



May 15, 2012

John P. Holdren  
Eric Lander  
President's Council of Advisors on Science and Technology  
White House  
Washington, DC

**Response to the PCAST Report to the President, *Engage to Excel***

Dear Dr. Holdren and Dr. Lander,

The Mathematical Association of America (MAA) strongly supports the fundamental message of the February 2012 report from the President's Council of Advisors on Science and Technology, *Engage to Excel: Producing one million additional college graduates with degrees in Science, Technology, Engineering, and Mathematics*. Appropriately, much of the focus of this report is on undergraduate mathematics education, which lies at the heart of all STEM education.

The PCAST report highlights the need to increase the number of students who obtain undergraduate preparation for careers in the STEM disciplines. It proposes some specific mechanisms for accomplishing this, including the need to draw on empirical evidence of what works. The report showcases the growing body of evidence for the effectiveness of using class time to actively engage students in thinking about the concepts they are learning, and for the effectiveness and power of student research programs to attract and motivate students toward STEM careers.

The report calls for more than just studying what works. It also points to the need to scale up successful programs to transform undergraduate science and mathematics education. Doing so will require partnerships that include universities, businesses, and government, and it will require the kind of national oversight and coordination and large scale program development that can be provided by the proposed Presidential Council on STEM Education.

MAA is the pre-eminent organization devoted to mathematics at the undergraduate level. Our efforts include a wide spectrum of programs: (1) outreach to precollege students and teachers, designed to attract and inspire talented students into STEM careers; (2) efforts to strengthen undergraduate mathematics programs, by promoting undergraduate research and broadening participation; (3) early-career faculty development; and (4) a full gamut of publications, meetings, and workshops that support faculty development through all career stages.

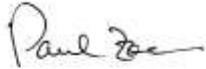
We hope that PCAST will now draw upon MAA's knowledge of what works in undergraduate mathematics education, and on MAA's experience in disseminating information through publications, meetings, and workshops. MAA is prepared to be an active participant as the PCAST recommendations are more fully developed and implemented.

In the attachment to this letter, we will comment on what the mathematical community in general and MAA in particular can offer toward the four overarching recommendations of the PCAST Report.

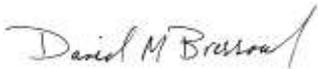
While we look forward to working with the proposed Presidential Council on STEM Education, we emphasize that the fundamental responsibility for implementing the recommendations that impact the mathematical sciences community must reside within this community. Our experience and the evidence we have and continue to collect give us the expertise and insight that are needed if the ambitious goals identified in the report are to be accomplished.

MAA anticipates partnering with federal agencies in large-scale development programs that implement prototype courses founded on research-tested student engagement strategies that can be adapted and adopted to improve student learning. By working together with colleagues in partner disciplines and coordinating outreach with other disciplinary societies, MAA believes we can catalyze widespread adoption of practices that will engage and inspire our future STEM leaders.

Sincerely,



Paul Zorn  
President



David M. Bressoud  
Past President



Michael Pearson  
Executive Director

[Attachment]

## Programs of MAA and other mathematical organizations that address the recommendations of the PCAST Report, *Engage to Excel*

### 1. Catalyze widespread adoption of empirically validated teaching practices.

The PCAST report begins its discussion of this recommendation with a call to educate undergraduate faculty in evidence-based teaching practices. The oldest and unquestionably the premiere program for informing new faculty about best teaching practices is MAA's Project NExT (New Experiences in Teaching). Started twenty years ago with a grant from ExxonMobil, it not only introduces new faculty to these best practices, it also provides an ongoing network of support via its active list servers and its lively reunions at national meetings. Through these networks, faculty learn how to deal with setbacks and unexpected situations and how to make best use of the resources at their disposal. Project NExT accepts about 80 new faculty per year. It has engendered a larger network of regionally based groups of new mathematics faculty, the Section NExTs, usually led by Project NExT alumni and reaching hundreds of young faculty each year.

In addition, MAA runs workshops at regional and national meetings on best teaching practices as well as summer workshops, under its PREP (Professional Enhancement Programs of the MAA) banner.

MAA has long been known for its publications on the teaching of undergraduate mathematics, reaching back to the 1950s when its Committee on the Undergraduate Program in Mathematics began to codify the standard mathematics curriculum that would be needed to prepare scientists and engineers. Its publication program continues regular reporting on research in undergraduate education and advice on implementing best practices. A decade ago, MAA published a series of reports under the title *The Curriculum Foundations Project*<sup>1</sup> that opened the dialogue between mathematics and its "partner disciplines"—including Engineering, Biology, Physics, and Chemistry—about what their students *really* need to take away from the courses taken in Mathematics.

This PCAST recommendation also talks about the need to develop metrics to evaluate STEM education. Part of this is embedded in *The Curriculum Foundations Project*. Before developing a metric, we need to know what it is we want to measure. Part of the job is to establish baseline data. MAA is gathering such data through its large-scale survey of mainstream Calculus I, the NSF REESE-funded project *Characteristics of Successful Programs in College Calculus* that is currently underway. MAA is also working with others in the field, such as Phil Sadler of the Department of Science Education at the Harvard-Smithsonian Center for Astrophysics whose *FICS-Math* project is helping to clarify the role of high school preparation in student success in college calculus.

---

<sup>1</sup> Ganter, S. and Barker, W., eds. 2004. *Curriculum Foundations Project: Voices of the Partner Disciplines*. Mathematical Association of America. Washington, DC. The report from a second round of workshops is currently in progress.

**2. Advocate and provide support for replacing standard laboratory courses with discovery-based research courses.**

Discovery-based learning is not just for the science lab. For over twenty years, MAA has highlighted and promoted this approach to learning mathematics and has regularly published textbooks that employ this approach. Today it offers the second edition of Smith and Moore's *Calculus: Modeling and Application*, a direct descendant of their *Project CALC* (Calculus As a Laboratory Course), as well as Marshall, O'Dell, and Starbird's *Number Theory through Inquiry*, an IBL (Inquiry Based Learning) textbook that gives the students no answers, only questions. Students learn by discovering the answers to a carefully selected progression of questions.

MAA is now partnering with the Educational Advancement Foundation and its Academy of Inquiry Based Learning to promote IBL and to provide both materials and the supportive network that is needed for those who would implement it. The annual EAF meeting is a highly energized gathering of three- to four-hundred enthusiastic faculty who are implementing IBL.

**3. Launch a national experiment in postsecondary mathematics education to address the math preparation gap.**

The focus of this recommendation is on the mathematical preparation of students as they enter college. The "gap" appears to refer to the difference between what these students have learned and what they need to know to succeed in a STEM career. The call is to our colleges and universities to do a better job of preparing K-12 teachers of mathematics and to do a better job of enabling those who are not ready for college-level mathematics to overcome their deficiencies. MAA takes strong exception to PCAST's suggestion that these jobs could be done better outside of the mathematics department.

MAA and other mathematical organizations do recognize that there are serious issues here that need to be and are being addressed. MAA is part of the Conference Board of the Mathematical Sciences which currently is finalizing the *MET2 Report*, an update of its publication, *The Mathematical Education of Teachers*, that first appeared in 2001. This publication, which draws on our best knowledge of what makes for an effective mathematics teacher, lays out the role of mathematicians and mathematics departments in ensuring that teachers have the mathematical content knowledge needed for success in the classroom and that they get the support and continuing education needed to flourish.

MAA is very much aware of the problem of students who enter college unprepared for college-level work in mathematics. Several organizations are tackling this problem, most notably the Carnegie Endowment for the Advancement of Teaching that is working on its Statway program that prepares students for and assists them in successfully completing college-level statistics and the New Mathways program under development at the Dana Center at the University of Texas, Austin. Both AMATYC (American Mathematical Association of Two-Year Colleges) and MAA are monitoring these programs.

MAA recognizes the critical importance of the issues highlighted under this recommendation: the preparation of teachers and the need for programs that assist students to overcome deficiencies in pre-college mathematics. However, these issues are secondary to the thrust of the PCAST report, which is to attract students to and retain them in STEM majors. In 2010, we graduated 254,000 students with bachelor's degrees in STEM fields and an additional 75,000 with associate's degrees.<sup>2</sup> The additional one million degrees called for in the title of the PCAST report would occur over ten years, and therefore this report calls for a 30% increase, steep but not unreasonable. The United States has a plentiful supply of students who have completed an extensive amount of mathematics in high school. Each year, over 600,000 high school students complete a high school course in calculus.<sup>3</sup> Over half of all high school graduates, at least 1.6 million students per year, have completed a course at the level of Precalculus or higher.<sup>4</sup> MAA's study of the 300,000 students who enroll in mainstream Calculus I during the fall term shows that these are students who do well on the SAT/ACT mathematics exams, enjoy mathematics, and consider themselves good at it.<sup>5</sup>

There is a large pool of potential candidates for STEM careers, a fact that is underlined by the fact that the number of full-time freshmen intending to major in a STEM field (Biological Sciences, Computer Science, Engineering, Mathematical Sciences, or Physical Sciences) grew by 54%—from 276,000 in 2007 to 424,000 in 2011—in response to the current economic crisis and the sharp downturn in employment.<sup>6</sup> The challenge is to enroll these students in the foundational courses for the STEM disciplines and to retain them during the first year of college.

Nevertheless, MAA recognizes that there is a serious preparation gap. Many high school students who think they are well qualified in mathematics in fact have a lot of catching up to do. A third of the graduating class of 1992 who passed calculus in high school took precalculus in college.<sup>7</sup> One in six of the students from the graduating class of 2004 who passed calculus in high school took remedial mathematics in college.<sup>8</sup> Many of these students seek and are shut out of STEM majors. In addition, many students are discouraged by their first college calculus class. Student confidence in mathematical ability drops by half a standard deviation between the start and end of Calculus I.<sup>9</sup>

---

<sup>2</sup> National Center for Education Statistics. *2011 Digest of Education Statistics*. Tables 298 and 301.

<sup>3</sup> Based on College Board data that 341,000 students took an AP Calculus Exam in 2011 and NCES data from the Educational Longitudinal Study of 2002 (ELS:2002) that 55% of those completing calculus in high school take the AP Calculus Exam.

<sup>4</sup> NCES Educational Longitudinal Study of 2002 (ELS:2002)

<sup>5</sup> Preliminary data from the MAA's national survey *Characteristics of Successful Programs in College Calculus*. See "The Calculus I Student" at [http://maa.org/columns/launchings/launchings\\_05\\_11.html](http://maa.org/columns/launchings/launchings_05_11.html).

<sup>6</sup> Higher Education Research Institute. 2012. *The American Freshman*.

<sup>7</sup> NCES. National Education Longitudinal Study of 1988 (NELS:88)

<sup>8</sup> NCES. Educational Longitudinal Study of 2002 (ELS:2002)

<sup>9</sup> Preliminary finding from the MAA's national survey *Characteristics of Successful Programs in College Calculus*.

If we want to impact the pipeline of STEM majors, then we need to work on what is happening in calculus both in our high schools and in our colleges and universities. Our high schools, colleges, and universities recognize the problems with calculus instruction. The challenge is to better understand how and why such courses fail so many students, to disseminate knowledge of programs that work, and to assist in and coordinate the improvement of these courses. This is a current focus of MAA activities.

**4. Encourage partnerships among stakeholders to diversify pathways to STEM careers.**

MAA has always been active in working with NSF and the Department of Education. It has regularly travelled to Capitol Hill to educate our senators and congressmen about the issues of undergraduate mathematics education. We regularly work with corporations such as Exxon-Mobil and Intel and with concerned businessmen to improve the teaching and learning of college-level mathematics. There is much more that we could be doing. We welcome the assistance of PCAST in promoting and coordinating these partnerships that will enable us to scale up the approaches and programs that work and transform undergraduate mathematics education.