Cross-Agency Priority Goal: Science, Technology, Engineering, and Math Education

FY2013 Q2 Status Update

Cross-Agency Priority Goal Statement

In support of the President's goal that the U.S. have the highest proportion of college graduates in the world by 2020, 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 1 million graduates with degrees in STEM subjects.

Goal Leader

Steve Robinson, Special Assistant, White House Domestic Policy Council

About this document

The Cross-Agency Priority (CAP) Goals were a key innovation introduced in the FY 2013 Federal Budget. These goals focus on 14 major issues that run across several Federal agencies. Each of these goals has a Goal Leader who is a senior level White House official and is fully accountable for the success and outcomes of the goal.

Historically, areas of shared responsibility for multiple government agencies have been resistant to real progress. Success in these areas requires a new kind of management approach – one that brings people together from across and outside the Federal Government to coordinate their work and combine their skills, insights, and resources. The CAP Goals represent Presidential priorities for which this approach is likeliest to bear fruit.

This report discusses one of these CAP Goals, the STEM Education Goal, in detail, describing the plan for achieving the goal and the current status of progress. To see the full list of CAP Goals and to find out more about them, we encourage you to visit performance.gov.

Contents

Overview

A number of economic and labor analyses suggest that if the United States is to maintain its global preeminence in the fields of science, technology, engineering, and mathematics (STEM)—and benefit from the social, economic, and national security advantages that come with such preeminence—then it must produce approximately 1 million more STEM professionals than are projected to graduate over the next decade.[1, 2, 3] To meet this goal, the United States institutions of higher education will need to increase the number of students who receive undergraduate STEM degrees by more than 30 percent over current rates by 2020.

Increasing retention of STEM students is a key area of opportunity

Achieving this ambitious increase in STEM graduates will require focusing on a key area of concern: the retention rate of STEM majors during the initial years of college. In its recent report, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, the President's Council of Advisors on Science and Technology (PCAST) concludes that retaining more STEM majors is the lowest-cost, most efficient policy option

[1] Carnevale, A.P., N.Smith, and J. Strohl. (2010). Help Wanted: Projections of Jobs and Education Requirements through 2018. Washington, DC: Georgetown University Center on Education and the Workforce.
[2] Lacey, T. A. and B. Wright. (2009). "Occupational employment projections to 2018." Monthly Labor Review 132(11):82-123.
[3] Langdon, D., G. McKittrick, D. Beede, B. Khan, and M. Doms. (2011). "STEM: Good Jobs Now and for the Future." ESA Issue Brief #03-11. Washington, DC: U.S. Department of Commerce.

to provide the STEM professionals that the Nation needs.

Data indicates that fewer than 40 percent of students who enter college intending to major in a STEM field complete a STEM degree.[4] Increasing the retention of STEM majors to 50 percent would generate approximately three-quarters of the targeted 1 million additional STEM graduates over the next decade by increasing the annual number of students with bachelor or associate degrees in STEM fields by approximately 75,000.

Furthermore, such an increase appears feasible. For example, one U.S. university recently succeeded in boosting graduation rates in STEM disciplines by nearly 50 percent.[5, 6, 7] To accomplish this result, the university worked to ensure that high-school students from schools that feed into the university were better prepared for STEM majors, increased student research opportunities, and improved teaching practices. This experience, and others like it around the country, is promising. A key next step for this goal, therefore, will be continued search for effective practices combined with efforts to adapt and scale those that appear most promising.

Strategies

To improve retention, PCAST examined the major reasons why students abandon STEM majors. Their findings included:

- uninspiring introductory courses and lack of effective teaching practices;
- lack of access to research experiences;
- difficulty with mastering the required mathematics; and
- insufficient focus on women and under-represented minorities.

In addition, the Administration and its partners need to strategically support greater innovation and multi-sector collaborations in higher education that can improve quality, productivity, and access within STEM fields. Collectively, progress on these fronts is essential to achieve this 1 million STEM graduates goal and to meet the President's 2020 call for the Nation to regain its global lead in college graduation rates.

To meet this goal, the Federal Government, working closely with potential delivery partners, will pursue the following strategies:

- Reorganizing federal STEM-education programs for greater impact, coherence, ease of evaluation, and focus on specific identified priorities, including undergraduate education. The FY14 Budget Request for STEM education would increase the total investment by 6

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[4] U.S. Department of Education, National Center for Education Statistics, 2003-04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09).
[5] http://step.utep.edu
[6] Brown, S. (2009). "Making the Next Generation our Greatest Resource" in *Latinos and the Nation's Future*, H. Cisneros and J. Rosales (eds.) Houston, TX: Arte Publico Press.
[7] Becvar, J.E., Dreyfuss, A.E., Flores, B.C., & Dickson, W.E. (October, 2008). 'Plus two' Peer-led team learning improves student success, retention, and timely graduation. *38th Annual Frontiers in Education Conference.* October 22-25, 2008, Saratoga Springs, NY.

percent over 2012 while reducing the number of programs across the 14 agencies from 226 to 110. The savings from program eliminations would be redirected to programs in the Department of Education, the National Science Foundation (NSF), and the Smithsonian Institution, including for a new $123 million program at NSF that will focus on improving the delivery of undergraduate STEM teaching and learning through evidence-based reforms.

- Identifying and implementing evidence-based practices to improve STEM teaching, and attract students to STEM courses.
- Providing more opportunities for students to do hands-on, real-world STEM activities through research experiences, especially in their first two years of college.
- Addressing the mathematics preparation gap that students face when they arrive at college using evidence-based practices that generate improved results.
- Pursuing a focus on women and underrepresented minorities.
- Identifying and supporting innovation in higher education.

At the same time, Federal Government science agencies will move forward on implementing the 5-Year Strategic Plan for Federal STEM Education prepared by the Committee on STEM Education of the National Science and Technology Council[8]. This report was transmitted to Congress in May in response to the requirements of the America Competes Reauthorization Act of 2010.

Metrics on the goal of increasing the number of STEM graduates must take into account that students take several years to graduate, and that there will be a lag between the actions taken by the Federal Government, and subsequent changes in the number of STEM graduates.

Milestones to support this work include:

- By quarter 3 FY 2013, the CAP Goal working group will work to develop a methodology to identify baseline, total number of STEM graduates, and other appropriate indicators or methods to measure progress on this goal.

Identifying and implementing evidence-based practices to improve STEM teaching, and attract students to STEM courses.

At the undergraduate level, a growing body of evidence supports the need to improve introductory college-level STEM learning experiences.[9] In traditional lecture modes, students typically learn less than 30 percent of the new concepts presented. A number of leading science educators have demonstrated effective practices that improve student performance by 50 percent or more by basing teaching methods on objective data, disseminating results, harnessing modern technology, and leveraging recent advances in educational and cognitive psychology.[10] Some undergraduate

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

[9] National Research Council. (2012). Discipline Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering. Washington, DC: National Academy Press.

[10] Deslauriers, L., Schelew, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. Science 332(6031): 862-864.

campuses are now building centers focused on supporting these new teaching methods with the goal of driving adoption of evidence-based pedagogical practices.[11]

- **Supporting undergraduate STEM education reform in key NSF higher education programs:** The President's FY 2014 Budget includes over $100 million in investments by NSF to improve undergraduate STEM education practices through research and development programs. As part of the STEM reorganization, NSF will be the lead agency in reforming STEM undergraduate education, coordinating efforts with a number of other Federal Agencies and Departments. NSF has also created a Priority Goal on undergraduate education which focuses on designing a suite of methods for documenting the extent of use of proven instructional practices in the institutions funded by NSF. As stated in NSF's Priority Goal[12]:

  > NSF funded the National Research Council to undertake a synthesis study regarding the status, contributions, and future directions of discipline-based education research (DBER) in physics, biological sciences, geosciences, and chemistry. DBER combines knowledge of teaching and learning with deep knowledge of discipline-specific science content. The study addresses questions that are essential to advancing DBER and broadening its impact on undergraduate science teaching and learning. It was released in May 2012.[13]
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  > Another way that NSF can advance its efforts to invest in the preparation of a strong S&E workforce is by encouraging and facilitating the use of empirically-based instructional practices in undergraduate STEM education. To do this first means establishing a baseline about the use of such practices.
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  > Institutions funded by NSF's undergraduate STEM education programs will be the most critical partners in this endeavor. Faculty members in those institutions will provide the baseline data about the nature of STEM instructional practices. A variety of organizations invested in STEM undergraduate education will also contribute to the achievement of this goal. Such stakeholder groups as the Association of Public and Land-grant Universities (APLU) and the Association of American Universities (AAU) will collaborate to define key terms, identify proven practices, and assist with engagement of the universities.

- **Continued momentum on partnerships with leading universities and industry to improve their undergraduate teaching practices:** In consultation with federal agencies, the Association of American Universities (AAU) launched a five-year initiative in 2011 with the intent of improving the quality of undergraduate STEM teaching and learning at

[11] For examples see the Center for the Integration of Research, Teaching and Learning, http://www.cirtl.net/
[12] http://my-goals2.uat.performance.reisys.com/goal_detail/NSF/388
[13] http://www.nap.edu/catalog.php?record_id=13362

research universities. The overarching goal of the initiative is to influence the culture of STEM departments at AAU universities so that they will use sustainable, student-centered, evidence-based, and active learning pedagogy in their classes, particularly at the freshman and sophomore levels. These demonstration projects will be the first phase of an effort to encourage broad-based, systemic reform of undergraduate teaching practices at AAU research universities that may serve as models of successful adoption for other colleges and institutions. In addition, in June 2012, building on AAU's work, nine leading university and industry groups, including the Business Higher Education Forum (BHEF), Association of Public and Land-Grant Universities (APLU), the American Council on Education (ACE), and the National Defense Industrial Organization (NDIA) committed themselves to work together on improving the first two years of college for STEM undergraduates. Through the President's Council on Jobs and Competitiveness, a close partnership was developed among NSF, GE, and Intel to support retention of engineering and computer science students through the NSF undergraduate education programs.[14]

- **Funding for STEM in Department of Labor's $2 billion fund for community colleges:** As part of the Trade Adjustment Assistance Community College and Career Training program, the U.S. Department of Labor (DOL) is investing $2 billion in competitive grants over four years (FY 2011 – FY 2014) that promote skill development in fields such as advanced manufacturing, transportation, health care, and STEM through partnerships between training providers and local employers. DOL is implementing and administering the program in coordination with the Department of Education (ED). With $1 billion planned in grants already awarded in FY 2011 and FY 2012 and an additional $1 billion in the next two years, the initiative complements President Obama's broader goals to help ensure that every American has at least one year of postsecondary education and that the U.S. has the highest proportion of college graduates in the world by 2020. These grants have the potential to improve retention for adult workers, by creating partnerships between industry and universities and supporting innovation in course design and teaching. Furthermore, all the intellectual property produced with these grant funds, which include a variety of digital STEM learning resources, will be released with an open license that allows their free use, customization, continuous improvement and repurposing by others.

- **Placing a greater emphasis on STEM-dependent sectors in the transformed Perkins-supported career and technical education.** In 2012, ED put forward a plan for reauthorization of the Carl D. Perkins Career and Technical Education Act, *Investing in America's Future: A Blueprint for the Transformation of Career and Technical Education*, which proposes that federal funds be used to support consortia between secondary and postsecondary institutions and industry/business that offer pathways to jobs in high-growth industry sectors. STEM occupations or STEM-dependent occupations in these sectors would receive greater emphasis than other in-demand sectors and occupations, as supported by State demand data.

[14] http://www.nsf.gov/pubs/2012/nsf12108/nsf12108.jsp

Key steps include:

Implementation of this strategy will include the design, piloting, testing, and application of a suite of methods to gather information about the nature of undergraduate STEM instructional practices in institutions, to be undertaken initially by NSF as part of the implementation of one of NSF's Priority Goals. These methods will enable academic institutions to benchmark their instructional practices in STEM fields. This will also include:

1. **Field input.** Solicit input from the field regarding evidence-based instructional practices through principal investigator meetings.
2. **Project funding.** Fund projects to measure the use of evidence-based instructional practices through the WIDER (Widening Implementation and Demonstration of Evidence-based Reforms) Dear Colleague Letter and solicitation.
3. **Revise program solicitations.** Revise program solicitations to either require or encourage the submission of baseline data on evidence-based instructional practices in proposals.
4. **Workshops.** Host regional workshops for PIs to gather and share information regarding the measurement of evidence-based instructional practices at Institutions of Higher Education.
5. **Information dissemination.** Develop a mechanism for dissemination of information about evidence-based instructional practices such as a resource network. A planning group will develop a solicitation for a funded activity to disseminate information learned through the above activities.
6. **Strengthen evidence-based capacity**. Review and revise existing monitoring systems as appropriate, to gather information about evidence-based instructional practices. Questions will be added to existing monitoring systems for undergraduate programs to capture the extent of current use of proven instructional practices.

Milestones to support this work include:

The National Science Foundation has published its milestones for this activity; they will include:

- In Quarter 1 of FY 2013, the working group plans to solicit input from program directors across NSF's directorates. Based on these conversations, solicitations may be revised to incorporate language in proposals regarding measurement of the use of evidence-based instructional practices at institutions of higher education.

- In Quarters 2 through 4 of FY 2013, regional stakeholder workshops about measuring proven instructional practices at the undergraduate level will be held.

- By August 2013, an NSF-supported summary of the literature on concept inventories for use in planning assessment of undergraduate STEM instruction will be released.

- Finalize report from stakeholder workshop. Because the deadline for reporting is September 30, 2013, a final document of the data collected will be available at a later time.

- Develop a mechanism for dissemination of information about evidence-based instructional practices such as a resource network.

Key milestone from other agencies and federal partners will include:

- In June 2013 the Administration collaborated with BHEF on a meeting to generate stakeholder support for the President's goal of preparing an additional 1 million STEM graduates. In summer 2013, the Administration will convene other federal agencies and non-governmental STEM education stakeholders to explore mechanisms to improve the quality of undergraduate STEM learning, including evidence of improved student learning outcomes, such as retention, persistence and degree attainment. This will also be an opportunity to highlight progress made on efforts such as those led by AAU, APLU, BHEF, and to stimulate additional public and private sector commitments.

Q1 Progress Updates:

- As a result of discussions with program directors across NSF directorates, NSF's working group developed language for undergraduate STEM education research and development solicitations. The language requires the inclusion of baseline data in the project description to provide context for the impact of the project. This language is in the Historically Black Colleges and Universities Undergraduate Program (HBCU-UP) solicitation and draft solicitations for Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES), Widening Implementation and Demonstration of Evidence-based Reforms (WIDER), Core Research and Development, and Expeditions in Undergraduate Education (E^2). As additional, relevant solicitations are revised or developed, this language will also be incorporated.

More opportunities for students to do hands-on, real-world STEM activities through research experiences, especially in their first two years of college.

In STEM fields, many students must wait until they are far along in their studies before they can experience the excitement of authentic scientific research experiences. Several studies found, for example, that college sophomores who engaged in research projects with a professor were significantly less likely to leave STEM majors than those who did not.[15,16,17,18,19] The effects of such

[15] Nagda, B. A., S. R. Gregerman, J. Jonides, W. von Hippel, and J.S. Lerner. (1998). "Undergraduate student-faculty research partnerships affect student retention." The Review of Higher Education 22: 55-72.
[16] Foertsch, J. A., B. B. Alexander, and D.L. Penberthy. (1997). "Evaluation of UW-Madison's summer undergraduate research programs (final report)." Madison, WI: University of Wisconsin-Madison, LEAD Center.
[17] Gilmer, T. C. (2007). "An Understanding of the Improved Grades , Retention and Graduation Rates of STEM Majors at the Academic Investment in Math and Science (AIMS) Program of Bowling Green State University (BGSU)." Higher Education 8: 11-21.
[18] Hunter, A-B., S. L. Laursen, and E. Seymour. (2007). "Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development." Science Education 91: 36-74.

experiences are quite positive for all students and have an especially high impact for women and members of other underrepresented groups in STEM disciplines.[20] For instance, the National Academy of Engineering has teamed up with universities across the country to create an engineering-focused "Grand Challenge Scholars Program." [21] This allows undergraduates at participating universities to organize their coursework, research, service and experiential learning around a Grand Challenge that fosters practical applications from the beginning of their undergraduate experience.

Key steps to realize this potential include:

- **Continued momentum on partnerships with industry to increase the number of STEM internships and other authentic research experiences:** Recognizing the critical role of improving STEM undergraduate retention, the President's Council on Jobs and Competitiveness has set a goal of increasing the number of U.S. engineering graduates by 10,000 per year. As a key step toward meeting that goal, the President's Council, in partnership with the Business Council, Business Roundtable, U.S. Chamber of Commerce, National Association of Manufacturers, and the American Chemistry Council, announced that over 45 industry leaders have committed to double the engineering internships available at their companies. The Administration will work with these key partners to continue to increase the number of such experiences available for freshmen and sophomore students. Already, these commitments will add approximately 6,800 additional opportunities per year for hands-on, technical job experience in engineering.

- **New efforts by science agencies to give more research, internship, and fellowship opportunities to undergraduates:** To meet this key challenge, the President's FY 2013 Budget includes a proposal for NSF to establish a new program called Expeditions in Education (E^2) to connect NSF's Education and Human Resources (EHR) directorate with all other NSF directorates and offices to use cutting-edge science and education research to provide new, innovative learning experiences that attract students into science. The U.S. Geological Survey is expanding its partnerships with community colleges and high school science longitudinal programs, such as GeoForce at the University of Texas, to provide early STEM experiences and internships as well as create job pathways for high demand careers in hydrology and geology. In addition, based on evidence synthesized in the PCAST report *Engage to Excel*, the broad range of federal science and technology agencies will explore increasing the number of STEM-focused internships and research opportunities that they make available to undergraduate students, especially at federal research centers and laboratories.

- **The Federal Government will work with its industry partners to encourage commitments to provide more experiences to undergraduate students and support**

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[19] Russell, S. H., M.P. Hancock, and J. McCullough. (2007). "The pipeline. Benefits of undergraduate research experiences." Science 316(5824): 548-9.
[20] President's Council of Advisors on Science & Technology, (2012) Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.
[21] http://www.grandchallengescholars.org/

student-focused competitions. Example of such programs include the Rice University Oshman Engineering Design Kitchen and Business Plan competition, the MIT $100K Clean Energy Challenge, the Secretary of Transportation's RAISE Award, Big Ideas @ Berkeley – programs that encourage students to think innovatively about solutions for real-world problems. The top teams in these competitions are often undergraduate or graduate students who have used their science and engineering skills to develop new technologies, and increase interest in STEM fields among their peers.

Milestones to support this work include:

- By September 2013, federal agencies that support undergraduate research through external grants or by having undergraduates working with scientists will develop a plan to document what year of college the undergraduates are in, including any metrics used by the agency on the impacts of these experiences on key outcome measures.
- By November 2013, federal agencies with capabilities to increase research experiences for students during the first two years of college will implement a plan by which the fraction of these students will be increased over the next five years and progress on that plan should be tracked, while ensuring continued support for upperclassmen, and reported yearly. Such a plan should recognize the greater burden that lower level students place on research supervisors and provide appropriate incentives to compensate, even if this modestly reduces the total number of students that can be supported. Key indicators for success in agency plans can include:
    - increases in research or industry experiences provided by federal agencies;
    - increases in engineering research or internship experiences provided by industry partnerships, and
    - introduce accountability systems to track the progress of the students, the quality of these experiences, and the impact on students' career paths.

Address the mathematics preparation gap that students face when they arrive at college.

Entering college without adequate mathematics skills not only limits students' ability to enter STEM careers, but costs a great deal—colleges spend at least $2 billion per year on developmental education in language arts and mathematics for underprepared students.[22] Federal agencies and their partners should work to reduce the math bottleneck using smarter approaches for remediation, such as summer and other bridge programs for high school students entering college, and improved entry level courses for college students that allow simultaneous progress in new subjects and improvement in areas of weakness or missing background.

[22] Strong American Schools. (2008). Diploma to Nowhere. Washington, DC.

Key steps to address this critical challenge include:

- **A new First in the World Competition.** ED's 2014 Budget proposal to support a $260 million First in the World Competition will develop, validate, and scale-up innovative post-secondary education practices, including those that address developmental education in math.

- **A new K-16 mathematics education initiative jointly administered by ED and NSF:** To support comprehensive reform efforts in K-16 education, the President's 2014 Budget includes a jointly administered initiative to improve mathematics education with $30 million from ED and $15 million from NSF. This initiative plans to use a tiered evidence-based approach to develop and validate effective practices.

Milestones to support this work include:

- By March 2013, ED and NSF will determine to the role each agency will take to improve mathematics education as part of its joint program, and lay out a roadmap for implementation.

- By August 2013, NSF and ED will have prepared a joint solicitation for proposals to improve K-16 mathematics education, and will have released that solicitation and made awards, pending available funding.

A focus on women and underrepresented minorities.

Women and minority groups traditionally underrepresented in STEM account for 70 percent of students on undergraduate campuses, yet they constitute only 45 percent of students enrolled in all science and engineering baccalaureate programs.[23] This proportion drops even further within certain critical STEM disciplines like engineering and computer science in which women, for instance, constitute only 18 percent of degree recipients.[24] Hispanic students often express above-average interest in pursuing a STEM degree but find themselves unprepared for college-level mathematics and science courses.[25] Bolstering underrepresented student interest and retention through increased preparation, access to mentors, and hands-on learning opportunities such as those described above will go a long way in meeting the 1 million student goal.

Key steps to achieve this goal include:

- **A breakthrough partnership between agencies and the private sector to create a more "equal future" for women and girls in STEM:** As part of the United States' commitment to the 12-nation Equal Futures Partnership launched in September 2012, eight federal agencies and five private organizations announced concrete steps to support women

[23] President's Council of Advisors on Science & Technology, (2012) Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics,
[24] National Science Foundation, National Center for Science and Engineering Statistics, (2012) Women, Minorities, and Persons with Disabilities in Science and Engineering, digest update, table 5-1
[25] Ibid, table 2-8

and girls in STEM disciplines. These commitments - which included analysis and integration of gender-disaggregated data from internship programs at National Aeronautics and Space Administration (NASA), and Discovery Communication's launch of STEM Power camps dedicated to teaching girls – seek to improve women's recruitment and retention through data collection, mentorship, research-based teaching, online skills training, and workplace flexibility. Support for these and other efforts (e.g., NSF's Career-Life Balance initiative, announced by the First Lady in September, 2011) will be continued and additional opportunities for action identified through follow-on collaboration with OSTP, the National Security Staff, White House Council on Women and Girls, and other federal agencies. In April 2013, an additional 10 countries and handful of private sector partners joined the Partnership, adding to the momentum of previous commitments.

- **Increased momentum for efforts to create productive campus climates through mentorship and technical assistance:** Breaking down the unintended barriers that lead women and members of traditionally underrepresented groups to drop out of STEM degree programs can improve retention.[26] For instance, increasing the recruitment and availability of role models and mentorship opportunities for underrepresented students has been shown to improve their retention in STEM fields, where feelings of isolation can often produce discouraging environments.[27] To this end, the Department of Energy (DoE), NASA, NSF, the Environmental Protection Agency, and Department of the Interior, as well as private partners like Harvey Mudd College and Piazza, have each announced new efforts to connect their own federal scientists to underrepresented undergraduates in STEM fields. Additionally, in 2012 both NASA and a seven-agency group headed by ED's Office for Civil Rights released technical assistance tools to help STEM departments at higher education academic institutions better understand and meet their obligations under Title IX. Continuing this effort through compliance and technical assistance efforts at ED, DoE, NASA, NSF, and Department of Health and Human Services can promote the sharing and adoption of best practices and available tools for positive climates.
- **Improve support for minority-serving institutions (MSIs) and other institutions with large numbers of students from underrepresented communities:** MSIs and other institutions with large numbers of students from underrepresented communities enroll 14 percent of college students in the U.S. These institutions "punch well above their weight" in STEM education. For example, Historically Black Colleges and Universities (HBCUs) account for only 3 percent of all degree-granting institutions but account for over 20 percent of all science and engineering degrees awarded to black students in the U.S. Nine federal agencies annually provide approximately $300 million in STEM education funding to MSIs. The National Science and Technology Committee on STEM Education, together with OMB, will work with MSIs to help navigate and, where possible, streamline different application

[26] Cheryan, S., J.O. Siy, M. Vichayapai, B.J. Drury and S. Kim. (2011). "Do Female and Male Role Models Who Embody STEM Stereotypes Hinder Women's Anticipated Success in STEM?" Social Psychological and Personality Science 2: 656-664.
[27] Hewlett, S. (2008) The Athena Factor: Reversing the Brain Drain in Science, Engineering, and Technology

processes by clarifying reporting requirements and providing definitions of key terms. If the burdens caused by these differences were removed, institutions could redirect valuable time and money toward improving student success and reporting on the impact of their efforts, and away from writing applications. Agencies will also seek to identify effective practices in serving these intuitions by reviewing indicators of success reported by MSIs. NOAA's Educational Partnership Program, for example, seeks to strengthen STEM capacity at MSIs and partner institutions. Success of this program has been illustrated by increased numbers of STEM faculty, STEM degree programs, leveraged funds for STEM programs and publication of scientific papers, leading to an increase in the number of students receiving STEM degrees.

In addition, within other key student populations such as veterans, federal agencies can build on partnerships such as MentorVet, a collaboration between MentorNet, Boeing, and the First Lady's Joining Forces campaign, to help more veterans interested in STEM who return to college to stay on track towards their STEM degrees.

Milestones to support this work include:

- In summer 2013, the Administration will convene Science and Technology (S&T) agencies responsible for Title IX compliance efforts to establish a path forward for aligning guidance and tools to improve compliance.

- In April 2013, the Administration highlighted the implementation of commitments made under the Equal Futures Partnership and identified opportunities for new commitments at the US Geological Survey, NSF, and the Office of Personnel Management and within non-governmental and private sectors.

- By June 2013, the Administration will convene a meeting with federal agencies, MSIs and other stakeholders to develop strategies for improving and streamlining application processes and funding models for MSI STEM programs. The Administration will report on the outcomes of the consultations and work with agencies to implement the most promising options.

- By July 2013, NOAA will convene a meeting of MSIs and other interested agencies to discuss effective practices and indicators of success.

Identifying and supporting the role of technology and innovation in higher education

Beyond these steps, there are a number of additional areas of potential innovation and multi-sector collaborations in higher education. Information technologies can do much more to make learning more accessible, more personalized, more compelling and more productive through quicker mastery and better retention. Well-designed simulations allow learners to bridge theory to practice. In addition, they can be designed to provide meaningful student assessments through

performance-based testing by providing scenarios that closely resemble real-world tasks. In fact, there is evidence that new learning technology can improve learning in at least the following ways: (1) broadening access to resources and experiences; (2) engaging students in active learning; (3) individualizing and differentiating instruction; (4) personalizing learning; and (5) maximizing teacher and student time.[28]

Three key initiatives proposed to support technology and innovation by the Administration are:

- **Creating breakthrough learning technologies through ED's Advanced Research Projects Agency-Education (ARPA-ED):** The President's FY 2014 Budget proposes to reserve a portion of funds within ED's Investing in Innovation fund to support a new entity, ARPA-ED, modeled after the Defense Advanced Research Projects Agency (DARPA). The mission of ARPA-ED would be to pursue the development of education technology and learning systems; support systems for educators; and create tools that improve education outcomes for all students, in both traditional and non-traditional learning environments.

- **Integrating technology into learning environments through NSF's Cyberlearning: Transforming Education program:** This NSF program seeks to integrate advances in technology with how people learn so that we can: understand how people learn with technology and how technology can be used productively to help people learn; use technology for collecting, analyzing, sharing, and managing data to shed light on learning, promoting learning, and designing learning environments; and design new technologies for these purposes. Of particular interest are technological advances that allow more personalized learning experiences, draw in and promote learning among those in populations not served well by current educational practices, allow access to learning resources anytime and anywhere, and provide new ways of assessing capabilities.

- **Creating a cross-agency infrastructure to conduct evaluations and do rigorous research at STEM agencies:** There has been a growing commitment for identifying and supporting what works, and understanding why, in the STEM education field through the STEM strategic plan and the Administration's broader evidence agenda. ED and NSF have contributed to these efforts by developing a common set of evidence standards that can be used to align STEM education research and development activities across the government and inform decisions on where to invest federal resources to accelerate learning. These efforts will be strengthened and carried out more efficiently as STEM education agencies come together through the management of this goal to create a common capacity that leverages each agency's strengths to identify and grow evidence-based practices, creating a strong foundation for performance measurement, evaluation, and technical assistance to agencies and grantees leading to significant improvements on the ground.

- **ED's First in the World Competition will support innovation in higher education.** FITW will spur the development, validation, and scaling-up of cutting edge innovations to

[28] Understanding the Implications of Online Learning for Educational Productivity
http://www2.ed.gov/about/offices/list/os/technology/implications-online-learning.pdf

reduce college costs, improve productivity, and boost postsecondary attainment rates. These practices include investing in alternative credentials from new technology-based learning platforms in cases where strong outcomes can clearly be demonstrated.

In addition, building off the ED's Education Technology Plan[29], the White House Office of Science and Technology Policy will work with federal agencies and their partners to identify new ways that technology and innovation can support the 1 million goal. These areas may include, among others:

- **Cognitive task analysis:** One recent study found that cognitive task analysis (CTA) can significantly increase the effectiveness of some forms of training.[30] CTA is a set of techniques used to elicit from experts (through interviews and observations) the processes they use to complete complex tasks. CTAs have been used by the Department of Defense in design of its internal training programs. Over the next year, ED is exploring partnerships with foundations to document existing CTAs created by the field that might be able to assist higher education institutions engaging in course design.

- **Digital tutors:** As discussed in the ED's Technology Plan,[31] researchers have long aspired to develop educational software that is as effective as a personal tutor-- one of the grand challenges in President Obama's innovation strategy.[32] DARPA and the Navy have supported the development of a digital tutor to train new Navy recruits to become IT systems administrators.[33] As a next step, VA is exploring a pilot to give returning veterans access to such training and track wage and employment outcomes.

- **Big data and analytics:** As discussed in a new report by the ED on the role of data and analytics in this area[34], there is growing interest in combining different technologies to discover more rapid ways to enable students to master important concepts in core academic subjects such as math and science. Over the next year, NSF's Computer Science Directorate and EHR are exploring partnerships to leverage this emerging area to accelerate impact on learning outcomes.

- **Competency-based learning:** Competency-based approaches to education have the potential for shortening the time to degree or certificate completion, developing stackable credentials that ease student transitions between school and work, and reducing the overall cost of education.[35] A number of universities are exploring additional work in this area, and over the next year, as follow-up to its Innovation Symposium held in Washington DC on October 1, 2012, the ED will be facilitating additional commitments by universities in this area.

[29] http://www.ed.gov/sites/default/files/netp2010.pdf
[31] http://www.ed.gov/sites/default/files/netp2010.pdf
[32] http://www.whitehouse.gov/issues/economy/innovation
[33] Fletcher, J.D. (2011). DARPA Education Dominance Program: April 2010 and November 2010 Digital Tutor Assessments. Institute for Defense Analysis. IDA Document NS D-4260.
[34] http://www.ed.gov/edblogs/technology/files/2012/03/edm-la-brief.pdf
[35] http://www.ed.gov/oii-news/competency-based-learning-or-personalized-learning

- **Open educational resources:** The rapid spread of interest in massive open online courses (MOOCs) and other open education resources (OER) create new opportunities in the potential democratization of undergraduate STEM education and reaching significant numbers of students with quality learning experiences at scale. Dozens of colleges and universities are using or producing OER across the curriculum. Some schools have created an "Open Course Library" that contains fully complete community college courses that can be freely accessed by students anywhere in the world 24/7.[36] ED has made strides to achieve its goal of promoting the development and adoption of new open technology-based learning tools and courses.[37] As a next step, ED, DOE, and DOL are working together on the National Training and Education Resources platform to identify, develop, repurpose, and enhance in other ways high-quality STEM OER learning experiences and make them widely available.

Milestones to support this work include:

- On a quarterly basis, the White House Office of Science and Technology Policy will update the National Science and Technology Council's Committee (NSTC) on STEM Education (CoSTEM) on these and new emerging areas of innovation, and ways agencies could be leveraging these opportunities to impact the 1 million goal.

Q1 Progress Updates:

- **Presidential Innovation Fellow at intersection of big data and learning**: As part of the Presidential Innovation Fellows program, NSF has announced its interest in recruiting a highly motivated and entrepreneurial innovator with a technical background in areas such as big data, machine learning, analytics, science and mathematics learning, and A/B testing, and an interest in applying these techniques to education research and online learning.

- **NSF workshop on MOOCs**: To continue to build the field in areas of online learning, in February, NSF hosted a workshop to build on a rich existing landscape of cyber-enabled education research, and explore recent developments, such as massively open online courses (MOOCs).

- **New collaboration between DARPA and IES on games for learning**: In December 2012, the Institute of Education Sciences (IES) in partnership with the Defense Advanced Research Projects Agency (DARPA) announced a new solicitation at the intersection of games and learning. The solicitation requests proposals for the development and evaluation of commercially viable education technology games in select topic areas to support student learning and outcomes in education and special education settings. The four topics within the solicitation include: (1) games for statistics and probability learning (IES topic); (2) games to support English learners (IES topic); (3) neuroplastic games for improving foreign language learning (DARPA topic); and (4) hybrid videogames/graphic novels to support computer science learning (DARPA topic).

[36] https://sites.google.com/a/sbctc.edu/opencourselibrary/
[37] http://www.ed.gov/sites/default/files/netp2010.pdf

Q2 Progress Updates:

- **New guidance from Department of Education on competency-based learning:** In March 2013, the Department of Education provided new guidance to institutions that wish to have direct assessment (competency-based) programs considered for Title IV of the Higher Education Act (HEA) program eligibility. The letter outlined how institutions can have competency-based programs approved under the current regulations on direct assessment programs.

- **New grant solicitation to support community college innovations announced by Department of Labor:** In April 2013, Department of Labor announced the availability of $475 million to create and expand innovative partnerships between community colleges and businesses to educate and train workers with the skills employers need. The competition will help support models that use advanced online and technology-based job training tools. Course materials developed by grantees will be available publicly through the Open Educational Resources initiative so that users may modify, update and build on their own instructional content.

- **New solicitation by NSF to support data-intensive techniques to improve teaching and learning**: In June 2013, NSF announced a new solicitation seeking the generation and use of data that range from micro-level data on individual learners, to data from online learning sources (such as massively open online courses), to meso-level data from the classroom that provide information to students and teachers about how learning is progressing, to macro-level data such as school, district, state, and national data, including data from federal science and policy agencies. Participants in the Ideas Lab, selected through an open application process, will engage in an intensive five-day residential workshop, the development of multidisciplinary collaborative proposals through a real-time and iterative review process, and, for the participant teams invited to submit full proposals, the subsequent submission of full proposals.
  http://www.nsf.gov/pubs/2013/nsf13565/nsf13565.pdf

- **Next steps by Office of Naval Research (ONR) to develop digital tutors:** In April 2013, ONR's Office of Research and its Warfighter Performance department announced next steps to develop cost-effective digital tutors that can tailor STEM instruction to individual student needs. Ultimately, the technology will be used to improve the skills of Sailors and Marines through the use of new online technologies.

5-Year STEM Education Strategic Plan

Complementing STEM CAP goal efforts, on May 31st, 2013, CoSTEM released a 5-year STEM Education Strategic Plan.[38] This plan is a roadmap to increased coordination among the federal agencies and for the creation of infrastructure and collaborations needed for improvement of existing federal programs. The Plan will promote new coordination approaches to enable progress in key areas including undergraduate STEM education, and other critical areas such as broadening participation in STEM, engaging youth in authentic STEM experiences, and improving STEM instruction, and bolstering graduate fellowships.

[38] http://www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

Contributing Programs and Other Factors

Programs likely to contribute in part or in whole to this goal include the following. This list may be modified over time.

Department of Education:

- Mathematics and Science Partnerships Program/Effective Teaching and Learning for a Complete Education;
- Investing in Innovation Fund;
- Improving Teacher Quality State Grants/Effective Teacher and Leader State Grants;
- Developing Hispanic Serving Institutions STEM and articulation programs;
- Proposed K-16 Mathematics Education Program (in collaboration with NSF);
- Upward Bound Math and Science;
- Teacher Loan Forgiveness;
- Supporting Effective Educator Development; and,
- Minority Science and Engineering Improvement Program;

NASA:

- National Space Grant College and Fellowship Program;
- Minority University Research Education Program;
- Formal and Informal Education ;
- Elementary and Secondary Education; and,
- Higher Education

National Science Foundation:

- Priority Goal: Develop a diverse and highly qualified STEM workforce motivated to participate at the frontiers;
- Proposed K-16 Mathematics Education Program (in collaboration with ED);
- Expeditions in Education (E^2);
- Minority Serving Institutions Programs;
- Science, Technology, Engineering, and Mathematics Expansion Program (STEP); and,
- Cyberlearning: Transforming Education Program

Department of Health and Human Services - National Institutes of Health

- NIH Undergraduate Research Experiences to Support Science Learning;
- NIH Intramural Summer Internship Program;
- Short-Term Research Education Program to Increase Diversity in Health-Related Research;
- Short Term Educational Experiences for Research (STEER) in the Environmental Health Sciences for Undergraduates and High School Students;
- Bridges to the Baccalaureate Program;
- Research Initiative for Scientific Enhancement;
- Undergraduate Scholarship Program for Individuals from Disadvantaged Backgrounds; and,
- MARC Undergraduate Student Training in Academic Research

Other Factors:
A number of organizations, foundations, and institutions of higher education, have expressed interest in meeting the President's challenge to graduate 1 million more STEM graduates by 2022. To accomplish this goal, agencies will bring their unique assets to collaborations with institutions of higher education, foundations, and other stakeholders in order to institutionalize the use of evidence-based STEM teaching practices and course design at 2-year and 4-year institutions of higher education. Thus, the creation of partnerships between the Federal Government and these stakeholders will be needed, and actions by non-federal entities will an essential piece of successfully accomplishing this CAP goal.

The Administration has also created the Educate to Innovate Campaign which, through public private partnerships, launched a STEM media campaign, held two White House Science Fairs, developed National STEM Design Competitions, and supported the creation of Change the Equation (a non-profit organization that coordinates the efforts of industry and foundations that support STEM education). Public-private partnerships related to these efforts have also spawned movements such as 100Kin10, a effort with over 100 federal, industry and foundation partners dedicated to reaching the President's goal of training 100,000 new effective K-12 STEM teachers over the next 10 years.

Additional References

Charter of the Committee on Science, Technology, Engineering, and Mathematics (STEM) Education
http://www.whitehouse.gov/sites/default/files/microsites/ostp/costem_charter_signed_01-31-11.pdf

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

Prepare and Inspire: K-12 Science, Technology, Engineering, and Math (STEM) Education for America's Future
http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf

Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.
http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf