

IMPROVING UNDERGRADUATE STEM EDUCATION (IUSE)

\$134,580,000
+\$29,180,000 / 27.7%

Overview

In FY 2016, the National Science Foundation (NSF) will continue and expand implementation of a coherent, coordinated agency-wide investment in undergraduate science, technology, engineering, and mathematics (STEM) education through the Improving Undergraduate STEM Education (IUSE) initiative, launched in FY 2014. IUSE is intended to increase the numbers, broaden the diversity, and improve the preparation of students who will enter STEM professions and enhance the readiness of the public to understand and use STEM in their careers and lives. These goals, and the development and implementation of effective undergraduate education programs, will be achieved through a vibrant partnership of scientists, engineers, mathematicians, and education experts.

A diverse and globally engaged U.S. STEM workforce, able to innovate and well prepared for the changing scientific landscape, is crucial to the Nation's health and economy. Yet there is deep concern across the private sector, government, and academe that access to higher education and high quality STEM education in particular, is unevenly available to our Nation's youth. It is critical that a diverse pool of undergraduates taking STEM courses and earning STEM degrees is adequately prepared with the STEM skills and knowledge to meet growing demands and to lead in emerging STEM areas. As the Nation's demographics shift rapidly, it is even more crucial to ensure the engagement of people from groups that traditionally have been underrepresented in STEM so that the diverse talent of the Nation is fully utilized. Recent reports of the President's Council of Advisors on Science and Technology (PCAST)¹ and the National Academies^{2,3} support the critical importance of broad engagement. The National Science and Technology Council Committee on Science, Technology, Engineering, and Mathematics Education (CoSTEM) identified undergraduate STEM education as a priority in its 2013 Federal STEM Education five-Year Strategic Plan.⁴

With an aim to rapidly and dramatically improve U.S. undergraduate STEM education, NSF is undertaking strategic coordination and integration of all its undergraduate STEM education investments within the IUSE framework. The NSF IUSE framework, developed in FY 2014, is built upon a knowledge base accumulated from decades of research, development, and best practices across the Nation in STEM undergraduate education. It is designed to accelerate improvement in undergraduate STEM education and yield measureable outcomes. IUSE integrates theories and findings from education research to support the partnerships necessary for frontier science and engineering research.

Excellent undergraduate education accessible to the full range of talent in the Nation is critical to the advancement of science. IUSE supports two of NSF's Strategic Goals: Goal 1: Transform the Frontiers of Science and Engineering and Goal 2: Stimulate Innovation and Address Societal Needs through Research and Education.

¹ President's Council of Advisors on Science and Technology (2012) *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf

² National Research Council (2011) *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. Washington, DC: National Academies Press, www.nap.edu/catalog.php?record_id=12984

³ National Research Council (2012) *Discipline-based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. Washington, DC: National Academies Press, www.nap.edu/catalog.php?record_id=13362

⁴ National Science and Technology Council, Committee on STEM Education (2013) *Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan*. www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

Total Funding for IUSE

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
\$81.84	\$105.40	\$134.58

Goals

The long-term goal of the suite of IUSE investments is to increase the numbers, broaden the diversity, and improve the undergraduate preparation of STEM professionals. The IUSE initiative is grounded in three long-term goals for NSF investments in undergraduate STEM education:

- **Improve STEM Learning and Learning Environments:** Improve the knowledge base for defining, identifying, and implementing innovative undergraduate STEM instruction (in all NSF-supported disciplines) that leads to improved student learning outcomes and fosters widespread use of evidence-based resources and pedagogies in undergraduate STEM education practice.
- **Broaden Participation and Institutional Capacity for STEM Learning:** Increase the number and diversity of undergraduate students recruited and retained in STEM fields and career pathways by improving the evidence base for successful strategies to broaden participation and implementing the results of this research.
- **Build the Professional STEM Workforce for Tomorrow:** Improve the preparation of undergraduate students so they can succeed as productive members of the future STEM workforce, regardless of career path, and be engaged as members of a STEM-literate society.

Approach

NSF will continue its agency-wide approach of using an IUSE framework which is built on the recommendations of cross-directorate design and implementation committees. The key principle guiding IUSE is that NSF investments in undergraduate education will be focused, strategic investments centered on addressing the greatest challenges in U.S. undergraduate STEM education. A significant obstacle to the development of U.S. STEM talent is undergraduate student retention. The U.S. lags behind much of the world in college degree attainment and production of STEM scientists.⁵ Across STEM fields, non-Asian racial and ethnic groups continue to be underrepresented in bachelor's degree attainment relative to their shares of the population.⁶ The primary IUSE investment, managed through the Directorate for Education and Human Resources (EHR), is to study educational outcomes for undergraduate improvement and to scale that improvement across all STEM domains and all types of undergraduate institutions. The Directorates for the Biological Sciences (BIO), Geosciences (GEO), and Engineering (ENG) all have discipline-specific investments, designed within the IUSE framework that will continue as part of the effort.

In FY 2015 and beyond, all directorates will be engaged in expanding the focus of IUSE to include undergraduate research courses, research experiences for undergraduates, and common outcomes. NSF's Research Experiences for Undergraduates (REU) sites and supplements programs fall within the IUSE purview, with budget and award decisions remaining within individual directorates. IUSE is governed by an IUSE Council comprised of Assistant Directors (ADs) and coordinated by the EHR AD.

Additionally, EHR's programs that focus on undergraduate education activities for minority serving institutions (MSIs) and groups underrepresented in STEM (e.g., Louis Stokes Alliance for Minority

⁵ President's Council of Advisors on Science and Technology (2012) *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf

⁶ www.nsf.gov/nsb/sei/edTool/data/college-14.html

Participation (LSAMP), Historically Black Colleges and Universities Undergraduate Program (HBCU-UP), Tribal Colleges and Universities Program (TCUP)) will be more fully integrated into IUSE through joint outreach, panels, co-funding, and partnerships. These and other activities ensure that MSIs can make the transition from a focus on capacity building to being part of the broader efforts to improve undergraduate STEM education. For example, effective models used at HBCUs and Hispanic-serving institutions (HSIs) can be studied to provide information for scaling and adaptation in other institutions.

NSF will fund a range of project types from foundational research to scale-up 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, cognitive science, and the social and behavioral sciences. The intent of IUSE is to build on NSF's unique strengths across the STEM disciplines and STEM education to focus on sustained improvements towards the goals described above. Such research is inherently interdisciplinary in nature. Aligned with the funding strategy will be the development of robust, common indicators and metrics to gauge progress towards the goals of IUSE.

There is an NSF-wide commitment to employing common goals and outcome measures, tailoring investments to address particular disciplinary challenges and understanding the differences, and increasing education investment in new and emerging areas of science. In FY 2016, all investments that are included within the framework will use a common name (e.g., "Improving Undergraduate STEM Education") with a subtitle, as appropriate, to signify a more specific focus. Investments/program dollars will remain in home directorates and divisions, but solicitations and program announcements will incorporate or reference agreed-upon language describing the framework and how the particular investment or program is situated within it.

Investment Framework

IUSE Funding by Directorate

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	\$1.82	\$2.50	\$2.50
Computer and Information Science and Engineering	-	2.00	-
Education and Human Resources	74.57	84.00	120.08
Engineering	5.45	6.00	6.00
Geosciences	-	10.90	6.00
Total	\$81.84	\$105.40	\$134.58

FY 2014 – FY 2015

IUSE was launched in FY 2014 in EHR with funding for awards in foundational and exploratory research, design and development implementation, and scale-up and effectiveness studies. This initial IUSE call attracted 1,097 proposals from across the disciplines in STEM education and an additional 600 applications to participate in the themed Ideas Labs through EHR partnerships with BIO, GEO, and ENG, in an attempt to clarify discipline-specific needs and solution approaches. In FY 2014, ENG in partnership with EHR and CISE announced a solicitation for Professional Formation of Engineers: Revolutionizing Engineering Departments (PFE: RED) to enable engineering departments to lead the Nation by successfully achieving significant, sustainable changes necessary to overcome long-standing issues in their undergraduate programs and educate inclusive communities of engineering students prepared to solve 21st century challenges.

Improving Undergraduate STEM Education

In FY 2015, IUSE coordination encompasses all investments in research and development that are critical for curricular improvement in undergraduate STEM education, within formal and informal learning environments, including those that:

- Use and build evidence about improved STEM instructional practices, with a focus on increased retention and persistence;
- Invite the successful participation and retention in STEM of students from groups traditionally underserved and underrepresented in STEM;
- Design and study innovative learning opportunities, including cyberlearning;
- Create, implement, and test program, curricular, course, and technology-driven models;
- Develop, implement, and test creative approaches for adoption of education research into disciplinary teachings;
- Develop and validate assessments/metrics for undergraduate STEM learning and instructional practice; and
- Conduct fundamental research on issues of undergraduate STEM teaching and learning.

FY 2016 Request

In FY 2016, the IUSE framework will be expanded to incorporate portfolio areas that support NSF's direct investments in students through fellowships and scholarships, and investments in students' participation in research experiences. It will be critical to retain directorate- and discipline-specific foci while at the same time basing undergraduate education investments on evidence, and using our programs as a basis for research and evaluation to ensure that we understand the impact and affordances of specific approaches to improvement. The refined IUSE framework that will be published in late FY 2015 will inform further coordination across all disciplines. In addition, all undergraduate programs across NSF will again be inventoried and reviewed to identify additional, emerging synergies and collaboration opportunities.

IUSE increases \$29.18 million in FY 2016, allowing expanded emphasis on bringing evidence-based instructional practices to scale for both the general improvement of STEM learning, and also to expand effective discipline-specific innovations. A key focus will be on strategies for engaging undergraduates in their first two years in authentic research experiences both in courses and in other settings. The IUSE investment within EHR will include partnerships with EHR programs focused on minority-serving institutions. GEO will continue to refine and align IUSE: Pathways into Geoscience (GEOPATHS) with the revised IUSE framework, as will ENG with the IUSE: RED program. Both of these programs emphasize the broadening participation and workforce development elements of IUSE. GEOPATHS will specifically address minority-serving institutions, furthering the FY 2016 introduction of building models of effectiveness for undergraduate STEM improvement in minority-serving institutions into the IUSE effort. BIO will continue with two IUSE programs, Partnerships in Undergraduate Life Science Education (PULSE), Research Coordination Networks in Undergraduate Biology Education (RCN-UBE), that emphasize the scaling of effective education practices within the biology undergraduate education community. The IUSE investments in fellowships and scholarships also will build on evidence to create robust, STEM learning environments for all students. All directorates will continue to manage and support REUs, informed by findings from education research that can strengthen the experiences and providing data that enhance our understanding of how to best offer research experiences that will benefit a wide range of students in varied settings and fields.

FY 2017 – FY 2020

As NSF accumulates a broader and deeper set of findings and evidence-based practices for improving undergraduate STEM education, we anticipate increased emphasis in later years in several areas. These include increasing access to undergraduate STEM learning and research experiences through technology, citizen science approaches, and apprenticeship and intern models; transition from pre-college to undergraduate STEM education; and transitions from undergraduate STEM education to the workplace and to graduate school. IUSE will also be coordinated with the NSF INCLUDES (Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science) pilot, particularly the Networks for STEM Excellence, and will incorporate the “collective impact” approach⁷ that is underway in higher education efforts related to college access and improvement.

Evaluation Framework

A major IUSE emphasis in FY 2016 will be the implementation of an NSF-wide crosscutting evaluation program, using the metrics that are under development in FY 2015. This work will coordinate with the ongoing CoSTEM effort across government to identify shared metrics. To support the activities of both IUSE and the CoSTEM implementation of the undergraduate strategic objectives of the Federal STEM Education 5-Year Strategic Plan, IUSE will fund a resource network to help with the common data collection necessary for a cross-agency evaluation effort.

IUSE metrics and indicators will be tailored to the three investment strategies; the development of these metrics and indicators will be a major focus in FY 2015. In FY 2016, the NSF Evaluation and Assessment Capability will work with EHR evaluation experts to implement data collection plans across the IUSE portfolio.

⁷ www.ssireview.org/articles/entry/collective_impact