

CATALYZING ADVANCES IN UNDERGRADUATE STEM EDUCATION (CAUSE)

Overview

A diverse and globally engaged U.S. science, technology, engineering and mathematics (STEM) workforce, able to innovate and well prepared for the changing scientific landscape, is crucial to the national health and economy. Yet there is rising concern that the numbers of graduates earning STEM degrees will not meet the demand for workers with STEM skills that is driven by technological innovation. Furthermore, the engagement of U.S. citizens from underrepresented groups in STEM is still alarmingly low. The National Science Foundation (NSF) is committed to serving a leadership role across the U.S. government in addressing these critical challenges and achieving important goals for increasing the numbers of STEM professionals. The cross-agency priority goal in STEM Education states, "...the Federal Government will work with education partners to improve the quality of science, technology, engineering and math (STEM) education at all levels to help increase the number of well-prepared graduates with STEM degrees by one-third over the next 10 years, resulting in an additional one million graduates with degrees in STEM subjects."¹ Likewise, the Committee on Science, Technology, Engineering, and Mathematics Education (CoSTEM) has identified undergraduate STEM education as a priority.²

The opportunities for increasing the numbers of STEM graduates have been analyzed in recent national reports. The President's Council of Advisors on Science and Technology (PCAST) report, *Engage to Excel*, and the National Academies report, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, underscore the lack of persistence of STEM students from all groups in the first two years of college. Further, the PCAST report recommends widespread implementation of evidence-based teaching practices, including the integration of discovery-based laboratories as having strong potential to enhance retention.³ The National Research Council report, *Discipline-based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*, provides an analysis of effective practices and a research agenda for continuing to build the STEM education knowledge base.

In alignment with the Administration's bold reorganization of STEM education, NSF will become the government-wide leader for undergraduate STEM education in FY 2014. NSF's new Catalyzing Advances in Undergraduate STEM Education (CAUSE) program is a natural evolution and consolidation of the Foundation's ongoing efforts to couple STEM disciplinary expertise with education research expertise to better understand and improve undergraduate STEM learning and persistence of students from all groups and to support STEM workforce development. CAUSE provides coherence across all NSF undergraduate education programs to maximize the effectiveness of NSF investments in improving the STEM learning experiences of all undergraduates. In addition, the CAUSE framework allows for incorporation of undergraduate improvement goals shared across federal agencies.

CAUSE is built upon a knowledge base informed by decades of work on STEM undergraduate education. It integrates education research with frontier science and engineering research to develop an innovative STEM workforce. Using a principle-based framework and investment strategy, CAUSE establishes four guiding principles for NSF's undergraduate portfolio:

- *NSF investments in undergraduate education will be focused, strategic investments centered on addressing the challenges in U.S. undergraduate education.* The greatest obstacle relative to the

¹ http://goals.performance.gov/goals_2013

² Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report (February 2012) www.whitehouse.gov/sites/default/files/microsites/ostp/nstc_federal_stem_education_coordination_report.pdf

³ From the PCAST report, *Engage to Excel*: "Retaining more students in STEM majors is the lowest-cost, fastest policy option to providing the STEM professionals that the nation needs for economic and societal well-being. (p. i.)"

development of U.S. STEM talent is student retention. The U.S. lags behind much of the world in college degree attainment and production of STEM scientists and engineers as only 40 percent of U.S. students who start in STEM majors finish.

- *The CAUSE portfolio will be established through collaboration among all directorates.* Creating this unified portfolio will entail sunsetting and consolidating existing programs, incorporating goals from programs outside of NSF as appropriate, reviewing new programs for alignment with the CAUSE framework, increasing NSF-wide planning and coordination, and developing common metrics and expectations for outcomes.
- *CAUSE will be informed by input from multiple sources, including the STEM disciplines and education research.* Input from experts and leaders in the STEM fields will be integral to the development of CAUSE and will improve the NSF undergraduate investment.
- *Development and future growth of the CAUSE portfolio will be based on demonstrated impact and effectiveness of NSF investments.* Evaluation and assessment of NSF’s investments in undergraduate education is essential and will inform decisions aimed at increasing the net funding available for improvement of undergraduate education.

Total Funding for CAUSE		
(Dollars in Millions)		
FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request
-	-	\$123.08

Goals

To maximize impact on STEM undergraduate education, a research and development-based planning matrix will be used to build coherence and complementarity in education investments across NSF and to inform strategic planning. CAUSE investments will align with the following three goals:

- Improve STEM learning and learning environments.
- Broaden participation in STEM and increase institutional capacity.
- Build the STEM workforce of tomorrow.

Approach

The goals of CAUSE will be pursued through three investment strategies:

- *Foundational research.* These investments focus on core research questions—such as how learners move towards expertise in a discipline, or best learn about concepts that are interdisciplinary – that are foundational for the improvement of teaching, learning, engagement, and retention and for serving as a basis for development, adoption/adaptation, and implementation of models, prototypes, and innovations.
- *Design-based research.* These investments support iterative approaches to design, implementation, analysis, and revision, including prototyping and building and refining models.
- *Scale-up and effectiveness studies.* These investments focus on the potential for leveraging NSF’s investments in foundational and design and development research. Key goals include the scaling of successful efforts on learning and learning environments, broadening participation, workforce preparation, and employing emerging technologies.

These funding strategies clarify the unique federal role in research and development in undergraduate STEM education and underscore the importance of leveraging these investments.

Scope

CAUSE is an NSF-wide investment that incorporates funding from established programs in the EHR directorate and other NSF directorates funded through the Research and Related Activities (R&RA) account. It is created by consolidating three Division of Undergraduate Education (DUE) programs: STEM Talent Expansion Program (STEP), Widening Implementation and Demonstration of Evidence-based Reforms (WIDER), and Transforming Undergraduate Education in STEM (TUES); several R&RA programs: BIO’s Transforming Undergraduate Biology Education (TUBE); ENG’s Research in Engineering Education and Nanotechnology Undergraduate Education (NUE); GEO’s Geosciences Education and Opportunities for Enhancing Diversity in the Geosciences (OEDG); and the cross-NSF program, Climate Change Education (CCE).

NSF will fund a range of project types from foundational research to scaling and effectiveness studies. Funding will be available for individual investigators and research teams with expertise cutting across one or more STEM disciplines and STEM education research, including discipline-based education research and the social and behavioral sciences. The intent of CAUSE is to build on NSF’s unique strengths across the STEM disciplines and STEM education to focus sustained research on the goals described above. Such research is inherently interdisciplinary in nature. Aligned with the funding strategy will be the development of robust indicators and metrics to gauge progress towards these goals.

Organizational Structure

CAUSE leadership will be provided by an Assistant Director (AD) Council; comprised of ADs designated by the Director and chaired by the EHR AD. EHR is charged with implementing CAUSE across all directorates and working with internal and external program evaluation experts to help develop a set of metrics by which program progress can be evaluated over time.

Investment Framework

CAUSE Funding by Directorate

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request
Biological Sciences	-	-	\$2.50
Education and Human Resources	-	-	97.08
Engineering	-	-	12.60
Geosciences	-	-	10.90
Total	-	-	\$123.08

Totals may not add due to rounding.

FY 2013

In FY 2013, the CAUSE AD Council will make recommendations to NSF leadership regarding governance, the framework for investment in undergraduate STEM education, and the timeline and roadmap for CAUSE implementation.

Key governance issues include:

- Discuss how reviewing and funding recommendations will be managed in FY 2013 and FY 2014, including how directorate contributions will be viewed (e.g., aimed to specific disciplinary needs, funds combined for the purpose of making awards at the initiative level, etc.).
- Discuss relationship to CoSTEM reports and other agencies' capabilities.
- Discuss how evaluation and assessment of the holistic STEM undergraduate education portfolio will be defined, mapped, and monitored for the intended impacts according to the three CAUSE goals.
- Establish a program officer implementation team to report to the AD Council.

To solidify and articulate NSF's framework for investment in undergraduate STEM education across the agency, the CAUSE AD Council will refine the proposed investment framework detailed above. Current programs and projects will be incorporated into the framework as a basis for achieving portfolio coherence beginning with FY 2013 awards (including analysis of projects by discipline).

A timeline and roadmap that spans the directorates will allow for synchronization of solicitations, common text, and narratives for FY 2014. Staff expertise in undergraduate STEM education and discipline-based educational research will be reviewed, with hiring proposed as appropriate. Coordination of PI meetings, processes for setting CAUSE priorities and special emphases, including plans for explaining the merger/integrated program to the multiple communities involved, also will be guided by the CAUSE AD Council.

FY 2014 Request

The FY 2014 requested funding will allow for awards in foundational research, design-based implementation, and scale-up effectiveness studies. The size and duration of the awards will be determined by the strength of the evidence behind the proposed intervention/project and resources necessary to achieve the desired outcomes. Based on lessons learned in the initial implementation of CAUSE, future adjustments will be made to the program, including size and duration of awards.

Evaluation Framework

The success of this framework will depend upon the development of realistic, robust metrics and indicators for gauging progress toward the larger national goals outlined above, notably improving retention among STEM undergraduates and broadening participation in STEM fields.

These metrics and indicators will be tailored to the three investment strategies and aligned with the CAUSE goals. While the specific metrics and indicators will need additional consideration, NSF's recent experience in this area points to a number of promising approaches.

Potential Assessment Framework: NSF CAUSE Investment

Investment Strategy	Potential Measure/Indicator	Relationship to Desired Outcome
Foundational Research	<ul style="list-style-type: none"> • Strategic monitoring of approaches and investment mechanisms, beginning with pre-award activities (development of logic models aligned with framework, issuance of announcements/solicitations; community response) • Identification of discipline-specific gaps in the literature and baseline evidence 	Will enable strategic NSF investment to create knowledge underpinnings in areas of specific need (e.g., research on the teaching and learning of computer science at the undergraduate level), and complementary investment based in EHR or R&RA directorates as appropriate that are aligned within the CAUSE Framework.

<p>Design-Based Research</p>	<ul style="list-style-type: none"> • Evidence of activities that promote design of solutions to issues and discipline-specific STEM challenges and test those solutions under local or ideal conditions (e.g., efficacy studies). 	<p>Creates a set of tested models and prototypes that allow for strategic investment in efforts at scale.</p>
<p>Scale-up and effectiveness</p>	<ul style="list-style-type: none"> • Partnerships and leveraging activities that take effective design and development efforts to scale and look at impact on particular groups, in particular contexts, etc. 	<p>Well designed and evidence-based approaches are implemented at scale for direct impact on improving retention and broadening participation in undergraduate education.</p>