

## IMPROVING UNDERGRADUATE STEM EDUCATION (IUSE)

**\$96,500,000**  
**-\$8,270,000 / -7.9%**

### Overview

Improving Undergraduate STEM Education (IUSE) underpins the agency’s commitment to the highest caliber undergraduate science, technology, engineering, and mathematics (STEM) education through a Foundation-wide framework of investments. By improving the quality and effectiveness of the education of undergraduates in all STEM fields, these investments enable NSF to lead progress nationally toward a diverse and innovative workforce and a STEM-literate public. As the National Science Board (NSB) has observed: “The ‘STEM workforce’ is extensive and critical to innovation and competitiveness.” Furthermore, the NSB writes, “Assessing, enabling, and strengthening workforce pathways is essential to the mutually reinforcing goals of individual and national prosperity and competitiveness.”<sup>3</sup>

Through the IUSE framework, which began in FY 2015, NSF coordinates its investments in undergraduates and undergraduate STEM education to enhance coherence and impact and to use shared metrics and evaluation approaches where appropriate. These investments address both general trends and specific disciplinary needs. Examples of general trends include the use of active learning approaches in undergraduate instruction,<sup>4</sup> the increase of undergraduate research courses, and attention to undergraduate degree completion. Examples of disciplinary imperatives include the need to recruit more women and minorities into majors in computer science, the importance of ensuring high-quality learning outcomes in introductory mathematics courses, the re-envisioning of introductory courses in the biological sciences in light of new research findings and theories, and the data science preparation of undergraduates in virtually all STEM disciplines. Moreover, new interdisciplinary challenges demand attention as automation and behavioral science—augmented by big data—revolutionize the workplace, the nature of work, and research practices.

Key reports and documents<sup>5,6</sup> contain persuasive arguments that a high-quality undergraduate experience is vital to preparing a diverse professional STEM workforce equipped to lead innovation, to growing a larger pool of STEM-savvy workers capable of employing STEM skills in business and industry, and to ensuring a STEM-literate public ready to support and benefit from the progress of science. NSF, with its mission to advance science, engineering, and education, plans to invest \$96.50 million in FY 2018 through coordinated investments both across and within directorates, aligned with a coherent framework for improving undergraduate STEM teaching and learning.

### Total Funding for IUSE

(Dollars in Millions)

FY 2016	FY 2017	FY 2018
Actual	(TBD)	Request
\$104.77	-	\$96.50

<sup>3</sup> National Science Board. (2015). *Revisiting the STEM workforce*. Arlington, VA: National Science Board. Retrieved from [www.nsf.gov/nsb/publications/2015/nsb201510.pdf](http://www.nsf.gov/nsb/publications/2015/nsb201510.pdf)

<sup>4</sup> Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science. *Proceedings of the National Academy of Sciences*. 111, 8410-8415. Retrieved from [www.pnas.org/content/111/23/8410.abstract](http://www.pnas.org/content/111/23/8410.abstract)

<sup>5</sup> 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*. Retrieved from [https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final\\_2-25-12.pdf](https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf)

<sup>6</sup> Coalition for Reform of Undergraduate STEM Education. (2014). *Achieving systemic change: A sourcebook for advancing and funding undergraduate STEM education*. Washington, DC: Association of American Colleges and Universities.

## **Goals**

NSF undergraduate investments map to one or more of the three IUSE goals:

- **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 and fosters widespread use of evidence-based resources and pedagogies in undergraduate STEM education.
- **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 implementing evidence-based successful strategies to broaden participation and by growing that evidence base.
- **Build the STEM workforce for tomorrow.** Improve the preparation of undergraduate students so that they can succeed as productive members of the future STEM and STEM-capable workforce, regardless of career path, and be engaged as members of a STEM-literate society.

## **Approach**

Six principles inform decision-making about strategic investments to achieve the three IUSE goals.

- Federal investment in undergraduate STEM education is critical to the development of the Nation's scientific workforce, and NSF has a leading role in this area.
- NSF investments in undergraduate education will be focused, strategic investments centered on addressing the greatest challenges in U.S. undergraduate STEM education.
- The IUSE portfolio represents coordination among all NSF directorates, while respecting distinct disciplinary opportunities, challenges, and needs.
- IUSE is informed by input from multiple sources, including STEM disciplines and education research.
- Development and future growth of the IUSE portfolio will be based on demonstrated impact and effectiveness of NSF investments.
- The IUSE framework will eventually accommodate all NSF investments in undergraduate education and will be aligned with agreed-upon, corresponding directorate goals.<sup>7</sup>

## **Investment Framework**

The IUSE framework uses findings from research and evaluation on STEM learning and education to address challenges common across undergraduate STEM education, as well as within specific disciplines. NSF IUSE core investments also serve as test beds for continued building of evidence for improvement of undergraduate STEM education across a diversity of institutional types. NSF IUSE-affiliated programs are positioned to connect to and benefit from the core activities. The framework draws upon a knowledge base accumulated from decades of research, development, and best practices in STEM undergraduate education.<sup>8,9,10,11</sup> New and ongoing investments within the IUSE portfolio will integrate theories and findings from education research, with attention to the needs and directions of frontier science and engineering research. This will generate new knowledge about learning, teaching, and implementation and how to improve the undergraduate preparation of a diverse STEM workforce.

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<sup>7</sup> All undergraduate programs have now been mapped to the framework and placed into two categories: 1) the IUSE core programs that were developed over the FY 2014-16 period as part of the agency-wide initiative, and 2) affiliate programs that are aligned with the framework, both informing and being informed by the work across both program categories. All are connected by their commitment to the IUSE principles.

<sup>8</sup> National Research Council. (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. Washington, DC: National Academies Press. Retrieved from [www.nap.edu/catalog.php?record\\_id=13362](http://www.nap.edu/catalog.php?record_id=13362)

<sup>9</sup> National Research Council. (2015). *Reaching students: What research says about effective instruction in undergraduate science and engineering*. Washington, DC: National Academies Press. Retrieved from [www.nap.edu/download.php?record\\_id=18687](http://www.nap.edu/download.php?record_id=18687)

<sup>10</sup> Bailey, T. R., Jaggars, S. S., & Jenkins, D. (2015). *Redesigning America's community colleges: A clearer path to student success*. Cambridge, MA: Harvard University Press.

<sup>11</sup> Smith, D. (Ed.). (2015). *Vision and change in undergraduate biology education: Chronicling change, inspiring the future*. Washington, DC: AAAS. Retrieved from [visionandchange.org/files/2015/07/VISchange2015\\_webFin.pdf](http://visionandchange.org/files/2015/07/VISchange2015_webFin.pdf)

The IUSE framework relies upon the following five investment strategies:

- **Build core knowledge through research and development (R&D):** R&D investments will grow the evidence base on how best to improve undergraduate education through education research, including discipline-based education research.<sup>12</sup>
- **Implement and scale evidence-based practices and tools:** These investments will allow for the execution of a program or activity by the building of a discipline-specific, test-case model, based on core research knowledge; such programs and models can serve as sites for implementation research that can help in understanding the impacts of intervention and generating new questions that need examination.
- **Catalyze departmental and institutional transformation:** This funding supports design and implementation of models for systemic improvement.
- **Scholarship programs:** Direct support to students to encourage entry and retention in STEM fields.
- **Disciplinary research experiences for students:** This funding engages students in research.

### **FY 2018 Investments**

A total of \$96.5 million for IUSE is requested in FY 2018.

The Directorate for Education and Human Resources (EHR) will explore allocating a portion of the IUSE: EHR budget to establish an IUSE Collaborative Opportunities Fund (ICOF). The fund will be used to incentivize cross-directorate collaboration to identify thematic areas of emphasis that target pressing challenges in undergraduate STEM education either in specific disciplinary domains or in interdisciplinary areas of convergent research. Once such themes are identified, cross-directorate teams of program staff will issue calls for proposals under the IUSE: EHR umbrella program with all aspects of proposal processing and decision-making managed by the cross-directorate teams and with funding from participating directorates. The ICOF mechanism will be available to use in all three pooled IUSE goals as appropriate.

In FY 2018, \$15.0 million is included for IUSE: Hispanic Serving Institutions (IUSE: HSI), with funding provided through the Division of Undergraduate Education and the Division of Human Resource Development. The primary goals of the IUSE: HSI activity are to promote research on engaged student learning at HSIs, to incentivize institutional and community transformation, and to promote fundamental research about what it takes to diversify and increase participation in STEM effectively, including research that improves our understanding of how to build institutional capacity at HSIs. These activities will address the Nation's need to make the STEM workforce more inclusive.

### **Goal 1: Improve STEM learning and learning environments**

- EHR will continue to develop indicators, metrics, and assessments to measure readiness for and progress toward widespread use of evidence-based resources in undergraduate STEM instruction. Program staff will seek to leverage any prior efforts for gathering data on indicators as a part of IUSE monitoring and evaluation and will use findings to shape future cross-directorate collaborations that enlarge the core IUSE investment activities.
- In EHR, applied research aimed at enabling improvements in undergraduate education at scale will continue to be a priority.
- Existing core IUSE investments, e.g. Research Coordination Networks: Undergraduate Biology Education (RCN: UBE), will present opportunities to make further progress on particular challenges facing the undergraduate enterprise in those domains.
- Themes associated with the NSF Big Ideas will present opportunities to leverage the ICOF approach, particularly with respect to interdisciplinary efforts.

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<sup>12</sup> Op. cit., National Research Council. (2012).

**Goal 2: Broaden participation and institutional capacity for STEM learning**

- Several EHR programs with a broadening participation focus or opportunity—Louis Stokes Alliances for Minority Participation (LSAMP), Historically Black Colleges and Universities Undergraduate Program (HBCU-UP), Tribal Colleges and Universities Program (TCUP), Advanced Technological Education (ATE), and Robert Noyce Teacher Scholarship Program (Noyce)—will explore alignment within the IUSE framework beginning in FY 2018.
- The IUSE: Pathways into Geoscience (IUSE: GEOPATHS) commitment to fostering broader and more inclusive pathways into careers in the geosciences will continue; as will the IUSE: Polar Research (IUSE: PLR) investment.
- Related efforts in the Directorate for Computer and Information Science and Engineering (CISE) to broaden participation will explore partnerships with relevant EHR programs, such as those mentioned above.

**Goal 3: Build the STEM Workforce for Tomorrow**

- Thematic evaluation begun in FY 2017 will continue with a goal of understanding how programs that directly support students with scholarships—e.g. Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM), Noyce, and CyberCorps®: Scholarship for Service (SfS)—contribute to workforce development and STEM degree completion for diverse populations.
- Leadership of the NSF directorates, with input from a Research Experiences for Undergraduates (REU) Coordinating Committee, will seek to build on prior discussions and expand the STEM research and experiential learning opportunities available to undergraduate students in NSF-funded large facilities, national laboratories, and centers.
- The IUSE: GEOPATHS program will seek to expand its efforts to create a broader and more inclusive pathway into careers in the geosciences via research experiences for undergraduates featuring active involvement in field campaigns and at high-level facilities, such as ships, airplanes, and data centers, with employer input about needed skills. Here there is an opportunity to leverage current activities supported by the ATE program.
- Projects in the IUSE: EHR portfolio will be encouraged to establish collaborations with the growing cohort of NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) Design and Development Launch Pilots and the NSF INCLUDES Alliances as they are awarded, to amplify each other’s impact.
- CISE will explore issuing a DCL or solicitation focused on knowledge generation and implementation of new strategies for undergraduate education in computer science, particularly in the face of growing enrollments and interest in computing as well as the growing support for curricular approaches that acknowledge the intersection of computer science and other disciplines, collectively referred to as “CS+X,” where “X” is a placeholder for other disciplines.
- NSF will collaborate again with the American Association of Community Colleges to sponsor and organize the Community College Innovation Challenge.

**Improving Undergraduate STEM Education  
Funding by Directorate  
(Dollars in Millions)**

Dir/Office	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request
BIO	\$2.74	-	\$2.50
CISE	1.98	-	2.00
EHR	87.00	-	87.00
ENG	6.90	-	-
GEO	6.14	-	5.00
<b>Total, IUSE</b>	<b>\$104.77</b>	<b>-</b>	<b>\$96.50</b>