mechanism works well for you (*e.g.,* online course, webinar, in-person workshop)? What technology tools would be helpful for you to enhance your learning and engagement to deliver transdisciplinary education to your students?

N/A

Develop and Enrich Strategic Partnerships

The Federal Government seeks perspectives to building STEM learning ecosystems through cross-sector strategic partnerships that promote work-based learning programs aimed at reskilling and upskilling. For the following questions, a STEM education partnership is a group of multi-sector partners united by a common vision of creating accessible, inclusive STEM learning opportunities that increase STEM literacy, expose learners to multiple STEM career pathways, and prepare Americans for jobs of the future.

18. What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

A successful work-based learning program can benefit from open communication and strategic planning that takes into account the needs of all partners. Federal agencies can expand partnerships by providing financial support and resources that provide opportunities for agencies to expand upon current work and increase opportunities for new development.

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success? What is the role of the private sector in a successful STEM learning ecosystem? What is your STEM ecosystem doing to support STEM education since the COVID-19 pandemic began?

The institution is in the process of establishing a STEM center in [redacted]*. Every effort will be made to develop and expand opportunities that lead to success for both teachers and students. Current efforts include the development of a plan that aligns with the federal STEM plan and participation in discussions about opportunities to further enhance* [redacted] *STEM professional development for teachers and engaging and inclusive activities for students.*

Build Computational Literacy

The Federal Government seeks information on building computational Start Printed Page 67382literacy in STEM education. In the Federal Strategy for STEM Education, computational literacy includes digital literacy, cybersafety, cyberethics, cybersecurity, data science, data security, intellectual property (IP), computational thinking, artificial intelligence, quantum information science, and digital platforms for teaching and learning. Considering this definition, please answer the questions below:

20. What are the benefits when integrating computational literacy within a STEM curriculum and/or with related standards, guidance, or resources? Please describe any challenges when integrating aspects of computational literacy into your instructional delivery.

No challenges have been identified. A benefit of integrating computational literacy within a STEM curriculum is that students are provided with an opportunity to develop or enhance problem-solving skills.

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.

No comment at this time.

22. What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs.

No comment at this time.

23. What technologies and resources do you currently use (*e.g.,* apps, learning management systems, collaborative tools, STEM websites, websites linked to curriculum)? Are there others you would like to use, that you do not have access to both for in-person and remote teaching and learning?

The institution currently uses Moodle as an LMS, WebEx, Zoom, and Teams

Community Use and Implementation of the Federal Stem Education Strategic Plan

The Federal Government seeks information on community utilization of the Federal STEM Education Strategic Plan.

24. Please describe how your organization has used the Federal STEM Education Strategic Plan. How does your work align with the goals and pathways identified in the Strategy (provided above)? What changes have you made to your program or activity in response to the Federal Strategy?

The Federal STEM Education Strategic Plan has been used to create the local plan for the establishment of the [redacted]*. The local plan's goals and objectives are in alignment with the federal plan.*

Please consider the term STREAM

Science
Technology
Research
Engineering
Aeronautics
Math

Responses by [redacted]

Question 1: What COVID-19 related digital barriers (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

- Access to computers
- Access to software
- Complications around learning styles that are more in person or a paper-based
- Client reliance on cell phones as their point of access internet; limited applications
- Had to become ready-made IT and tech instructors in addition to the content experts
- Partnered with Tech System; procured additional hardware (laptops)
- Basic navigation and computer usage skills
- Knowledge and level of comfort with using software and platforms
    - Zoom, Google classrooms, Microsoft Teams, basic email systems (limits on size, firewall issues)
- Work from home challenges; no direct immediate access to IT staff
- Wi-Fi/ broadband stretched to its limits
- Affordability around the necessary broadband to do virtual-based / interactive engagement platforms

18. What factors drive successful work-based learning programs?

- Have retention efforts built into the costs
- Clarity of information, knowing the next steps
- Progressive wage increases
- All research indicates that the ROI positively impacts industry performance, safety, costs, efficiencies, retention
- Proof of competent workers drives economic development and regional growth n
- Acknowledging the emotionality and human centered impact on individual success

What elements encourage or **discourage** students, schools, or industries from participating?

- Reporting is costly – time, seen as "invasive / intrusive", confusing, very bureaucratic – isn't in industry speak
- Costs associated with:
  - Wages
  - Related technical instruction
  - Loss of productivity is a real cost to the employers but also perceived
- Concerns over the "population" that "qualifies" for public workforce/ education grants
- Barriers experienced by employers aren't being addressed, skills are missing, but investments need to be made in soft skills, people skills, addressing mental health/AODA challenges, team work, anger management
- Fear over organizational "cultural" shifts that will come with changing talent supply /pipelines
- Terms of commitment – marketplace moves more quickly than codified contracts (ie with apprentices or investments in incumbent workers).
- Market-based hiring - while not sustainable, employers still have the ability to cream and "throw money" at the skills gap issue as short term fix,

How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities?

- Investment in workforce; more cost sharing with employers so they are not shouldering the full costs (ie: apprenticeship – wages, RTI, etc)
- Providing funding for capacity building efforts by intermediaries
- Reward high road employers through workforce development invests; intentionality in what employers are connected to the opportunities
- Reward career pathways and careers, not jobs
- Invest in success and retention efforts intentionally – more longitudinal
- Provide more guidance and advisement on hiring and retention practices for employers that encourage competency-based assessments of candidates, diversity,

If your organization provides work-based learning opportunities, how has the COVID–19 pandemic impacted your program? How has your organization made adjustments in response?

19. If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success?

- Flexibility being agile
- Positivity and willingness
- Demystify the “exclusiveness” of what STEM is; begin to translate how its already embedded and existing with what is happening everyday

Smart alignment, pro-industry language that makes it approachable, digestible

What is the role of the private sector in a successful STEM learning ecosystem?

- Best practices within apprenticeship have career pathways, wage progression, etc….,
- Connect to the public workforce system and education institutions early
- Continuous validation, investment, and encouragement around professional development, “adult” education amongst workforce at all experience levels
- Expansion of CTE across all occupations / industries
- Move away from the emphasis around a “traditional” four year degree education institutions

What is your STEM ecosystem doing to support STEM education since the COVID–19 pandemic began?

Organization: We are the [redacted]

Question: Increase Diversity, Equity, and Inclusion in STEM, Question 12.

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

I. Who are we, and who do we target?

[redacted] Furthermore, we foster community and promote the intellectual development of current and future [redacted]. We work with the program and the Department of Biology to implement changes and collate resources. In carrying out our mission, we seek to identify ways to better serve underserved groups in STEM.

II. What are the methods we use to increase Diversity, Equity, and Inclusion in STEM?

RECRUITMENT

<u>*Current efforts*</u>

Since our organization was formed in April 2019, [redacted] has mostly focused on **<u>eliminating financial barriers</u>** to program admission, since these barriers are recognized as an important contributor to disparities in representation of diverse groups in STEM (Eisen, 2020; Chakraverty, 2020). Thus far, we have successfully advocated to have links to application fee waivers posted directly next to the application link on the [redacted] website. Moreover, the [redacted] no longer requires GRE scores for admission to the graduate program (Wilson, 2018).

The focus of our department's recruitment efforts for underrepresented students has been on **<u>signaling the openness of the [redacted] community</u>** to students from different backgrounds. Our organization has assisted in this endeavor in at least three ways. First, ***we developed stickers*** that read 'you are welcome here,' accompanied by a variety of study organisms in the colors of the rainbow. These stickers are posted on the doors of most laboratories in the [redacted]. Second, ***we meet with recruits during our program's orientation week*** to answer questions and provide a 'crash course' for graduate school, and we have also established a peer mentorship program (described below). Third, ***we created a resource document for graduate students*** (also described below) that includes information on cultural centers, community events, disability access, maternity resources, and welcomingness that may otherwise be difficult to find online.

Future suggestions

Our department, and especially the [redacted], is not representative of the demographic composition of the U.S. This lack of diversity in our program is problematic, specifically for trainees from underrepresented groups, because it is difficult to visualize your own success without seeing people with your identity succeeding (Archer et al., 2015). Additionally, having faculty from various backgrounds and from underrepresented groups can help improve the sense of community and reduce the sense of isolation for graduate students from these groups, as well as improve mentoring outcomes (Miller and Orsillo, 2020; Brunsma et al, 2017). ***We have advocated for our program to make an intentional effort to hire faculty and postdocs from underrepresented groups***. These efforts could be especially successful with group/cluster hires so that the faculty themselves do not then feel isolated. To date, this has not resulted in more-diverse faculty hires in our department..

Our program could also improve by **intentionally targeting a wider, more diverse audience with program advertisements**. For example, by intentionally contacting and forming partnerships with small liberal arts colleges, historically Black colleges and universities, and state universities, we can reduce the tendency of the program to recruit graduate students from already-privileged backgrounds.

GRADUATE STUDENT RETENTION AND INCLUSION

Current efforts

One potential contributor to the lack of diversity and inclusion within STEM-related fields is the presence and persistence of financial barriers (Eisen, 2020). To address this issue, [redacted] and the [redacted] have taken several actions. Earlier this semester, [redacted] ***successfully obtained a grant to create a laptop loaner program***, through which students can borrow laptops either short- or long-term for their research. The purpose of this program is to reduce potential unforeseen financial burdens in the event that one's laptop needs replacement mid-year.

In addition, ***the Department of Biology provides enrichment travel funds ($300 per year, per student) to use for travel and conference expenses***. These awards help all students immensely, particularly economically-disadvantaged students who might not otherwise be able to participate.

Short-term psychiatry and counseling services are available for students enrolled in classes. As part of their health center fee, students are entitled to an evaluation and counseling session at no cost. Additionally, graduate students are eligible for EAP (Employee Assistance Program) counseling services. This service provides six online counseling appointments per presenting issue. However, these programs are not sufficient for economically-disadvantaged students who require long-term, regular counseling (see *Future Suggestions*).

One of the major barriers to retention of underrepresented groups in science at all levels (particularly for BIPOCs) is a sense of loneliness, isolation, alienation, and lack of a sense of community (Quarterman, 2008; Miller and Orsillo, 2020, Eisen, 2020). In order to address this barrier to retention, ***our organization implemented a peer mentorship program***, which pairs first year students with more experienced graduate students. This program helps new students network with their peers in the program and receive guidance and advice on successfully navigating the program. As a new program, metrics are not yet available; however, based on student feedback, the program appears to be effective in promoting a stronger sense of community and continuity in our graduate program. A recent meta-analysis of graduate student peer mentorship programs suggests that these programs benefit students by increasing their confidence, reducing feelings of isolation, and improving networking opportunities (Lorenzetti et al., 2019).

Future suggestions

Graduate students are six times more likely than the general population to experience anxiety and depression (Evans, 2018), and this disparity is even more pronounced for BIPOC, women, and transgender graduate students (Arnold et al., 2020). Many students cite financial limitations as a barrier to accessing mental health services, especially therapy and counseling. We have repeatedly advocated for our department to offer **free mental health services** to all graduate students, but no action has been taken as of yet. For graduate students (although similar efforts would no doubt benefit postdoctoral scholars and faculty), we could offer free mental health services to all students in our department (~150 graduate students) for roughly the budget of supporting a single graduate student in our 5-year program.

While our department provides exit surveys for graduating students, the current survey does not identify needs that may be specific to certain groups or address issues like a (lack of) sense of community. We feel that departmental improvement in the DEI space will hinge on the solicitation of and response to student feedback, with specific attention paid to those from underrepresented groups.

ACHIEVEMENT AND ADVANCEMENT

Current efforts

The [redacted] currently has little ability to track the achievement of its graduates once they leave the program. In order to create a mechanism to track these metrics, [redacted] ***created an alumni network*** database that tracks all students who have entered the program since 2003. Besides the ability to track the positions that graduates hold, this network is also useful for matching current students with mentors from similar backgrounds or who are interested in similar industries, as well as for inviting seminar speakers.

[redacted] has also been actively working on **identifying and demystifying the 'hidden curriculum' of graduate school**. We have collated resources about the university, department, courses, and town into a document accessible by all graduate students in the department. This document includes information about navigating the graduate program itself (since access to this information previously varied widely by lab), as well as potentially sensitive topics, such as accessing financial and medical resources. This is a living document that is constantly growing as additional topics are identified.

Furthermore, [redacted] has created mechanisms for **facilitating conversations about grad students' program and career pathways**. We successfully advocated for the program to require ***individual development plans*** (IDPs) for grad students and to ***revise the format of annual committee meetings*** to include a period of time where the student can speak to their committee without their primary advisor present, which can facilitate networking with committee members and potentially increase retention. Both of these mechanisms increase communication between students, advisors, and committee members and can help resolve any tensions between advisors and students concerning plans and trajectories before they become major points of conflict. Both of these mechanisms are in their first year of implementation, so we do not yet have data on their effectiveness.

Future suggestions

We suggest holding **symposia or a seminar series that includes researchers from underrepresented groups** in the style of [redacted] To foster academic collaborations and connections across departments, we recommend a research equivalent of "speed dating" outside of an individual's program [redacted] or across departments. We also recommend thoughtful consideration of authorship guidelines, particularly for authors who are undergraduate students or junior graduate students, at least within individual labs.

A disproportionate amount of Diversity, Equity, and Inclusion labor is performed by individuals from underrepresented groups. This work takes time away from research and is typically unrewarded in academia. We recommend **broadening evaluation metrics for success within the program that translate into meaningful career**

contributions. These metrics could take the form of awards for outreach, teaching, work in diversity, and other forms of service for both graduate students and faculty. Given that most Ph.D. students do not pursue long-term careers in academia (Ghaffarzadegan et al., 2015), we recommend embracing opportunities for work in industry. We believe that allowing students to use internship experience as a dissertation chapter shows an appreciation for careers in industry and provides a practical reward for this work.

III. How do we evaluate these methods?

Current efforts

Currently, ***our primary metric for evaluating student success in the*** [redacted] ***is the newly-created alumni network***. This document serves as a tool for networking with alumni and lists their current positions and email addresses. As an evaluation tool, the alumni network allows us to quantify the number of alumni from the [redacted] that are currently employed in academia, our field, or outside of our field. This document also contains information about student retention and achievement, such as the number of years alumni were in the [redacted], the years that they joined and left the program, the names of their advisor(s) while in the program, and whether the alumnus finished the Ph.D. program successfully or transferred from a Ph.D. to a M.S. degree.

Future suggestions

In the future, ***we would like to implement program-specific exit surveys for graduating students*** as an additional metric for assessing student achievement in the [redacted]. These surveys would include questions about each graduate students' experience in the program and would allow students to provide any suggestions for improvement that they may have for the program.

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Responses submitted by [redacted]

Future Opportunities in STEM Education- What COVID-19 related digital barriers (*e.g.*, access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge? In addition to the immediate and mandatory transition to remote learning brought on by the Spring 2020 outbreak of COVID 19, instructors and students were thrust into providing a learning environment using a virtual platform in all disciplines. Because science and engineering disciplines traditionally have utilized "hands-on" learning experiences, the expanded use of virtual modes of instruction presented multiple challenges. For example, many upper-division courses in related disciplines use lab-based and project-based performance assessments to evaluate student learning. Unfortunately, many commercially available learning platforms are tailored for introductory and lower-division courses, and often, the costs of these resources are prohibitive. These challenges were amplified by the factor that most K-20 faculty and administrators were limited in formal professional development related to remote and digital instruction. Thus, all educational institutions were faced with providing immediate teacher and staff training.As a consequence of many of the students of our region living in rural areas and high-poverty areas, there was a lack of internet access, uninterrupted service, and funding to meet the need for broadband services. For the same reasons, many students relied on institution supplied computers; however, due to COVID 19 mitigation, student access to institutional facilities and equipment was limited and restricted. Virtual laboratory simulations, heavy in animation and interactive content combined with the use of available lower-priced computer tablets and notebooks (e.g., Chromebooks) lacking in the memory to execute necessary function added to the existing challenges. However, the need to overcome these challenges (e.g.inequitable access to education, technology, resources, etc.) gave rise to opportunities such as new and accelerated collaborative endeavors with organizations like [redacted] GEAR UP, Discovery Education, and Coursera. [redacted]

Audience: postsecondary, PK-12 students Addressing: schools , teachers/faculty/instructors, learners

What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (*e.g.*, virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (*e.g.*, pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas. Our institution provided professional development opportunities for faculty training, e.g., Quality Matters sponsored training workshops. Some institutions and school districts were responsive in meeting the needs of faculty and students by providing computer laptops for loan. However, due to a limited supply and campus distance, many students did not receive a computer. As a result, subgroups of students have opted to use their cellphones to access virtual learning platforms, which is not recommended due to difficulty with content and image interpretation and the omission of pertinent information, "dangling" content. Faculty were encouraged to join various webinars and virtual instructional sessions to enhance their ability to navigate through software packages, including their institution's learning management system(s), and to gain knowledge and practice with various instructional modalities. Learning Management Systems (LMS) were expanded to included conference settings for recorded or pre-recorded lessons, shared screen display, and audio and visual transmissions without interruption. Faculty and teachers (preK – 16) were challenged with using existing virtual platforms, e.g., Google Meets and Skype, to produce virtual communications with students; in partnership with an institution's LMS for virtual course delivery. This approach has presented problems in terms of length of time per online discussion (without being cut off for exceeding the time limit per session) or wi-fi connectivity issues that include video and audio functions. Audience: PreK-12, postsecondary Addressing: school systems, schools, teachers/faculty/instructors, learners, other

What positive experiences using remote learning technologies have you had in recent months and how can they be enhanced or institutionalized to present new opportunities in STEM education? How has [or could] the Federal Government helped support these innovative technologies? Our public institution has offered virtual courses and summer programs to more students in far away from physical locations, which provides an opportunity to recruit students from areas of the country and abroad who may not otherwise enroll at our institution. A major (positive) impact has been to train STEM faculty in using technology to become more creative and innovative for teaching in the 21st century environment. Faculty and high school teachers are experiencing more interaction in building student success programs. Dual enrollment and "banking" courses are being offered to a broader audience of high school students to enter college after high school. Also, improved relationships among teaching staff have developed through shared goals and training, including college faculty and teachers at all grade levels. Audience: postsecondary Addressing: teachers/faculty/instructors

What are the greatest challenges that have emerged related to inequities in STEM with the shift to online education and training? What solutions did you identify, and what gaps remain in your ability to deliver/receive equitable STEM education services? How did you measure your solution's success? Traditionally, STEM faculty were trained to engage students in "hands-on" experiences in a laboratory class setting. Digital technology and online education have challenged faculty at all levels of teaching experience and training to rethink class activities and seek additional teaching/ learning resources. Open Educational Resources and other digital resources are being used to help meet challenges in pedagogy and assessment for online course delivery modes. Our institution has also provided professional development training opportunities in Quality Matters training and other specialized training relevant to the discipline or teaching area. As the population of faculty increased with online course training, collaborations were built among some faculty to enhance their course delivery modes with additional digital programs to meet student needs in grammar, composition, and technical writing. Additional resources were "discovered" and shared among faculty for organizing course content in a meaningful way for online delivery; also, innovative digital platforms were "paired' to traditional platforms for effective teaching and best practices. This effort continues to improve each day. Audience: postsecondary Addressing: teachers/faculty/instructors, learners

What areas of professional learning would be most beneficial to educators providing remote instruction (*e.g.*, utilizing formative assessment, small group collaboration, facilitating meaningful discourse or inquiry, creating rigorous alternative Start Printed Page 67381assessments for those without access to technology/broadband)? Once faculty and teacher surveys are disseminated and reviewed, it is expected professional learning opportunities would benefit teachers in utilizing formative assessments, creativity in meaningful discourse or inquiry, rigorous, developing more rigorous and convoluted problems to solve, and group collaborations with faculty on and away from campus. Also, disciplines of study can build collaborative groups among faculty from different regions of the country. A significant challenge continues to be in the area of access to technology/ broadband. For example, during August, a devastating hurricane hit [redacted] and surrounding areas of the state. Electricity, among other public services, were interrupted for days to weeks. This devastation due to weather conditions caused many problems for students, faculty, and staff at all education levels within the region.

In our College of Education, our HUB team has created and leveraged instructional resources for our [redacted], and our local school districts. Also, partnerships with Discovery Education and Coursera have allowed the University to address critical instructional challenges on and off-campus. [redacted] The partnership has now extended to PK-12.

Audience: preK-12 , postsecondary, adult Addressing: school systems , teachers/faculty/instructors, learners

What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19? Were these actions helpful *** As a result of the recent pivot, our team has worked to identify world-class partners that co-construct content on unique platforms that are accessible with and without broadband connectivity. With partners including Discovery Education, [redacted] GEAR UP, Cyber.org, and Coursera, faculty, staff, and students have benefited and can continue learning synchronously and asynchronously at their leisure. Innovative solutions, including credit and non-credit bearing pathways, have allowed users /students/customers a flexible and personalized learning opportunity in an uncertain and tumultuous time. [redacted]

Audience:preK-12, postsecondary, adult, informal Addressing: school systems, schools, teachers/faculty/instructors, learners, other

Develop STEM Education Digital Resources - What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website? If so, please provide a link for reference. What aspects of this website should be utilized on a Federal website if such a site were developed?

- National Girls Collaborative Project , https://ngcproject.org
- Girls Who Code, girslwhocode.com
- ITEEA, https://www.iteeea.org
- Discovery Education, www.discoveryeducation.com
- Coursera, www.coursera.org
- Cyber.Org, cyber.org
- Mott Afterschool, https://www.mott.org/work/education/afterschool/
- [redacted]
- NASA, www.nasa.gov/content/educator-resource-center-network
- [redacted]/
- [redacted]
- [redacted]

Audience:PreK-12, postsecondary, adult, informal Addressing: school systems, schools, teachers/faculty/instructors, learners, other

Increase Diversity, Equity, and Inclusion in STEM - What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success? At a university level, [redacted] has established a division of Inclusion Initiatives & Student Success lead by Dean Devonia Love-Vaughn and her staff who are implementing several actions: capitalizing on the momentum and motivation created by the Black Lives Matter march organized by students of [redacted] and neighboring [redacted]; continuation of the state of the Black Tech Students sessions to discuss in an open and safe space the challenges of being a Black student at [redacted] during times of racial unrest; the development of the Inclusive Excellence Advisory Council that will help inform inclusion initiatives on our campus; and policy and processes brought forward from the Naming Committee, which is charged with assessing and vetting the naming of spaces and facilities on our campus.

The College of Education learns from and aligns with these university initiatives in several ways. First, all teacher candidates take a course called Diverse Learners. This course focuses on the awareness, knowledge, skills, and dispositions needed to identify, assess, teach, accommodate, and manage diverse learners' instructional needs. We understand, however, that these essential topics must be reinforced and practiced throughout the program. Diversity, equity, differentiation, language, socioeconomic status, race, achievement gaps, and structural inequalities in schools are topics embedded in STEM education coursework and field experiences. Our field experience placements, both in schools and in other educational programs, include various settings with diverse populations. One example is a partnership we started four years ago with a local organization assisting students seeking their high school equivalency test (HiSET). The students come from a variety of backgrounds and represent a wide range of ages, learning abilities, and in some cases, language barriers. In our Classroom Interactions course, participants actively engage in the lesson planning and tutoring of these students to help them gain their high school diplomas. [redacted] is one of 19 national universities that has been selected to participate in a three-year institutional change initiative known as IChange as part of Aspire: The National Alliance for Inclusive & Diverse STEM Faculty. In addition to furthering our efforts toward inclusive excellence in our faculty recruitment, success, and retention, change aims to ensure faculty use inclusive practices in teaching, advising, and research mentoring. Dr. Katie Evans, Associate Dean of Strategic Initiatives in the College of Engineering and Science, has been asked to lead this campus-wide effort. Audience: preK-12, postsecondary, adult, informal Addressing: school systems, schools, teachers/faculty/instructors, learners, other

Engage Students Where Disciplines Converge - How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (*e.g.*, a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (*e.g.*, more engaging for students, school/administration promotes transdisciplinary learning), and how does it benefit your students' learning? Transdisciplinary learning is critical for students entering 21st-century careers. There are specific examples of programming and outreach at our university that bridge the gap between the disciplines and make the instruction and engagement more engaging and applicable in the real world. Examples of significant efforts and interdisciplinary partners at [redacted] include the following:

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Audience:preK-12, postsecondary, adult, informal Addressing: school systems, schools, teachers/faculty/instructors, learners, other

Develop and Enrich Strategic Partnerships -The Federal Government seeks perspectives to building STEM learning ecosystems through cross-sector strategic partnerships that promote work-based learning programs aimed at reskilling and upskilling. For the following questions, a STEM education partnership is a group of multi-sector partners united by a common vision of creating accessible, inclusive STEM learning opportunities that increase STEM literacy, expose learners to multiple STEM career pathways, and prepare Americans for jobs of the future.

As part of the [redacted] initiative led by the [redacted] is a group comprised of educators, non-profit and government leaders, and industry partners. [redacted] Our structure includes a hub will be led by a director. The home institution of the director will be [redacted]. Leadership at the hub work in tandem at 6 specific satellites along [redacted]. The satellites include [redacted]. Leaders at each of these physical and virtual sites are critical for understanding some of the greatest strengths and opportunities related to STEM at their respective satellite institutions and in their communities. The regular and open conversations at the community level are brought back to the hub site, and the STEM director of the region will help communicate the opportunities and challenges to those that help inform, support, and guide the regional work. The hub leadership will also help better leverage existing regional resources, including contracts, regional/national/international partnerships, and funding sources to ensure that we are ensuring the greatest impact possible for those we serve. Audience:preK-12, postsecondary, adult, informal Addressing: school systems, schools, teachers/faculty/instructors, learners, other

Build Computational Literacy - What are existing programs, content, curriculum, or education and training opportunities that inform successful examples of building computational literacy in STEM education? Identify both Federal and non-federally sponsored research and programs. [redacted] offers a Bachelor of Science degree in Cybersecurity, Computer Science, and a certificate program in data analytics. The department of Computer Science receives both federal and non-federal support from agencies including the Department of Education, National Science Foundation, Department of Defense, [redacted], AT&T, IBM, Dell, Cyber Innovation. [redacted] staff and faculty have helped co-construct curriculum with Cyber.org for PK-12, including most recently content for Computational Thinking: https://cyber.org/computational-thinking. Additional cyber and computational thinking related efforts at [redacted] include the following:

[redacted]

Audience:preK-12, postsecondary, adult, informal Addressing: school systems, schools, teachers/faculty/instructors, learners, other

Future Opportunities in STEM Education

Question #2:

I am [redacted] For over 25 years, [redacted] has focused on improving the quality of life and level of inclusiveness for individuals with cognitive and mobility disabilities. Our research focuses on the areas of rehabilitation engineering and assistive technology, and our current research portfolio includes robotics, computer-brain interfaces, and alternative energy sources for mobility devices.

Several [redacted] staff and students are, themselves, individuals with disabilities (Iw/D), and their insight and personal experiences have resulted in numerous projects and patents that have positively impacted the lives of Iw/D (along with their caregivers) around the world. We take every opportunity to highlight the successes of our students and staff to a larger audience in an effort to entice K – 12 students with disabilities to consider STEM programs of study.

We offer a NSF-sponsored REU program each summer, and we believe that a new program that would pair current high school students with disabilities (grades 9 -12) with university students and staff to serve as mentors would create greater interest in STEM at the post-secondary level for Iw/D. While many advances have been made in terms of accessibility and assistive technology, there remains a dearth of Iw/D in STEM.

By implementing a research/mentoring program during high school, there is a greater opportunity for students to consider (and plan for) post-secondary STEM programs.

[redacted] would be happy to serve as the test site for such a program and we would gladly share our experiences and data with a larger audience to assist with wider implementation. The program would be a 4-week on-site program that exposes students to various elements of rehabilitation engineering/STEM subjects and would include tours, demonstrations, and individual meetings/projects with university staff and students (Iw/D). The program would culminate in a final presentation where participants would present the results of their research project.

NSF National STEM Education Plan Input

<u>Question 1</u>: What **COVID-19 related digital barriers** (e.g., access to broadband or computers, digital learning platforms, online educational resources) have you found most prominent, impactful, or difficult to overcome? Are these barriers resolved fully, or partially? If resolved, how was that achieved? If not resolved, what barriers remain to resolving the challenge?

Across multiple programs, we have found that access to a stable internet connection is a major challenge in Arkansas, a primarily rural state. In efforts to address this issue, many Arkansas public school districts parked WiFi-equipped busses throughout their districts to allow for internet access to students and the public when the pandemic began. The [redacted] has signed agreements with AT&T and T-Mobile to purchase WiFi access points and data plans at a reduced cost for every school district in the state [redacted] Likewise, institutions of higher education in Arkansas also extended their WiFi access to parking lots for public use during the pandemic [redacted] Resources, such as this interactive map of citizen-reported networks [redacted] help the public identify WiFi hotspots in their area. Despite these efforts, WiFi access remains a challenge for many of the more rural areas of the state, as can be seen in the interactive map.

Another challenge that was identified was a lack of access to a device suitable for remote learning. One initiative that seeks to address the challenge of resource accessibility, including internet and device access, is the Tech Depot recently opened in Newport Arkansas. Created as a partnership between the Office of Skills Development, the Newport Economic Development Commission, the City of Newport, and the Arkansas Center for Data Sciences, the Tech Depot provides access to state-of-the-art tech resources, including computers and robust internet connectivity, in an area that has traditionally lacked ready accessibility to those resources. The Tech Depot will serve as the primary location for training for several Registered Apprenticeship Programs in the area. This approach of providing a central location for tech resources will likely be duplicated in other under-resourced areas of the state in the future.

Finally, another minor barrier with IT Apprenticeship programs in particular was the almost instantaneous transition from in-person to remote training and work experience at the beginning of the COVID-19 pandemic. Fortunately, the IT area was well-prepared for such a transition, and many of the key stakeholders were already sufficiently familiar with critical programs and processes for remote delivery (for example, remote meeting programs). Given the ongoing situation, there is now an increased effort to establish and expand fully remote apprenticeship programs.

Question 17: If you are a **studen**t, what specific delivery mechanism works well for you (e.g., online course, webinar, in-person workshop)? What technology tools would be helpful for you to enhance your learning and engagement to deliver transdisciplinary education to your students?

Though there has not been a widespread formal survey of students in Arkansas on these subjects, many students have provided anecdotal input. Students have indicated that it is important to use Learning Management Systems to help facilitate an experience as close to a "live" experience as possible (video conferencing in particular has proved especially useful towards this goal). Many aspects of the learning experience (though not necessarily content) must be conscientiously replicated remotely, such as recognizing each student in Zoom graduation ceremonies, or providing virtual opportunities for networking and getting to know educators, fellow students, and employers.

Despite the fact that many students are growing accustomed to remote learning, many students at community colleges throughout the state have expressed that they would prefer in-person learning. However, many students have also expressed that they greatly appreciate the flexibility that asynchronous remote learning can provide.

Question 18: **What factors drive successful work-based learning programs?** What elements encourage or discourage students, schools, or industries from participating? **How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities?** If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

Some of the major factors that drive successful work-based learning are a dedicated mentor, known deliverables, and a genuine learning opportunity. It is crucial that a well-defined "need" is identified, usually a task or project a company or organization actually needs accomplished, though they do not necessarily have the resources to pursue themselves. In this sense, small businesses and nonprofits are typically excellent partners for these initiatives.

One of the major elements that discourages industry partners from participating is a lack of resources to develop the project in a way that would be conducive to the classroom. Many employees do not have the time needed to oversee a work-based learning project.

Consequently, one of the major ways Federal agencies could expand collaborative work-based learning opportunities would be to provide support for organizations that facilitate these opportunities. An external body providing facilitation assistance and Project Management assistance is often a crucial piece that lessens the workload of the industry partners while improving the learning experience of students. For example, the Arkansas Center for Data Sciences has proposed a project which would establish an Arkansas Small Business/Nonprofit Enabler (ASMBLER) initiative. This initiative would connect small businesses and nonprofits with students seeking work experience, which will help them become qualified for IT jobs in the future.

Finally, it would also be beneficial to have more support for “externships” for teachers. That is, experiences through which teachers may gather real-world experience themselves by working with industry partners on limited-term projects. This in turn may help teachers provide more industry-relevant instruction or improved facilitation of work-based learning projects.

[redacted]

November 20, 2020

National Science and Technology Council's (NSTC) Committee on STEM Education (CoSTEM)

RE: [redacted]: STEM RFI Response

Dear Members of CoSTEM,

Thank you for giving the [redacted] the opportunity to provide input into the implementation of the *Federal STEM Education Strategic Plan*. [redacted] is a research, policy, and advocacy organization dedicated to strengthening and advancing the work of public universities in the U.S., Canada, and Mexico. Its 232 U.S. members include public research universities (203—including all land-grant universities), state university systems (26), and affiliated organizations (3). [redacted] agenda is built on the three pillars of increasing degree completion and academic success, advancing scientific research, and expanding engagement. Annually, its U.S. member campuses enroll 4.3 million undergraduates and 1.2 million graduate students, award 1.2 million degrees, employ 1.1 million faculty and staff, and conduct $46.8 billion in university-based research.

In all responses, we are referring to higher education institutions, with a focus on public research universities and land-grant institutions. Following our introductory comments, we are providing responses to "Future Opportunities in STEM Education", **questions 1, 6, and 8;** "Develop STEM Educational Digital Resources"**, question 9;** "Increase Diversity, Equity, and Inclusion in STEM"**, question 12**; and "Develop and Enrich Strategic Partnerships"**, questions 18 and 19.**

The federal STEM education plan included as a priority goal to increase the diversity, equity, and inclusion (DEI) in science, technology, engineering, and mathematics (STEM), and we strongly support the inclusion of this critical goal in the next version of this five-year plan. Ensuring that we have the fullest participation possible in STEM is vital to the economic prosperity of the nation and to providing equitable access to rewarding careers for all. We support continued investment in the DEI-focused programs within the federal agencies. As noted in the National Academies *Minority-serving Institutions* report (2019), minority-serving institutions (MSI) have a vital role to play in expanding STEM talent, producing one-fifth of the nation's STEM bachelor's degrees, yet these institutions remain underfunded. Programs such as the National Science Foundation's (NSF) Historically Black Colleges and Universities (HBCU) Undergraduate Program, NSF's Hispanic-Serving Institutions, the Department of Education's Minority Serving Institution Partnership Program, the United States Department of Agriculture's (USDA) 1890 Facilities Grants Program, and others, help MSIs deliver high-quality educational opportunities to students. Additionally, we support the individual programs across the federal agencies that help broaden participation and expand our STEM talent. As example of one of these programs, we highlight in a later section APLU's work in the NSF INCLUDES project.

As noted in the *Progress Report on the Federal Implementation of the STEM Education Strategic Plan*, the service that federal agencies provide for work-based learning for students via national labs and other partnerships is a valuable resource for public research universities. We also highlight the important role that federal agencies can play to improve data science training and access to data for education purposes. We note, specifically, NSF's commitment for a Data Science Corps.

The federal STEM education plan included as a priority goal to engage students where disciplines converge, and to encourage this, we support the diversity of mission-specific programs across federal agencies. Because these programs are embedded in agencies whose missions span broad goals such as economic development, protection of human health, and regulation of various activities, students and researchers exposed to these missions must expand their thinking beyond their single discipline, even well beyond the STEM disciplines.

In the next version of the federal STEM education strategic plan, we encourage the National Science and Technology Council's (NSTC) Committee on STEM Education (CoSTEM) to identify priority areas that require significant, sustained, and cross-agency coordinated investment, to provide a clear pathway for cross-agency funding to occur without undue burden to applicants, and to focus on investments that help us take an ecosystems approach to addressing critical problems at significant scale in these priority areas.

Relatedly, we encourage investments that advance implementation science that help translate educational research into practice. These include supporting the study of implementation science, institutional pilots for educational interventions, learning networks of institutions to better understand how to adopt and adapt evidence-based practices, coalitions to take these interventions to scale, workshops where practitioners can engage with researchers to translate research into consensus practices, opportunities to pollinate practices across networks via meta-network convenings, and entities that create synthesis reports of this work across all of these domains, such as the National Academies of Science, Engineering and Medicine's (NASEM) Boards on Science Education and Higher Education and the Workforce

We need a better understanding of what we have learned from current projects and how those align and build on one another. We encourage federal investments that allow for meta-analyses of programs to align commonly tested strategies for more valid assessments of efficacy and implementation at scale. Such multi-program examinations should be made public to promote adoption and adaptation.

We also encourage developing a knowledge infrastructure for STEM education programs across the federal agencies, helping connect funded projects, awarded institution/organization, the target of the intervention, and outcomes and research products. This would help the education community better understand what we have learned from current projects and how those align and build on one another. This could be done via knowledge graphs or using social network analysis tools across the federally funded education research and implementation portfolio. Additionally, we encourage the committee to consider ways in which federal investment could advance the sharing of education data via supporting data repositories and curation.

Future opportunities in STEM education
Question 1 *- What COVID-19 related digital barriers have you found most prominent, impactful, or difficult to overcome?*

Prior to and during the COVID pandemic, one of the largest barriers to remote learning across all educational domains has been the lack of reliable and robust broadband for all students, especially students who have access to fewer resources. Federal investments supported by state/state systems disseminating the nation's digital infrastructure would aid all students. [redacted] member institutions are in all fifty states, in rural and urban areas, and we commend institutions for how they have supported students in the pandemic by providing Wi-Fi hot spots and devices during this time ameliorating some of the lack of broadband access.

Question 6. *What data/information is the most important to collect about STEM education during the disruption of educational systems because of COVID-19?*

NASEM's *Indicators for Monitoring Undergraduate STEM Education* (2018) outlined possible indicators that would help us understand the progress we are making on improving undergraduate STEM education. The report focused on undergraduate **STEM** education, but these indicators could be re-purposed to compare pre- and post-COVID outcomes for all disciplines. The NASEM committee recommended that indicators should be disaggregated by demographic categories where possible. Many of the indicators NASEM identified do not have relevant data that is collected nationally. Many institutions do collect data on some of these indicators, but this is not systemic, comprehensive, or easily accessible. The lack of complete data makes it more challenging for policymakers to implement evidence-based decisions. Further, institutions lack access to key information they need to assess their performance and improve. [redacted] strongly supports the College Transparency Act, H.R. 1766/S. 800, which would provide the comprehensive higher education outcomes data needed to answer key questions for policymakers, institutions, and students and families.

Another resource is [redacted] report, which was funded by NSF INCLUDES. The report includes an analysis of available national and federal data sources for points along the STEM pathway from undergraduate students to the professoriate. It may be useful as a reference for determining the feasibility of indicators.

Other resources are the SEISMIC project, which is a collaboration of 10 large public institutions that are using institutional data from large foundational STEM courses to understand and reduce equity gaps in STEM programs, and the *COVID-19 Transfer, Mobility, and Progress: First Look Fall 2020 Report* from the National Student Clearinghouse Research Center. This report sheds light on the loss of community college enrollment and its impact on transfer and equity gaps.

Question 8. *What actions did your STEM Learning Ecosystem take to support learning in response to COVID-19?*

As soon as the pandemic forced schools to move courses online, [redacted]—in coordination with [redacted] partner, Every Learner Everywhere—shared a faculty playbook, *Delivering High Quality Instruction in Response to COVID-19*. As part of this consortium, [redacted] also contributed to a second version of *The Adaptive Courseware Implementation Guide*, which supports use of AI-derived tools that assist learners and faculty. [redacted] will soon be releasing a guide for supporting faculty collaboration through departments for highly enrolled courses.

[redacted] institutions provided data and insight on instructional practices that aligned to greater student satisfaction with their remote courses. The report *Suddenly Online: A National Survey of Undergraduates*, co-funded by NSF and the Bill and Melinda Gates Foundation (BMGF), revealed that students did not "attribute their struggles to poor instructor preparation or limitations inherent in online learning." This is critical in understanding students' social learning needs and for improving outcomes for all students. Additionally, STEM education would benefit from having more examples of how STEM impacts society to help increase student motivation in STEM courses.

Develop STEM education digital resources
Question 9. *What type of web-based resources and opportunities would you hope to find on a STEM education website? Are there existing resource websites that could serve as a model for a Federal website?*

Appendix 2 of the *Progress Report on the Federal Implementation of the STEM Education Strategic Plan* has a table of federal agency programs and which goal they address. This inventory would be more useful if it included links to the program description, solicitations for proposals, associated resources from the funded projects in those programs, and any analyses of the impact of that federal program. It could also include the eligible entities and/or target audience for the intervention (i.e. students or organizations/institutions).

A database of STEM education innovations could be modeled after the STEM Education Innovation Database for the Network of STEM Education Centers (NSEC), funded by NSF. This database allows tagging of practices and resources that includes activity type, program components, target audience, and point of intervention at an institution of higher education. The federal version could include tags that correspond to the goals (e.g. Build Strong Foundations for STEM Literacy, etc.) and pathways (Develop and Enrich Strategic Partnerships, etc.). In this database, federally funded programs/projects could respond to a series of questions about their program/project. See here for possible questions.

The community also needs a better understanding of implementation fidelity and sustainability. While many innovations are described in detail, there is often a lack of understanding about the implementation processes. There is a lack of information on how generalizable one set of innovations is to another institutional context, and there is a lack of information about why these changes were sustainable or not. Including this kind of information into an inventory would be helpful.

Increase diversity, equity, and inclusion in STEM
Question 12. *What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM?*

[redacted] co-leads the NSF INCLUDES Aspire Alliance, which is a multi-institutional collaboration funded by NSF. The grant supports [redacted] efforts to help universities cultivate a more diverse and inclusive faculty that will attract greater numbers of underrepresented students into STEM fields and enhance their success. As part of this alliance, the IChange Network (ICN) is 54 institutions that are committed to a more diverse and inclusive STEM faculty. In this alliance, we aim to build the capacity of institutions and institutional leaders to catalyze and sustain institutional change to better support underrepresented groups of faculty and students. Participating institutions begin with a self-assessment process to identify areas of strength and growth around recruiting, hiring, and retaining a diverse and inclusive STEM faculty. They use the results of the self-assessment, in consultation with network peers, to develop robust action plans to identify, implement, assess, and scale promising practices across STEM colleges and departments. A team of technical advisors provide concierge-style service to support campus change efforts, while a competitive grants process helps to fund innovation and cross-network learning.

The IAspire Leadership Academy, led in partnership with the University of Georgia, elevates the preparedness of academic leaders from underrepresented groups so they can aspire to and succeed in academic senior leadership roles. Fellows gain critical leadership skills across numerous competencies and learn how to lead institutional change in the increasingly complex environments in which STEM faculty operate. They apply their learning on leadership and change management at their home institutions through institutional action projects.

Resources produced by the Aspire Alliance include *A Guidebook for a Campus Self-Assessment of Successes and Challenges in STEM Faculty Diversity and Inclusion (2020)* and *Leveraging Promising Practices: Improving the Recruitment, Hiring, and Retention of Diverse & Inclusive Faculty.* As this is an NSF-funded project, there is a robust evaluation plan, and we can provide more details if needed.

[redacted] produced an NSF-funded report, [redacted], examining trends in engineering degrees conferred at national and institutional levels to determine areas of growth among various groups, changes in racial, ethnic, and gender diversity in engineering, and which colleges and universities graduate a larger number of underrepresented groups in specific engineering disciplines. Furthering expanding this work, [redacted] began a new NSF-funded project to analyze the current state of diversity in the computer and information sciences field.

As another resource, Sarma and Bagiati (2020) provided a commissioned paper for NASEM's *Imaging the Future of Undergraduate STEM Education workshop*, which identifies and describes ten current innovations that are needed in STEM education, with a focus on equity. These include active learning, supporting learning experiences that happen outside the classroom, enhancing inclusive entrepreneurship and innovation, and more.

Develop and enrich strategic partnerships

Question 18. *What factors drive successful work-based learning programs? How has your organization made adjustments in response?*

A number of innovations and new kinds of partnerships are driving expansion of work-based learning programs. One example is the integration of high-quality industry certifications into four-year degrees. Workcred, in partnership with [redacted] and its permanent partner, the Coalition of Urban Serving Universities (USU), and the University Professional and Continuing Education Association (UPCEA), recently completed a [redacted] that identified opportunities, challenges, and practical examples associated with integrating these certifications into bachelor's degree programs in order to create more opportunities for students to earn credentials with labor-market value. Many of these certifications are in STEM fields—for example, cybersecurity, data science, health sciences, and advanced manufacturing. These certifications can enhance a college education with specific skills needed by employers, resulting in students earning a certification while pursuing their degree or earning a certification at the end of their degree program, achieving a more comprehensive education. This requires a partnership between universities and certification bodies; these certification bodies nurture the essential partnerships with employers that determine the requirements for the certifications.

Certifications within degrees often require experience and therefore may increase students' chances for summer employment and work-based learning experiences during the academic year. A few universities are already doing this but expanding these examples by funding pilot projects could offer great value for both students and employers as well as faculty who benefit from aligning their curriculum more closely to evolving industry standards.

[redacted] has released two reports on the results of a comprehensive survey of 11,000 employers, faculty, alumni, and students that explored the top employability skills preparedness gaps among college graduates. [redacted] focuses on the quantitative data analysis, while [redacted] is a qualitative analysis of the open-ended survey questions. Both reports and an [redacted] are part of the [redacted] series on employability skills in agriculture and natural resources.

Question 19. *If you are currently engaged in a STEM learning ecosystem, what are the characteristics of success?*

Several of our projects are based, in part, on a collective impact (CI) model – to simultaneously work across sectors (institutions and institutional types, disciplinary societies, national organizations, industry, and funders) and across systems (top-down with institutional leaders, bottom-up with faculty, and middle-out with centers and departments) to achieve systemic change and national-scale outcomes. We have used this model for our efforts to improve success in STEM for students from underrepresented groups (URG) in postsecondary education, a complex societal problem for which the CI framework is designed. CI is a proven approach to build and sustain success across large, disparate groups through shared vision, alignment, open communication, transparency, mutually beneficial efforts, and learning from data and experience (Kania and Kramer, 2011). We develop mutual agendas to ensure a common understanding of the goals and a beginning exploration of a joint approach to achieving it. Continuous communication provides a platform for trust to be developed, all voices heard and concerns to be addressed, and ideas to be discussed among groups with different roles. Intentional sharing of and learning from one another ensures that the work of each partner can collectively advance our knowledge. [redacted] has been a pioneer in networked improvement communities (Martin and Gobstein, 2015) in mathematics education, including three NSF projects using the CI approach, and currently employs a collective impact approach as a member of the Aspire Alliance.

As another example of our systems approach, the Student Engagement in Mathematics through an Institutional Network for Active Learning (SEMINAL), funded by NSF, initially involved work by 12 universities to better understand how to implement active learning in undergraduate mathematics classes. The project will be publishing its first book on what it has learned, due out by the AMS by the end of the year. SEMINAL has grown to 24 partner universities with over 100 faculty members, with which we will study differences in progress between institutions involved in SEMINAL for its first four years and those that had not had the earlier benefit of participation in an improvement network.

Sincerely,

[redacted]

[redacted]

National Science Foundation Request for Information

[redacted]

Questions identified by category and question number:

Questions prepared by [redacted]

[redacted]

Future Opportunities in STEM Education
Question #3 Response:

Personal Experience:

I've been using Audible recently with our book club books. It got me thinking what an innovative concept that is not only for busy and fast-moving lifestyles to consume information but also to cater to different learning styles. For those that are stronger in auditory learning vs visual or hands on (or have reading or other disabilities), perhaps having activity guides or STEM concepts being audible with educational programming is a strength.

Another app I've been using just recently is Noom. It's a physical and mental well-being program that uses psychology concepts to achieve awareness, learning and improving. A couple of components that have stood out:

- The program asks questions to tailor the approach to the learner and it increases interest and relatability.
- In each segment it embeds questions periodically to check for understanding and shares the correct or incorrect answers and explanation to cement the learning.
- Based on information put in, it anticipates physiological strengths and weakness to continue to encourage and engage. It's truly a smart app.

There are positive capabilities of utilizing any educational content to engage learners and even as an Extension tool with programmatic content to cement concepts and enthusiasm. It could extend the impact from a limited program duration (like 1 week) if students could engage with content for a longer duration.

Program Experience:

An example of positive outcomes using remote learning technologies occurred this past summer when 82 students from a high poverty school in LAUSD participated in our week-long [redacted]. Five instructors facilitated five sessions of roughly 16 students per group.

All participants had sufficient access to internet service and devices in order to participate virtually. The virtual nature of the program meant that from an equity standpoint, all children, regardless of their physical location or zip code, had equal access to a high-quality learning experience.

The success of the program, as evidenced by high satisfaction comments from teachers, parents and students had to do with the overall design and teacher support included with the [redacted]. The success we saw over the summer could be institutionalized - if we had more funding for curriculum, materials and supplies and teacher training - to replicate the program during the school day.

For Instructors: Every teacher brought a different skill and comfort level with technology and knowledge of how to facilitate engaging, on-line instruction. This variety of expertise required us

[redacted]

to provide a straightforward, step-by-step curricula with scripted dialog coupled with meaningful, engaging videos to support the subject matter. This ensured quality and consistency in synchronous, virtual instruction, which encouraged and enabled instructors to act as advisors and champions of children's self-directed exploration. The scheduling and timing of sessions was also important to create the right balance of synchronous sessions and self-led learning time.

For Students: As evidenced by survey results, materials and student guidebooks were given high marks. Parents reported that student learning continued well beyond the scheduled program week. Thus, learning was not bound by space or time. Student attendance at live sessions was high, because they were excited to share and collaborate in an on-line environment that celebrated creativity and differences in their projects.

For Parents: Parents reported gratitude for on-line instructors who supported language barriers and offered one-on-one time with students when needed, in addition to scheduled group sessions. Many parents were as equally engaged with the projects as their students were and supported project-building with items found around the house. They were often seen in the background, watching the on-line sessions unfold.

> Parent comments:
> "The interaction her program instruction provided has helped my child look forward to more online experiences, when prior to your camp, she had no interest in online camps. Thank you!"
>
> "My girl was very shocked at all the activities, this is a camp her first year and the truth was very diverse; the teacher who helped her is a great person and you can be very grateful and hopefully this good experience will be repeated."
>
> "Once camp was over, the first thing my daughter said to me was, "keynote, never give me a screwdriver unless you don't want me to start taking things apart to see how they work!" :) I am so happy she is open minded to new ideas involving STEM projects. Great program!"

[redacted]

Future Opportunities in STEM Education
Question #5 Response:

Think about learning to write.

The first few months of school in the Fall of 2020 have been devoted to learning how to hold a pencil, how to form letters, and how to group them on a page to make a sentence. They are now looking towards bringing those concepts together to write a story that can “speak” and “move” from the perspective of another person.

The past 6 months have been focused on getting educators familiar with the tools available to them to facilitate online instruction. While it is good that educators feel more comfortable with tools and concepts in distance learning, it does not sound like many teachers have focused on the journey of a student learner (at least not yet).

Teachers are now positioned to leverage their prior knowledge and apply it to student learning. How do I efficiently check for understanding, and then use those formative results to drive ongoing instruction? Can we trust students in a collaborative learning situation online? How do we continue to build virtual classroom culture (and what does that even look like)? Who are the teachers that are achieving instructional goals with anything except direct instruction online, and how are they doing it?

Teachers need to be able to have access to professionals that have answers to the questions above and have a clear plan on how to incorporate solutions into their instruction.

Short and Sweet Answer:

Teachers have some knowledge on technology and tech basics to get kids together and attempt to learn. They DO NOT have many examples or training on what this all looks like when it is woven together. Teachers need to observe a quality online lesson. They would benefit from guidance on writing a distance lesson plan from experts. They would benefit from PLNs or mentor teachers that can observe their instruction and provide feedback. They would benefit from district support if they want to have students break into small groups online in break-out rooms.

Teachers don’t know what is possible right now with online learning, so they are just teaching basic recall questions because it’s “safe” and it seems to work easily in online instruction.

[redacted]

Increase Diversity, Equity, and Inclusion in STEM
Question #12 Response:

Museum Exhibits:

[redacted] The History Room at the [redacted] brings greater diversity and honor the stories of great Black inventors. This new, upcoming exhibit reveals stories with which many visitors are likely to be unfamiliar. This meaningful exhibit is designed to educate visitors, promote greater representation within our museum and share awareness of and appreciation for Black inventors whose stories have too often gone untold.

[redacted] selection process:

Over the years, research has been commissioned to specifically identify potential Black, other minority, and women candidates. We also have ongoing initiatives to identify and confirm Black, minority, and women candidates as Inductees.

Curriculum:

The [redacted] program values diversity and is committed to providing a platform for all children to explore, make, and create. The [redacted] curriculum designers have consulted with experts in the fields of diversity and accessibility and have made concerted efforts to ensure the overall program experience is accessible, provides support, and allows participation of all children. Pilot tests intentionally incorporate diverse students and teachers, and their feedback helps our program provide experiences that create an environment where all inventors are valued, respected and important.

The [redacted] program strives to cultivate a culture of acceptance, providing the professional educators who lead the program with insights, tips, and strategies to help ensure all children are successful and represented. By helping children celebrate diversity of ideas and problem-solving styles, [redacted] models valuing diversity beyond traditional frameworks.

Research* shows that children must have exposure to innovators with whom an emotional connection will resonate. A diverse array of inventors are featured in the [redacted] program, and children are encouraged to employ empathy as they create and design. For example, in the 2020 national series, innovators who are racially diverse, blind, dyslexic, and paraplegic are integrated into the media supporting the activities. Children's exposure to modern-day, diverse innovators is a key strength of our programs.

Upcoming Research:

Forthcoming research, which will be Pilot and Feasibility Study—*Employing Choice to Build Equity, Agency, and Confidence in Elementary-Age Children in Informal STEM Education (ISE) Programs*—a hybrid research/evaluation case study of the [redacted]

[redacted]

The [redacted] curriculum weaves together Science, Technology, Engineering, Art, and Mathematics (STEAM), along with Creativity and Innovation, Intellectual Property, and Entrepreneurship through the lens of invention. The focus of this project is to explore the impact of choice in Informal STEM Education (ISE) programs in an effort to promote equity, empower agency, and build confidence in participants. In other words, we will identify how an ISE program can measurably improve participant engagement and outcomes by providing mass-customized experiences that transcend place, provide meaningful learner choice, and inspire children by featuring a diverse inventor role models in STEM.

[redacted] has redoubled efforts in our programs to scaffold and support all components of social-emotional learning to ensure that teachers and students see a direct connection between themselves and our programs.

Examples:

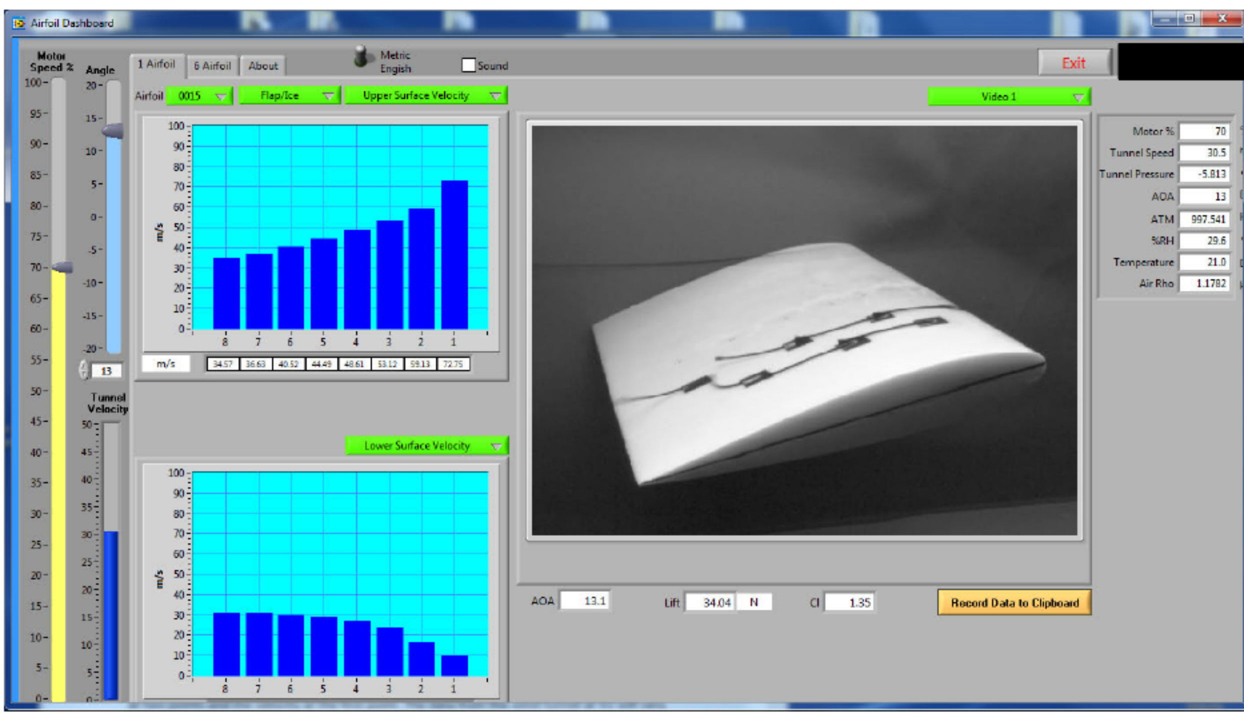
- Critically assessing promotional materials to ensure cultural diversity is reflected.
- Adjusting program materials to ensure cultural and racial diversity is reflected and honored (i.e. blogs, inventor profiles).
- Specifically seeking out opportunities to work with funding partners to offer our programs in underserved and underrepresented areas (i.e. Clarksdale MS).
- Work with various community outreach initiatives to ensure that our programs are offered to underserved/underrepresented groups (i.e. Above & Beyond Agency Afterschool in Byram MS; Sabine Chamoun – Afterschool Cohort in AL/MS/GA).

[redacted]

What we have done at [redacted] is produce a software program that allows students to conduct laboratory experiments with software. The data the students are seeing is real data recorded from an actual wind tunnel test in progress. This is not a virtual reality CFD program of what we think the data should be. This is the real data. The presentation of the recorded data is very similar to working on the actual equipment. It is even using most of the actual program that was used to collect the data.

The experiments that are conducted on the actual lab equipment are extremely repeatable. Allowing the student to control the inputs to the recorded data experiments, they will produce the same results as if they were right next the actual equipment.

The obvious advantage of this approach is that the "equipment" is always available to as many students that need it from either the school lab or their home computer. It does not need any maintenance or changeover time.



See below for a 10-minute video introduction to the program.

[redacted]

We have created a complete set of Blended Learning lesson plans so the teacher does not have to teach the theory. The lessons also include a great deal of Videos to show the student how various things actually work. The Graphics screens to illustrate how they work and the math to prove it. Finally, we animated the algebraic formulas to show the students how the formula is manipulated to come up with the correct answer. The fact that there is a reason for doing the formula and that all of the variables in the equation relate to something tangible really helps in understanding why they are doing the formula. We also use 3-D animations to illustrate the operation of sensors and other things.

For the hands-on portion of the lab we can have students 3-D print an airfoil for an R/C airplane and see how their design flies. Or for a more advance lab we can have them send us a shape of their airfoil and we will mount it in a small wind tunnel. They can then operate the wind tunnel remotely via the internet to get the lift data from their airfoil. They can then calculate what the performance of their airfoil will be.

We will also have a program for drones, electric 1/10 scale R/C car bodies and wind turbine blades.

We will also be doing a very similar program for other pieces of laboratory equipment such as a 1/10 scale R/C car chassis dynamometer, a model roller coaster for dynamics, single cylinder engine dynamometer, Garret GTCP-85 turbine engine APU and a rocket motor experiment.

When GDJ Inc. sells a wind tunnel to a University for Mechanical Engineering Fluids classes, in most cases the University purchases experiments to do laboratory experiments. The school will purchase a set of two venturis a 10° and a 13.5° venturi, 3 different airfoils shapes and often other experiments. They also purchase either a water manometer or Data acquisition system to read the pressure over the surface of an object being tested in the wind tunnel. This allows them to do calculations based on the pressure data.

They start with the venturi and the continuity equation which deals with calculating the velocity in a tube due to a restriction increasing the velocity. This equation is very good for learning beginning algebra since the equation is very simple: $A1 \times V1 = A2 \times V2$. A is the area of the venturi and V is the velocity.

In most cases a laboratory technician will install a Venturi in the wind tunnel and connects all of the tubing from the 16 static ports on the 10° venturi to the data acquisition system. For the lab the students come in and turn on the wind tunnel and move a slide bar on the computer screen to increase the motor speed to a certain test section velocity and take the data from different points on the surface of the venturi to calculate the velocity at V2 by knowing the area at two points and the velocity at the first point. The data from the wind tunnel at V2 will very closely match their calculation since the flow at 10° is a steady state flow.

Next the Lab technician will install the 13.5° venturi in the wind tunnel and the student will repeat the experiment. The data at V2 will not match their calculation since with the 13.5 there is a flow separation that causes an error in the data. Air will only expand at 10° total (5° per top and bottom) after a restriction. This the beginning of aeronautics and illustrates why an airfoil stalls.

With the recorded data lab for the venturi. The student's conduct the experiment with the software in the exact same way. Except they do not have to wait for the lab technician to install the 13.5° venturi they just click on a toggle switch to change to 13.5° recorded data. There is absolutely no difference in conducting this experiment with the actual wind tunnel and the recorded data.

With the recorded data the students also hear the sound of the wind tunnel change with the velocity of the wind tunnel. They also get to select different versions of the data screen to illustrate the data differently.

They next move on to the airfoils and pretty much the same thing happens. A technician will install a NACA airfoil in the wind tunnel and the students will use the software program to change the velocity of the wind tunnel and the angle of attack of the airfoil. They will normally start with the NACA 2415 airfoil.

Visually the students will get to see how by changing the velocity of the test section and the angle of attack of the airfoil a flow separation will occur and a stall will happen. They see this by the use of yarn tuffs on the surface to illustrate the airflow. When the yarn is straight that is a laminar attached flow. When the yarn is dancing all over that is a detached, turbulent flow.

The students also take the lift data from the airfoil to calculate the lift of the airfoil at various airspeeds and angles of attack. The student can then compare their data to the known published NACA data for the airfoil.

The lab technician will then install the other two NACA 0015 and 4415 airfoils in the wind tunnel and the students can repeat the experiment individually and see how changing the camber of the airfoil will affect both the stall of the airfoil and more importantly the lift data one at a time. Changing the airfoil in the wind tunnel will take the technician a couple of hours since there are 16 tubes to connect and the airfoil angle of attack has to be set level when the data screen reads zero.

To be very honest at most schools unless the lab technician is very good, the students only get to do the lift experiment with one airfoil. It is just too much work to constantly change the airfoil. Many high schools and community colleges do not have laboratory technicians, so the teacher is required to do the changeover after class.

With the recorded data program again the student controls the wind tunnel velocity and angle of attack of the airfoil in the exact same way. They also get to view the airfoil in the wind tunnel with a video screen. When they rotate the angle of attack of the airfoil, they see the airfoil rotate as they move the slide bar and also see the tuffs show a stall in the exact same way.

This is what a virtual reality CFD program of an airfoil definitely can not do. They cannot show the student with a video what is happening to the airflow over the surface of the airfoil. This is very important when it comes time for the professor to explain what is happening.

They take the lift data in the exact same way and they can also see if their calculation is correct by comparing their answer to the lift data on the screen. The big difference is when it comes to taking the data from the other 2 airfoils. With the recorded data program, the student just selects the other airfoils and can conduct the experiment with the NACA 0015 and the 4415 airfoils. There is no extensive maintenance required for the changeover.

We were also able to show the data from all three airfoils on the data screen at the same time by putting 6 individual data boxes on the screen. This allows the students to see how the camber affects the lift by allowing them to see the lift data from all 3 airfoils at the same time. This is an excellent way to allow the student to visually see how the shape of the airfoils affects the lift. This can not be done with an actual wind tunnel only with the recorded data lab. The students can also custom design their own data screen by putting any data presentation they want in each of the 6 boxes. Each individual data box has its own pull-down menu.

We have also included 4 different flap settings on the NACA 2415 to show the students how the flaps are used to change the lift and drag of the airfoil at takeoff and landing. Plus, we have attached 2 different 3-D printed edge ice shapes to show how icing affects the lift and stall of the airfoil. Both of these experiments will be very popular with the flight school ground training.

Thank You

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Comments Due: November 20, 2020
Submission Type: API

PUBLIC SUBMISSION

Docket: NSF_FRDOC_0001
Recently Posted NSF Rules and Notices.

Comment On: NSF_FRDOC_0001-2586
Request for Information

Document: NSF_FRDOC_0001-DRAFT-0467
Comment on FR Doc # 2020-23443

Submitter Information

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Submitter's Representative: (b) (6) [redacted]
Organization: [redacted]

General Comment

See attached file(s)

[redacted] and education Non For Profit has teamed up with [redacted] to provide an excellent method for teaching technical subjects to all students.

This method of using recorded data labs and media rich video lesson plans remove many of the barriers in providing a high quality technical education to our inner city schools.

The schools will not have to deal with the high cost of the technical lab requirement and training the teachers on subjects they may not be familiar with.

This lab deals with wind tunnels and aerodynamics. We also have labs for electric vehicles, roller coasters, internal combustion engines and turbine engines.

Attachments

[redacted]

[redacted]

[redacted]

[redacted]

October 19, 2020

VIA ELECTRONIC FILING

Ms. Cindy L. Hasselbring
Assistant Director, Sr. Policy Advisor, STEM Education
Office of Science and Technology Policy
Executive Office of the President
Eisenhower Executive Office Building
1650 Pennsylvania Avenue
Washington, DC 20504

Subject: White House Office of Science and Technology Policy (OSTP) Request for Inputs related to the implementation of the Federal STEM Education Strategic Plan, *Charting a Course For Success: America's Strategy for STEM Education.*

Dear Ms. Hasselbring,

[redacted] is submitting the following written comments in response to OSTP's request for information regarding implementation of the Federal STEM Education Strategic Plan. [redacted] believes STEM education is an important to enable the next generation of innovators and 21st century thinkers

At [redacted], our focus is on helping students develop a strong foundation in science, technology, engineering and math so that they can be successful in classrooms today, in college tomorrow, and in what we hope will be STEM careers in the future. Only through our collective efforts can we get students to believe that STEM concepts and STEM careers are within their reach and that they are capable problem-solvers.

We hereby submit the following comments to the OSTP request for information published in the Federal Register on September 4, 2020. Our comments cover the below-specified sections of the request for information, including five of the questions.

Respectfully submitted,

[redacted]

For Questions or inquiries please contact

[redacted]

[redacted]

2. What new or existing educational programs, opportunities, or concepts would enhance remote (both synchronous and asynchronous) education? Please indicate which education system you are addressing and if the interventions are targeted toward schools, teachers/faculty/instructors (e.g., virtual field experiences for preservice teachers, flexibility in scheduling classes, virtual internships, micro credentialing), learners (e.g., pre-recorded sessions focused on enabling consistent instruction with individualized delivery options), or other areas.

With the current COVID-19 pandemic, [redacted] is very aware of the challenges educators face in the transition to virtual learning and we are there supporting teachers and students every step of the way. [redacted] like educators, has had to reinvent the way we work in education. Moving from a face-to-face to a virtual learning professional development model is a challenging, urgent, and necessary process, but one that is driven by our commitment to teachers and education leaders. We have adapted several of our long-standing offerings, and they are proving to be effective in a remote setting, including:

- [redacted] organization provides flexible, adaptive professional learning opportunities for teachers designed to enhance remote STEM education. The [redacted] organization, which began over 25 years ago and has grown to an international initiative, provides professional development to tens of thousands of teachers around the world. Many [redacted] educators are still in the classroom and experiencing, first-hand, the challenges imposed by the COVID-19 pandemic. They willingly share their classroom expertise with other teachers through focused professional development...keying upon how [redacted] technology can make mathematics and science become visible and alive for students. [redacted] professional learning supports teachers in the secondary education system (grades 6-12) through virtual and on-site workshops, job-embedded coaching and curricular resources focused on enhancing remote STEM instruction using [redacted] technology.

- **GEAR UP partnerships:** [redacted] provides rich, meaningful STEM learning experiences in a distance learning environment through partnerships with higher education institutions. Working with one of our largest [redacted] partners, Eastern Oklahoma State College, [redacted] developed a customized, professional learning plan consisting of a series of remote STEM workshops delivered over a 5-month period. The workshops were supplemented with online, job-embedded coaching to best support teachers' individual goals and challenges. We also developed curriculum alignments to help teachers leverage [redacted] interactive lessons, including many STEM simulations that support distance learning. According to one teacher, [redacted] professional learning is effective because it focuses on "the way we could adapt the technology to fit into the coming year's virtual learning needs.

- **Robotics Remotely**: In Utah, secondary STEM teachers served by the Utah State University STARS! GEAR UP program are experiencing similar challenges. To support teachers' goal of providing hands-on STEM projects remotely, [redacted] designed a series of virtual workshops that leveraged coding and robotics with [redacted] technology. One session modeled how secondary STEM teachers can facilitate a robotics challenge remotely with their students, which was well-received by teachers and highlighted in [redacted].

- **Plug-and-Play Lessons:** [redacted] video series are designed to support middle and high school students in a host of STEM courses. These lessons provide students on-demand tutorials in a fun, engaging format led by expert educators, such as former NFL player John Urschel. Teachers use them as supplemental resources to complement their own curricula and have characterized them as essential during remote learning sessions.

- **STEM Projects:** Coupling video lessons with [redacted] provides teachers with ideas for students to engage in design and robotics using [redacted] calculators and the [redacted]. [redacted] STEM projects are designed to expose middle and high school students to project-based, real-world challenges where they use existing technology to design and innovate.

- **University Outreach:** [redacted] normally offers in-person, hands-on engineering workshops at universities around the world so that engineering students can learn how to design products using the same [redacted] technology that our customers use. However, due to COVID-19 limitations, we turned this experience into a virtual [redacted] Summer Design Project. Undergraduate engineering students from universities around the world had the opportunity to grow their design skill set through projects that use the [redacted] – a [redacted] robotics systems learning kit– as well as additional [redacted] parts. Students also had access to virtual office hours with our university marketing team for a sound-following robot, a portable medical assistant, and even an iPhone turned into a virtual robotic pet that can follow people around.

- **Dedicated, Remote Learning Support:** As an organization, [redacted] continues to seek new ideas and resources to support STEM teachers during this pandemic and beyond. We have created a web page dedicated to [redacted]. This page features technology support for our handheld calculators along with links to the Smart Space video lessons. Additionally, the page features links that will take the user to several professional development sites – all focused on delivering professional learning online.

At [redacted], our dedication to teachers and students during this crisis will not waiver – we are more committed than ever to meeting the needs of schools and districts.

12. What are the methods utilized by your organization to increase the recruitment, retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? For context, please briefly provide information on what groups your organization targets through these interventions? How are these interventions evaluated for success?

One of the aspirational goals from Charting A Course for Success: America's Strategy for STEM Education is to increase diversity, equity, and inclusion in STEM. The report goes on to say that the national benefits of a strong STEM foundation cannot be fully realized until all members of society have equitable access to STEM education and there is much broader participation by those historically underserved and underrepresented in STEM fields and employment.

(p.5) Years before this report was published, the founders of [redacted] and our company's early leaders were tireless, vocal advocates of equity in education during a time when most Black and Latinx students were educated in segregated schools that were funded at rates much lower than those serving White students. Their legacy is woven throughout our company and our efforts to make our headquarters' city of Dallas, Texas, a better, fairer place to live, with a common focus on education opportunities for students who were at a disadvantage. To this end, some examples of [redacted] outreach in the Dallas-area include:

- KIPP Texas -DFW Public Schools in the Dallas-Fort Worth area, a free public charter made up of 7 schools serving students from grades P-12.
- Early financial support for what is today [redacted] (previously Dallas County Community College District), one of the largest, most diverse community college systems in Texas.
- The founding of the [redacted], which gives area students a local pathway to obtaining a college degree.
- The Head Start Greater Dallas program, to prepare pre-K children in the southern sector of Dallas for elementary school, including literacy, social and family services, and extended day learning.
- The Language Enrichment Activities Program (together with Southern Methodist University), an early childhood pre-reading curriculum that became the basis for education policy initiatives by Texas First Lady Laura Bush.
- Collaboration with Julia C. Frazier Elementary School (now the Frazier House) in South Dallas, the Citizens Council and the Dallas Regional Chamber of Commerce to improve Texas Assessment of Academic Skills (precursor to modern skills assessments) of predominantly Black Frazier students.
- Improvements in Dallas public libraries.

This commitment to equity in education has been carried forward by every [redacted] CEO, and in the decades following our founding, tens of millions of dollars of [redacted] and company funds have been invested in programs and organizations that improve the quality of schooling for young people who are experiencing significant educational roadblocks — either because of the color of their skin, their family's income level, or even because of their home's postal code.

To contribute to these challenges, over the past five years, [redacted] and the [redacted] have given more than $150 million toward education in the United States. Specific to STEM education, the [redacted] alone has invested more than $50 million in STEM education since 2010 to improve education outcomes and opportunities for students of color who historically experience economic and educational barriers. These include:

- In 2012, the foundation collaborated with Educate Texas and the suburban Lancaster Independent School District (LISD) to build a districtwide model for STEM education: $8.2 million has been given to date to transform an under-performing district in Dallas' southern sector into one that outperforms other Dallas area districts. Students are 96% Black and Latinx, and 88% are economically disadvantaged. The results of the investment have been impressive: LISD students now outperform their peers in math across the state, compete and rank among top Texas teams in robotics competitions, and are being accepted to a broader selection of colleges and universities with highly selective admissions policies at a much higher rate. Student population also grew at twice the rate of Dallas County – a sign of renewed community pride and trust.

- In 2018, the [redacted] and Educate Texas announced an effort to replicate and scale the Lancaster ISD model to a STEM feeder pattern in Richardson ISD with a three-year, $4.6 million grant. Funds from the grant are being used to implement a "STEM for All" concept that is reshaping the teaching and learning of STEM subjects across all grade levels, from pre-K through 12th grade within the Lloyd V. Berkner High School attendance zone (16 schools serving more than 10,000 students from 80 different countries). Students are 63% Black and Latinx, and 59% experience economic disadvantages.
- Funding for a STEM-specific training program for Dallas and Grand Prairie public school principals through the University of North Texas at [redacted]. The program, which launched in 2018, is implementing an innovative approach to preparing the charter school network in southern Dallas. Students are 97% Black and Latinx (majority Black).
- Urban Teachers and Teach for America programs to recruit and retain effective math and science teachers to urban areas of Dallas.
- Two decades of support for the National Math & Science Initiative College Readiness Program, a proven methodology that increases qualifying Advanced Placement (AP) scores for students and improves teacher effectiveness in teaching AP math, science and English courses.
- [redacted], mentoring and grants to local organizations that encourage confidence, teamwork and learning for students who have limited access to these opportunities. This includes middle school and high school robotics competitions and programs with the Boys and Girls Clubs of Greater Dallas; Girls Interested in Engineering, Math and Science; Girls Inc.; Girl Scouts of Northeast Texas; St. Philips Community Center; and Girls who Code, among others.

Our commitment to build equitable communities through the transformative power of education remains our highest giving and volunteering priority.

Within the [redacted] organization itself our inclusive culture creates a place for all employees to be heard, be themselves, contribute at a high level and make a difference. Embracing diverse backgrounds, perspectives and approaches to problem-solving continue to make the culture of our organization more inclusive, stronger and our products more innovative.

To create an inclusive and diverse workforce, [redacted] focuses on:

- Advancing inclusion globally through our diversity and inclusion programs by connecting leaders, human resource managers and employees to resources, training and open discussions about how inclusive behaviors can impact productivity and innovation.
- Hiring diverse talent. [redacted] partners with a diverse mix of universities, diversity conferences and programs to broaden our outreach and attract more diverse talent. We use college recruiting programs such as internships and rotations as well as new programs, including an initiative to attract and hire veterans and a "returnship" program for experienced professionals returning from a career break. These programs broaden our access to great talent with a variety of backgrounds and experiences.
- Cultivating a diverse leadership pipeline through our programs to develop and retain high-performing, diverse talent, so our leadership reflects our workforce. We are committed to growing our leaders from within, and we train our leaders on inclusion and diversity through our high-potential and leadership development programs and initiatives.

- Investing in our future through science, technology, engineering and math (STEM) education. [redacted] invests to help build the next generation of engineers through community involvement and giving, with a focus on helping better prepare girls and Black and Latinx students, since these groups are traditionally underrepresented in STEM fields.

[redacted] has created a [redacted] For more than 30 years, the [redacted] has helped educate employees and surface topics that matter to employees through 15 grassroots employee resource groups (ERGs). Our journey started in 1989 with the women's and Hispanic ERGs and has grown to include more than 10,000 members, a strong employee-led diversity council and an executive sponsor committee of company officers. Open to all [redacted] globally, ERGs encourage employees to discuss challenges, share ideas and create opportunities to provide development, career advice and community involvement that supports both members and the local community. All [redacted] have goals and objectives that are aligned with and in support of our values. Here are a few ways our ERGs are making an impact:

- **Women's Initiative** (WIN). WIN members around the world focus on increasing our company's female talent pipeline, advancing women in technical leadership roles, and strengthening our communities through mentorship with organizations such as Girl Scouts to give young girls visibility into a STEM career.
- **Hispanic/Latino Initiative** (Unidos). Unidos members focus on recruiting top Hispanic talent to [redacted] and regularly attend the Society of Hispanic Professional Engineers conference to recruit new college graduates. They also represent [redacted] at the Congressional Hispanic Caucus in Washington, D.C., each year.
- **Black Employee Initiative** (BEI). BEI members focus on the recruitment and retention of Black employees through professional development and mentoring. Members of BEI also represent [redacted] at the Congressional Black Caucus in Washington, D.C., each year.
- [redacted] **Pride**. Pride's focus is to create an environment of respect at [redacted] so that people of all sexual orientations and gender identities, as well as perceived sexual orientations and gender identities, can be their true selves at work, and maximize their creativity and productivity. [redacted] Pride's Safe Space program focuses on LGBTQ+ awareness in the workplace. Recently, this ERG led an effort to expand and facilitate safe space conversations within our Technology and Manufacturing Group and expanded training to five factory sites, reaching more than 200 first-line supervisors and senior leaders.

[redacted] commitment to equal employment opportunity extends to recruiting, hiring, training, promotion, transfers, compensation, benefits, termination, and all other terms and conditions of employment. [redacted] administers employment decisions at [redacted] in a nondiscriminatory manner without regard to race, color, religion, sex, gender, gender identity and expression, sexual orientation, marital status, national origin, ancestry, age, disability, genetic information, protected medical condition, pregnancy, military and veteran status, or any other characteristic protected by applicable law (collectively, "protected characteristics"). [redacted] does not tolerate any harassment, intimidation or violence. [redacted] is committed to following the eight ILO fundamental conventions on equal remuneration without discrimination, ensuring the remuneration of all employees based on their qualifications and not on their gender identity or personal characteristics.

[redacted] ability to grow and thrive depends on recruiting and retaining the best talent in the industry. Candidates choose [redacted] again and again because we offer:

- Exciting and impactful work across a number of markets, businesses and product lines.

- The opportunity to collaborate with the brightest minds in technology.
- Competitive pay and benefits packages designed to help our employees live their best lives.
- Career development opportunities where employees feel empowered to own their career paths.
- An inclusive and diverse culture where all employees can be themselves and bring their best to work.

Our recruiting strategy centers around hiring a large number of new college graduates; many start their [redacted] careers in our global rotation programs. These programs offer new graduates hands-on, meaningful experiences from their very first day on the job, and provide training and development opportunities to quickly make an impact at [redacted]. We offer internships around the world, which are our primary source for hiring entry-level talent into the global rotation programs.

For highly specialized technical and business roles, we have a sourcing and hiring strategy for experienced candidates that help us identify, network and recruit the best and brightest in the industry to come work at [redacted]. We recruit from the states and countries where we operate, particularly for entry-level and managerial positions, and then train and develop employees for more advanced or senior roles.

Retaining employees with institutional knowledge, technical and operating expertise, and extensive relationships within our company is a top priority for [redacted]. We recognize that retaining women and minorities, who are traditionally underrepresented in technology, is critical. We invest in these groups with tailored career development plans and provide mentors who encourage their professional growth. Two examples of our efforts include:

- Our **Women for Technical Leadership** program, which helps build a diverse talent pool of women with the intent to help them eventually become a business or technical leader at our company.
- Our **Advancing Leadership** initiative, which helps accelerate leadership capabilities for a diverse set of team leads or first-level managers to prepare them for a broader scope of responsibility.

[redacted] conducts pulse surveys quarterly to understand what's on our employees' minds and to gauge their job satisfaction and engagement in their work. In a recent survey:

- Around 90% of our employees said that their jobs provide them with interesting and challenging work.
- Approximately 90% said that they are proud to work at [redacted] and about 95% know that they are contributing to the company's success.

At [redacted], employees own their career and development with the support of human resources, their managers, and programs and resources we provide. We invest in training and development programs to advance employees' learning in classrooms, online and through on-the-job stretch assignments. We encourage employees and managers to meet at least twice a year to discuss performance goals and career development. [redacted] Business Leader Development program accelerates readiness across all business organizations, with women making up 30% of participants. The program includes four interactive work sessions designed to give employees a deeper understanding of profit and loss leaders and culminates in a two-day business simulation exercise.

Through our investments in our community, at the local, national, and international levels, [redacted] believes that all citizens must have strong foundations in STEM. Embracing diversity and inclusion makes us stronger...in our schools and in our workplace. Our efforts are working and are valued, and we recommend that organizations, businesses, and individuals contribute in these important ways as well. We strongly support the Federal STEM reports' challenge to increase diversity, equity, and inclusion in STEM through our philanthropy, our mission in education, and in our hiring of the best and brightest candidates in our workforce.

13. How do you or your organization use transdisciplinary learning, integrated STEM, convergence, or engineering design (e.g., a community or global design/innovation challenge) in your experience? What topical areas in your curriculum do you teach to provide transdisciplinary learning opportunities? What approaches do you use to teach transdisciplinary learning? Why do you use this approach (e.g., more engaging for students, school/administration promotes transdisciplinary learning) and how does it benefit your students' learning?

In 2017, [redacted] convened and facilitated a meeting attended by representatives from Advance CTE, Council of State Science Supervisors (CSSS), Association of State Supervisors of Mathematics (ASSM), International technology and Engineering Education Association, and Council of Chief State School Officers (CCSSO). The focus of this meeting was "How can K-12 STEM education be implemented well and what policy is necessary to make it happen?"

This meeting gave rise to a concerted, year-long effort to create the paper STEM^4: The Power of Collaboration for Change (STEM^4) The representatives called for balance in implementing K-12 STEM education by protecting the integrity of the individual disciplines of Science, Technology, Engineering, and Mathematics, while making meaningful connections in contrast to "integration". The challenge lies in identifying how to most effectively make those connections.

Shortly after the STEM^4 paper was released in July of 2018, we were very excited to see how our paper validated several of the pathways cited in Charting A Course for Success: America's Strategy for STEM Education. The paper specifically referred to engaging students where disciplines converge using STEM as an interwoven and complex pursuit that blends disciplines and makes STEM learning meaningful and inspiring. (p.9) The very nature of the acronym STEM implies the importance of the four disciplines but all too often "doing STEM" is wrongly interpreted as simply adding another science or math class.

Though the writers of the STEM^4 paper all represented organizations that were dedicated to supporting specific disciplines representing STEM, [redacted] saw this as an opportunity to bring these organizations together to discuss how their disciplines intersect. Although the authors of the paper all agreed that change is necessary, merely acknowledging the need for change is not enough. Collaborating on the paper provided the opportunity for these disparate organizations to learn more about the disciplines they support and how they converge.

In researching the STEM[4] paper, the writers found evidence indicating pervasive disparities in STEM preparedness can be traced to race, ethnicity, language, socioeconomic status, and gender. The writers felt that students' P-12 and after-school experiences should develop the skills needed to contribute to and live successfully in a global society. Some of these skills are:

· Complex Problem Solving · Coordinating with others · People management · Critical thinking · Negotiation	· Quality control · Service orientation · Judgement and decision-making · Active listening · Creativity

These skills are not taught separately from content, but by strategically integrating the practices of science, technology, engineering, and mathematics as tools that students use to explain phenomena, define problems, design solutions, and communicate their understandings. To be fully prepared for college or the workforce, however, students' P-12 experiences must also include the use of technology in authentic ways.

The "T" in STEM is often misunderstood or simply ignored within current curricula. The rate of change in technology is exponential; there has been more progress in the last five years in the areas of automation and Artificial Intelligence (AI) than in the previous fifty years. Technology is not restricted to only digital technology. It is much broader and often misunderstood. Technology, in all forms, is how people modify the natural world to suit their own purposes – the collection of processes and knowledge people use to extend human abilities and to satisfy human needs and wants. These statistics create an urgent and constantly increasing need for schools to keep pace with technology offerings.

The STEM[4] paper identifies three main principles to drive and implement outstanding STEM education research and practices. Each principle represents a critical component of a complex system designed to ensure academic preparation and career awareness of STEM for all students, including explicit attention to STEM-specific opportunity gaps. Understanding these principles is critical for STEM stakeholders to achieve STEM preparedness.

Principle 1: STEM education should advance the learning of each individual STEM discipline. This principle allows for the integrity of learning the individual disciplinary concepts independent of integration and organic relationships. The richness of the content from each discipline is delivered without changing the basic structure or purpose and emphasizing the rigor appropriate to the grade level as defined by high-quality standards (i.e., NGSS, CCSS-M, CCSS-ELA, STL, etc.). Research has demonstrated that a hands-on and student-centered learning approach in which students design solutions to authentic problems is far more effective than rote learning. All students should be held to high academic expectations, and all stakeholders must work to dismantle inequities and unproductive beliefs about students' abilities.

Principle 2: STEM education should provide logical and authentic connections between and across the individual STEM disciplines. The academic disciplines of science, engineering, and mathematics contain natural, coherent connections for students at all ages starting in early childhood. Technology serves as a means for highlighting these coherent connections and engaging with the creative thinking and problem solving required by authentic, real-world scenarios. This integrated view of STEM education serves as a theoretical and pedagogical premise, driving the necessary knowledge and understanding to develop appropriate solutions to human issues and needs. All four disciplines work together as students engage in design challenges, laboratory experiences, and tasks that integrate the disciplinary concepts. All students must have access to appropriate technology and experiences that integrate the STEM disciplines authentically. Comprehensively, these experiences serve to support students as they elicit the relevant mathematical or scientific ideas in a technology and engineering context, connect ideas productively, and reorganize their conceptual understandings.

Principle 3: STEM education should serve as a bridge to STEM careers. Student interest and confidence in STEM are strongly correlated with postsecondary success in STEM fields. Ineffective STEM education rarely includes career counseling, curricular connections to business and industry, or any formal means to increase students' awareness of, interest in, and motivation to pursue STEM-related careers. Effective STEM education, on the other hand, prepares students to transition to any next step they choose, including two-year institutions, four-year institutions, military options, or direct paths into the workplace. Career advising should be a key component of a STEM education. For example, meaningful interactions with industry experts and authentic experiences within STEM work-based opportunities can help students make connections to academic content and explore their STEM-related interests. By partnering with businesses and industries, schools can offer integrated coursework and projects that support academic as well as career and technical program standards. These types of collaborative partnerships among P-12 systems and business, industry, the arts, and higher education institutions are required to ensure all students have knowledge about and access to STEM-related post-secondary career pathways.

The STEM[4] paper strongly validates the Charting A Course for Success: America's Strategy for STEM Education report through the three principles it has defined. Though both documents were created separately, but in parallel, the messages that each convey align strongly to amplify the message that transdisciplinary teaching and learning is essential to growing STEM education and communication between agencies and entities.

18. What factors drive successful work-based learning programs? What elements encourage or discourage students, schools, or industries from participating? How can Federal agencies expand partnerships with the private and non-profit sectors and educational institutions to train the workforce needed for jobs of the future through work-based learning opportunities? If your organization provides work-based learning opportunities, how has the COVID-19 pandemic impacted your program? How has your organization made adjustments in response?

[redacted] is a technology company that requires employees who have been immersed and proficient in STEM disciplines and skills. Charting A Course for Success: America's Strategy for STEM Education details the importance of a STEM workforce to support America's economic growth as well as fostering innovation to improve the way we live. We believe that the investment that [redacted] makes in education will reap dividends in the long run by producing skilled and knowledgeable talent to join our company. However, it is much more than simply looking at how STEM education is important to [redacted] future. Quality STEM education along with work-based experience helps to support all sectors of America's economy, including agriculture, energy, healthcare, information and communication technologies, manufacturing, transportation, and defense along with areas that have not even been imagined as yet. (p. 6)

Every year, [redacted] hires hundreds of college students at our sites around the world as part of our recruiting/talent pipeline development strategy. We recruit from universities with top departments in our hiring areas – engineering, finance, marketing, for example. At [redacted], we do not simply hire and let the new employee figure it out. When an intern joins [redacted] they don't shadow. They do not make copies. They dive into meaty projects right away that challenge them to find creative solutions to complex problems. And they get access to invaluable insight and mentoring from [redacted] top leaders.

Interns who are offered a job at [redacted] upon completion of their internships are placed into a rotation program, after they graduate, that allows them to jumpstart their career at [redacted]. The goal of this rotation program is to provide early career professionals – starting on day one of the job -- with the chance to solve problems and gain on-the-job experience through a variety of hands-on, meaningful experiences. They also receive mentoring from more experienced [redacted] employees to help them learn the value of personal connections to grow a long-term career. And during their first year, they also participate in our [redacted], which offers engineering and professional classroom courses, quarterly hands-on sessions with experts, and opportunities to meet other early career employees at [redacted] as well as our senior leaders.

With respect to our more experienced employees, they tend to stay at [redacted] because of the number of opportunities we offer all of our employees. It's not unusual to have employees stay for the entirety of their careers because of the variety of experiences we offer in career growth. In fact, we have many 25-, 30- and even 40-year employees, including our CEO, who began his career at [redacted]

Due to the COVID-19 pandemic, we pivoted [redacted] summer intern program to a virtual experience. Hundreds of college students joined [redacted] for our first-ever virtual internship program – an abbreviated experience, with full pay, for many around the world with unique opportunities to do meaningful work.

[redacted] overall goal is to provide an environment in which every person can thrive. We want our employees – no matter their backgrounds, work styles, ideas or differences – to feel empowered to be who they are and do their best work.

To lend some perspective to [redacted] investment in work-based learning programs, in the last several years [redacted] has hired between 500-600 interns a year in the U.S. 70% of those interns are eligible for an offer to convert to a New College Grad hire (the others are going back to school to complete their education). 80% of those who receive an offer accept the New College Graduate role. In sum, [redacted] yields around 250 new college grad hires in a given year as a result of a robust internship program.

With respect to [redacted] efforts to promote STEM education events, let's start with the why -- Data paints an alarming picture of why it's so important to invest in education, and why we can't let students back away from math and science. We live in a world that demands STEM aptitude, yet too few students are prepared to succeed in such a world.

All of the programs in which [redacted] invests in have the goal of cultivating STEM competencies in students and growing the quality and quantity of STEM educators, one of the greatest influences of student academic success.

Over the past five years, [redacted] and the [redacted] have given $150 million toward improvements in kindergarten through 12th grade STEM education, most of which goes toward STEM teacher and principal effectiveness. The majority of grant recipients include nonprofit education partners in North Texas, where making a positive, long-lasting impact in the community is part of our legacy. Last year we gave $7 million in education grants, and more than 250,000 students and 7,000 teachers benefitted from the grants, 93 percent of which included economically disadvantaged students. [Program examples: Teach for America, Teaching Trust, the National Math and Science Initiative's College Readiness Program; STEM feeder patterns and districts; Girl Scouts of Northeast Texas]

For high school, in addition to mentoring robotics students and sponsoring programs through FIRST, VEX and BEST – [redacted] has a small high school internship program at our headquarters in Dallas, where we bring in between six and 10 students during the summer who are from underserved areas of North Texas. The intent, however, isn't necessarily to teach them to be an engineer. While we do expose them to what engineers do, the real goal is to teach them life and workplace skills. And if they decide to major in a STEM field, that is even better.

From the university standpoint: In addition to hands-on design contests, [redacted] also works with university professors worldwide to equip engineering students with curriculum and real-world technology that will help them learn and apply engineering principles so they will be prepared to succeed on day one of their engineering careers.

[redacted] believes that providing the opportunity and experience for young people to work in STEM industries opens their minds as well as strengthens their skills. Providing all of our citizens a strong foundation in STEM opens the doors for opportunities for their future and the future of America. As Charting A Course for Success: America's Strategy for STEM Education aptly states tomorrow's workers and today's learners, and the learning experiences provided to them, will directly impact how many decide to pursue STEM careers as well as how ready they will be to do so. (p. 6)

21. What components, key concepts, or topics should be included to integrate computational literacy into STEM education at all levels? Please explain what they are and why they merit special attention.

In the document, Charting A Course for Success: America's Strategy for STEM Education, building computational literacy is highlighted as one of crosscutting pathways and it emphasizes how computational thinking is a critical skill for today's world. Computational literacy, by definition, is the way in which an individual organizes their thinking to utilize technology, such as a computer or a calculator, in order to achieve the desired results. As a technology company, [redacted] is very aware of how technology is always changing and advancing. It stands to reason that as educational technology evolves, the ways in which students are taught and how they interact with technology also needs to advance. The Federal STEM report supports that within the scope of computational literacy, students are expected to engage in computational thinking, a problem solving process; typically broken down into decomposition, pattern recognition, abstraction, strategies for organizing and searching data, creating sequences of steps called algorithms, and using and developing new simulations of natural and designed systems. Computational thinking is the "bread and butter" for computer scientists but the skills inherently gained through practice can be applied in other STEM fields and general academics.

In today's classrooms, student exposure to the use of computing technology is ubiquitous. Whether the device is a laptop, a calculator, or a cell phone, students are required to employ skills such as critical thinking and communication when used as part of an integrated curriculum. [redacted] as an organization, believes that data science and the need for computational literacy is a foundational core concept and, therefore, should be reflected within all disciplines in P-12 curricula and beyond.

Unfortunately, the reality is that, as important as computational literacy is, students are all-too-often taught at a basic level…focusing on the measures of center in data or making data plots. This approach does little to prepare students for college courses which focus on procedural and test statistics. Students need to be exposed to opportunities where they are challenged to reason abstractly, think "out of the box", and collaborate to reason statistically.

To this end, some of the ways in which students can gain experience in computational literacy is through collaborative projects, where students are exposed to opportunities to work with authentic data. These projects expose students to challenges where they can visualize and summarize data, model and simulate situations that require data analysis, and communicate results in writing, orally and graphically. The International Data Science in Schools Project Framework suggests that data science involves behaviors such as problem definition, formulation and communication of solutions, where students learn to identify meaningful data, evaluate the data for patterns and significance and share their findings.

So, specifically, what are some components that should be included in STEM subjects to support computational literacy? The fact that we live in an information age where an eye-popping 90% of the data created by humanity has been generated in just the past two years warrants a look at the mathematics we teach our students. We need to put data and the analysis of data at the center of high school mathematics in order to ensure that every student leaves high school with an understanding of how to use data. Many districts are substituting statistics for algebra II. As an example, in Los Angeles Unified School District ,over 2000 students have taken statistics in lieu of algebra II.

[redacted] works with teachers, students and districts to embrace computational literacy and the use of data. We have designed our calculator technology to be user-friendly and support a host of purposes. [redacted] affords teachers and students the opportunity to embrace computational thinking using devices that fit into the palm of their hands. Devices such as the [redacted] that have been upgraded with Python coding language allow students to learn a language prevalent in the workplace. The [redacted] hub provides students with the opportunity to learn to code through a gentle introduction to object-oriented programming. As we have mentioned in our response to Question 2, coupling Smart Space video lessons with [redacted] provides teachers with ideas for students to engage in design and robotics using TI calculators and the [redacted]. [redacted] STEM projects are designed to expose middle and high school students to project-based, real-world challenges where they use existing technology to design and innovate.

Educational technology as a whole, whether through computer science, embracing computational thinking, or problem-solving, is a key pathway to future success. Equitable access to and an understanding of digital technology is essential for all Americans.

[redacted]

Response to Notice of Request for Information on STEM Education

RFI Document Number 2020-19681

19 October 2020

Prepared by:

[redacted]

Point of Contact:
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Secondary Point of Contact:
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Background

I am a teacher and researcher at [redacted]. Under a grant from the National Science Foundation (Grant No. 1842086) we have developed and taught a novel set of courses on quantum computing tailored to incoming freshman and sophomore students. In addition, we also teach a year-long high school course on quantum computing under a separate grant from the Office of Naval Research (Grant No. N00014-18-1-2233).

Future Opportunities in STEM Education, questions 3,4,8

3.

The most significant positive impact remote learning has had on our class is that it drove us to move from a traditional slideshow/worksheet style lecture to using Jupyter notebooks for presentation of the lecture materials. In the Jupyter notebooks we are able to integrate visualizations and programming exercises into the prose and graphics of the lectures, so that students get immediate feedback on their understanding. The embedded format of the exercises allows the students to play with variations of the ideas without distracting themselves or others from the focus of the class. The new format also allows the lessons to be packaged in such a way as to stand alone more easily to accommodate asynchronous learners or even to quickly and efficiently enable a new instructor to begin teaching the same material.

A STEM-wide push toward embedded media would help the development and acceptance of this type of notebook-style instruction. Much of STEM media is still based on historical forms of communication such as traditional paper-based articles (or their text document digital forms) and slideshows rather than taking advantage of truly digital forms of communication such as interactive documents with embedded media and simulations. Beyond financial support of the development of new communication styles, the acceptance of these styles should be reinforced by their use in more formal settings such as official reports, applications, and articles.

4.

Two main challenges have emerged with the shift to online education, and they both concern reaching the student. The first, more apparent challenge is unequal access by students to quality computers and high-speed internet. Our class relies on the ability of a student to access our teaching materials at a minimum, but the personal instruction is built on video communication. With the move away from on-campus activities, many students no longer have access to high quality computers and high-speed internet. This puts them at the significant disadvantage of not participating in the live lectures or having easy communication access to us as instructors. The second, less apparent challenge is that students with academic or personal issues may more easily stop participating in class or stop attending altogether without being noticed by the instructor. We work to reach out to students who are having difficulties whether academic or personal, but noticing those difficulties in the first place is much more difficult with remote education.

8.

In response to COVID-19, our learning ecosystem went to fully virtual instruction. This included the use of the video-conference software Zoom for class meetings. We also began to support a more asynchronous approach for some students. This involved our posting of class materials and online correspondence, so the students could accommodate family responsibilities and still learn during times outside of the normal class meetings.

We converted much of our instructional materials from slideshows and worksheets to interactive Jupyter notebooks. In addition to the lecture prose, these notebooks include embedded visualizations, graphics, worked examples, practice problems, and programming exercises. By combining all the materials for each lecture into a single, integrated document, we improved the accessibility of the lesson. The students also gain immediate feedback about their understanding of the material through completing the embedded exercises.

Build Computational Literacy, question 21

21.

STEM education should include simulation and, specifically, visualization of problems and solutions to improve student understanding and capability. By having students visualize problems through graphing, sketching, and diagrams multiple senses are stimulated by the same material, leading to better retention. Adding visualization of problems and problem-solving strategies adds another perspective which will help solidify understanding for students of different learning types.

Additionally, the creation of visualizations for STEM topics requires simple but important skills in communication as well as computational literacy. The simple act of correctly labeling graphs can ingrain ideas of how to effectively communicate. Using software to create plots requires the ability to interact with technical computer programs and to hone the ability to communicate specifically. Re-forming ideas in multiple ways such as on paper, inputting to a computer program, and displaying as a multidimensional plot, helps to solidify the students' understanding of the topics under study.

Community Use and Implementation of the Federal Stem Education Strategic Plan, question 24

24.

Our freshman level quantum computing class is part of [redacted], which works to connect early students to research faculty and to provide experiences specifically with research skills. On average, close to 50% of the program's students are women, and close to 50% come from underrepresented groups. We have also reached out to multiple industry leaders including IBM and Microsoft to build strategic partnerships through guest lecturers and use of computational resources such as the IBM Quantum Experience and Microsoft's Quantum Katas. We have had students leverage their experiences in our class to help earn internships or full-time positions with IBM, Microsoft, Google, and Oak Ridge National Laboratory.

Quantum information and computing is an inherently interdisciplinary subject with strong ties to math, physics, computer science, and electrical engineering. Rather than focusing on the individual subjects, we highlight the advantage that a diverse perspective can give. For example, we use polarization of light to demonstrate that a computer science problem of either horizontal (0) or vertical (1) can be reinterpreted as a diagonal superposition of the two (0+1).

We teach the students the basics of quantum information science before moving into hands-on application of algorithms which includes teaching them how to write computer programs in Python. Though it is not the main focus of the class, all of our students are taught how to program in order to facilitate the application of quantum computing techniques. As we give the students more foundation of quantum information theory, the focus is always on how to apply the lessons. We do without much of the historical background quantum science in favor of quickly moving to practical implementations of quantum computing algorithms. By focusing on implementation rather than derivation, our students are able to perform quantum computing tasks that will be immediately applicable to research or even industry issues when the hardware becomes available.

In order to further the goal of developing digital resources, we have converted our lecture slideshows and worksheets into interactive digital Jupyter notebooks. These notebooks allow us to embed visualizations, work problems, and programming exercises into the lecture material in a single, interactive document. A collection of these notebooks constitutes the entire curriculum which could stand alone as instructional material (though explanation from a knowledgeable instructor adds enormously to the learning experience).

From:	(b) (6) [redacted]
To:	Hasselbring, Cindy L. EOP/OSTP
Subject:	[EXTERNAL] OSTP.EOP Mail Submittal / discard past emails please
Date:	Friday, January 15, 2021 2:48:03 PM

Dear Suzanne H. Plimpton, Cindy Hasselbring and anyone else reading this email.

If you feel that BRICK building sets are an important part of teaching STEM concepts in the classroom then I encourage you to continue reading this email.

Obviously BRICK building systems are important.

Just so that you know, [redacted] is a valid alternative to traditional BRICK building systems.

We are MADE IN THE USA - 100% - Right here in [redacted].

[redacted] are an interesting toy for children on the spectrum. They enjoy the challenging aspects of triangulated building systems. Nature builds with triangles, BRICKS do not.

With effort we sell many kits to schools directly. We call them one by one. We also sell on Amazon.

Thank you,

[redacted]