MATHEMATICIANS' CENTRAL ROLE IN EDUCATING THE STEM WORKFORCE

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President Obama's Council of Advisors on Science and Technology (PCAST) recently released its report *Engage to Excel: Producing one million additional college graduates with degrees in Science, Technology, Engineering and Mathematics* (STEM)[1]. PCAST identifies mathematics as a bottleneck in undergraduate STEM education. The report recommends teaching and course development of college level mathematics *"by faculty from mathematics-intensive disciplines other than mathematics"* and further recommends "a new pathway for producing K–12 mathematics teachers from ... *programs in mathematics-intensive fields other than mathematics."*[2] Although we share much of PCAST's concern for the state of STEM education, we are in strong disagreement with these specific recommendations.

We call upon the mathematical community to rise to the challenges set forth in the PCAST report. Consider applying to the National Science Foundation and the Department of Education for funds intended to support college-level education initiatives. Initiate further collaborations with STEM colleagues to learn what mathematics their students need and to develop curricula which satisfy those needs. Email **president@ams.org** information about past and existing programs designed to improve college-level mathematics education so that they may be listed on the designated American Mathematical Society (AMS) website[3]. Devise new methodologies for teaching which work at your college/university and which might scale up to help address the national imperative of training more well-prepared STEM graduates. Disseminate your findings within the mathematical and scientific communities.

The response which follows has been prepared by a subcommittee of the AMS Committee on Education (CoE) informed by comments from the full CoE as well as the AMS Executive Committee and Board of Trustees. The quotes from the PCAST report are repeated, for the response is intended to stand on its own. It will be delivered to PCAST, the Office of Science and Technology Policy, and various funding agencies.

[1]Available at http://www.whitehouse.gov/administration/eop/ostp/pcast/docsreports
[2] *Ibid.*, p. 30. Italics added for emphasis.
[3]See http://www.ams.org/programs/edu-support/innovations-college-level

Position statement

> Mathematicians strongly support President Obama's goal of increasing the number of college graduates with STEM training. We promote high quality undergraduate mathematics education not only to increase numbers of STEM graduates but also to assure that these graduates have the education and perspective to succeed in an evolving, increasingly technological world. In active collaboration with our STEM colleagues, we shall continue to explore enhancements to entry-level college mathematics curricula to serve STEM students.

In response to the recent PCAST report *Engage to Excel*[4] the mathematics community recognizes the need to publicize its commitment to developing quality entry-level college education. One of our fundamental goals is to broaden the spectrum of students successfully prepared for STEM careers. In order to achieve this goal, we must enable an increasingly diverse cohort of students to acquire core mathematical concepts and basic mathematical reasoning. A solid foundation in mathematics is essential for successful STEM education, for this paves the way for flexibility in a changing workforce environment.

Some of the specific comments and recommendations in the PCAST report have caused alarm and consternation in the mathematics community. In particular, we strongly object to the recommendations for "teaching and course development of college level mathematics *by faculty from mathematics-intensive disciplines other than mathematics*" and "a new pathway for producing K–12 mathematics teachers from ... *programs in mathematics-intensive fields other than mathematics.*"[5] We firmly assert that **it is essential that mathematicians be actively engaged in the planning and teaching of the mathematics courses that form the foundation of STEM education.** Mathematicians' understanding of the common mathematical themes that arise in applications across STEM disciplines place them at the center of STEM education. Mathematicians guide students to explore their ideas using skills which will apply beyond immediate problems; we facilitate students' efforts to understand the principles and logic that underpin applications. A mathematician's primary training is to think effectively about quantitative problems, and we are dedicated to communicating our understanding to our students.

Mathematicians are eager to continue their partnership with other STEM colleagues to adapt mathematics curricula and pedagogy. In this way, mathematicians are constructive partners in translating basic mathematical concepts and reasoning to science and engineering. We seek to enhance the ability of all STEM students to apply quantitative and critical thinking skills from mathematics to other disciplines. In order to achieve the President's goal of greatly increasing the number of well-prepared STEM graduates, heightened efforts need to be made to adjust the curricula of mathematics courses for STEM students so that the material effectively reflects the mathematics that arises in STEM fields. Mathematicians support efforts by the Department of Education and the National Science Foundation to achieve pedagogical and curricular reform through funding of collaborations between mathematicians and other STEM scientists.

[4] Available at http://www.whitehouse.gov/administration/eop/ostp/pcast/docsreports.

[5] *Ibid.*, p. 30. Italics added for emphasis.

The mathematics community embraces experimentation in teaching methods, technology for the augmentation of learning, and adaptation of curricula. Such efforts need to be carefully assessed, with care taken in defining and interpreting assessment metrics. Mathematicians recognize that there is not just "one problem" to solve, that promoting knowledge of basic mathematics and a facility with its use requires dramatic improvements in pre-college mathematics education and an encouragement of problem-solving talents. No single pedagogical method will be suitable for every classroom, no curriculum is appropriate for all students. Success in education is not achieved by simple formulas: there are many different successful ways of teaching mathematics, techniques adapted to the variation of talents of both students and teachers.

We call attention to the many efforts to meet the challenges of teaching entry-level college mathematics. Some of these may be found listed on the American Mathematical Society (AMS) website[6], others have been recognized by special awards[7], and others are discussed in various reports[8]. Although experimentation, innovation, and implementation of pedagogical methods typically occur at the local level, the insights gained from local efforts can be disseminated nationally by the AMS and other national organizations. The AMS can also play an important role in encouraging cooperation between mathematicians and researchers in mathematical education.

Our society requires many more young people who are well trained and confident in their use of quantitative and technological methods. In order to reach as many students as possible, education in entry-level college mathematics must continue to evolve. No easy answers are available, but the mathematical community welcomes the challenge of joining with our STEM colleagues to develop new approaches to enhance the learning experiences of those many students who aim for careers requiring a sound STEM education. This challenge requires sustained commitments of time and resources from mathematicians, faculty from other STEM disciplines, granting agencies, colleges, and universities.

[6]See footnote 3

[7]See http://www.ams.org/profession/prizes-awards/prizes.

[8]For example, the AMS report, *Towards Excellence*, is available at http://www.ams.org/profession/leaders/workshops/towardsexcellence.