Preparation of the Next Generation of College Mathematics Teachers

Tim Hodges
University of Cincinnati

REPORT TO THE PRESIDENT

ENGAGE TO EXCEL: PRODUCING ONE MILLION ADDITIONAL COLLEGE GRADUATES WITH DEGREES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

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"…Moreover, success depends on the engagement by great leadership. Leaders, including the President of the United States; college […] leadership; and others, must encourage and support the creation of well-aligned incentives for transforming and sustaining STEM learning."

PCAST Engage to Excel: A few quotes

“Economic projections point to a need for approximately 1 million more STEM professionals than the U.S. will produce at the current rate over the next decade if the country is to retain its historical preeminence in science and technology. To meet this goal, the United States will need to increase the number of students who receive undergraduate STEM degrees by about 34% annually over current rates. ”

“Fewer than 40% of students who enter college intending to major in a STEM field complete a STEM degree. Merely increasing the retention of STEM majors from 40% to 50% would generate three-quarters of the targeted 1 million additional STEM degrees over the next decade. ”

“Better teaching methods are needed by university faculty to make courses more inspiring, provide more help to students facing mathematical challenges, and to create an atmosphere of a community of STEM learners.”

PCAST Engage to Excel: A few more quotes

“Transforming STEM education in U.S. colleges and universities is a daunting challenge. The key barriers involve faculty awareness and performance, reward and incentive systems, and traditions in higher education.”

“Learning theory, empirical evidence about how people learn, and assessment of outcomes in STEM classrooms all point to a need to improve teaching methods to enhance learning and student persistence. […] STEM faculty need to adopt teaching methods supported by evidence derived from experimental learning research as well as from learning assessment in STEM courses.”

“A significant barrier to broad implementation of evidence-based teaching approaches is that most faculty lack experience using these methods and are unfamiliar with the vast body of research indicating their impact on learning.”

AAU Undergraduate STEM Education Initiative 2011

"The goal of the AAU Undergraduate STEM Education Initiative is to help influence change in the culture of STEM departments at AAU universities so that they will use evidence-based, student-centered, active, sustainable pedagogy in their classes, particularly at the freshman and sophomore levels."

Quick Facts

- According to the OECD, in 2009 the U.S. ranked 27th out of 29 developed countries in the % of students who earned bachelor's degrees in STEM.
- 16% of undergraduate degrees in the US are STEM (cf Germany 28%, China 43%)
- 60% of all students who begin in mathematics will drop out of these fields by their senior year, (cf. 30% in the humanities and social sciences)
- 90% of students who switched out of STEM fields cited poor teaching as a concern
- The AAU advisory committee contains 3 physics professors but no mathematics professors

Four Strategies

1. Disseminating curricula and pedagogy;
2. Developing reflective teachers (defined as those who use their own knowledge/experience/skill to improve their instructional practices);
3. Enacting policy (including incentives and quality assurance measures);
4. Developing shared visions (including departmental-level collaboration and institutional-level actions).

Towards a Highly Qualified and Effective Instructional Workforce

1. Pedagogical training of PhD students
2. Development of early career faculty
3. Continuing development of late career faculty
4. Training and development of adjunct and contingent faculty
5. Education and training of department heads

1. Pedagogical training of PhD students

- Primary focus is generally the basic skills of teaching (lecturing) along the lines of Krantz's *How to Teach Mathematics*
- Training and mentoring mostly provided by self-taught senior faculty
- Varies from one day to a semester
- Quality of follow-up varies
- Training based around "empirically validated teaching practices" rarer.

Prevalence of training programs

(Source: J Bookman, Duke U)

- 77% of PhD departments provide training program for TA's
- 65% of departments provide week-long or semester-length training program.
- Most programs without training programs would like to implement them

How *not* to be a terrible teacher

" [A] professor will sometimes prepare for a lecture, *not* by writing some notes or browsing through the book but by lounging in the coffee room with his colleagues and bemoaning (a) the shortcomings of the students, (b) the shortcomings of the text, and (c) that professors are overqualified to teach calculus. Fortified by this yoga, the professor will then proceed to his class and give a lecture ranging from dreary to arrogant to boring to calamitous… The good news is that it requires no more effort, no more preparation, and no more time to be a good teacher than a bad teacher. The proof is in this booklet."

Steve Krantz, *How to Teach Mathematics,* 1993

2. Development of early career faculty

- Mentoring by senior faculty
- Formative peer-review
- Workshops provided by university's "Center for Teaching and Learning"
- Discipline-based workshops
- Courses in theory of cognition and learning

3. Senior faculty

- Strong role models
- Familiar with best practices in mentoring and peer-review
- Well-developed administrative and leadership skills.
- Familiar with empirically-validated teaching methods
- Leaders of change and development

4. Adjunct faculty

- Quality maintained by pruning and selection
- Often outside of PhD student training programs (may only have MS)
- Development as for early career faculty when possible
- Greater incentive to participate in training and development
- May have training in education college

5. Department Heads

- Role model
- Quality control and assessment
- Incentives
- Implementation of pedagogical and curricula development
- Strong leadership
- Effective delegation
- External and internal funding

PCAST Engage to Excel: Challenges

- Faculty lack knowledge of evidence-based teaching
- Lack of facilitation and rewards for good teaching
- Limited resources
- Grading and workload across majors
- Institutional isolation
- Challenge of change

Case Study : Mediocre State University

You are the new Head of a mathematics department at a Midwestern state university. Your Dean has read the PCAST report and would like to improve the quality of science and mathematics instruction at MSU. He asks you to put forward two proposals for significant change.

The previous Head was willing to make some changes to improve instruction but it wasn't his top priority and follow-up wasn't strong. There is a two-day training program for the TAs but little follow-up after that. The department has a large service-teaching load which is split into a mixture of small and large classes, most of which are taught in a traditional lecture-style. DFW rates are around 30-40% for the service courses, where they have been for the last 20 years. Instruction at the lower level is shared by full-time faculty (both tenure-track and non-tenure-track), adjuncts and graduate students. Online student evaluations are mandatory and average overall evaluations are around 4 out of 5. A certain amount of peer-evaluation is done. Both student and peer-evaluations are a component in the RPT process but assessment of teaching quality remains controversial. New faculty are assigned mentors but the program is not well-defined and the usefulness of the mentoring process varies enormously. The senior faculty are a mixed bag, some excellent, many good, some real problems.

What changes do you propose?

Discussion Topics

- Training of GA's. What are examples of successful/unsuccessful training programs? What are the best practices?
- Mentoring of junior faculty. What are the obstacles to a successful mentoring program and how are they overcome? Is mentoring a fad or an essential ingredient?
- Formative peer review. The blind leading the blind or a highly effective component of pedagogical training? Models of highly successful FPR.
- Education in cognition and learning. Should this be standard?
- Assessment of teaching. Student evaluations and peer review are common but not enough. How should we be assessing teaching.
- Incentives. Carrots and sticks that work
- Avoiding negativity – creating a positive attitude in the coffee lounge
- Adjunct faculty – how do we best help them continue to improve?
- Senior faculty. Getting the most out of our most experienced teachers. Working with poor teachers with tenure.