

JMM Panel Discussion 1/17/14: Summary

A panel invited by the TPSE Math organizing group led the project's first discussion of issues facing undergraduate mathematics education. Panel members were **Michele Cahill**, Carnegie Corporation of New York; **Jo Handelsman**, Yale University; **Brit Kirwan**, University of Maryland; **Joan Leitzel**, Ohio Mathematics Initiative; Congressman **Jerry McNerney**, California's 9th District, PhD in Mathematics; and **Phillip Griffiths**, moderator, Institute for Advanced Study.

The following is a summary of remarks from both panel members and attendees.

Phillip Griffiths, panel moderator, introduced the topic of transforming post-secondary mathematics education, reviewing key challenges that face both the mathematics community and educational institutions. Among these challenges are adapting the math curriculum to the career needs of students; new ways to educate students who are poorly prepared for post-secondary math; changing demands on faculty, departments, and institutions; and the need for stronger partnerships with other STEM disciplines.

He noted that the meeting was supported jointly by the Sloan Foundation and Carnegie Corporation. He introduced the panelists, who each gave opening comments.

Brit Kirwan said that reform will not happen without the full commitment of institutions, including departments, faculty, and administration. It is each state's responsibility to get more people into and out of college with a mathematics degree. Other points:

- Math is the #1 barrier to college completion. Part of the reason is poor preparation of entering students. He summarized results of a University of Maryland study, involving three cohorts. Students starting out as mathematics majors were more likely than any others to change majors before graduating, despite their demonstrated interest and capability in math.
- On the other hand, they were most likely to graduate from college. "This tells me that math departments can have a disproportionate impact on college completion." He had attended a meeting the day before with President Obama and other university presidents, where stronger mathematics education was expressed as a national goal.
- What can we do: Be engaged in serious exploration of new teaching and learning strategies, collecting data so as to understand what works. Rethinking teaching and learning must take into account the new generation of net-savvy students who want to be in charge of their access to information.
- Online education is important because of (1) advances in cognitive science ("We know a lot about what imprints information on the brain"); and (2) powerful software informed by (1). Also the ubiquitous internet. "So highly interactive learning has a place."
- The University of Maryland supports innovations in academic transformation, including the Open Learning Initiative (OLI) of Carnegie Mellon University. OLI has had "striking" results, with its students doing at least as well as those in traditionally

taught sections. The University of Maryland also partners with Ithaka and Coursera in studying the flipped classroom setting.

- Two other trends: (1) encouraging the rethinking of general education math courses, with promising early results from Quantway, Statway, and Mathway, and (2) more time on task in developmental and entry-level courses makes a huge difference (e.g., use of the “math gym”). Dropout rate reduced 50%.

Jo Handelsman described herself as a “microbiologist by training and instinct. It’s always flattering when mathematicians think they have something to learn from a biologist.”

When she worked on the PCAST report *Engage to Excel*, “one thing we found was that math was the single biggest barrier to training STEM majors.” Also, skills of those coming into college are deficient. We need many more STEM majors than we are producing; economists say the workforce in general needs more than a million at the BS level over the next 8-10 years. “Daunting.”

Other fields have quickly become more mathematical, notably biology, and problems have become more difficult, such as “gene dosage” – how much does a given gene contribute to a given characteristic. “We need many more mathematically trained students.”

Our most important challenge in mathematics is to train K-12 teachers. Those teachers all learn from us, inherit our habits, and play them out in their classrooms. Much of the nation’s math problems develop in grades 5-8, with an enormous gap between American students and those in other countries. U.S. teachers don’t have to be trained in math to teach up to the 8th grade. Students are not taught the relevance of what they are learning.

What to do?

- Bring relevance into the classroom so students see math problems couched in context – especially underrepresented groups. Such groups say they want to serve society, or return to their communities, but don’t see science/math as a route to do that.
- Offer more joint courses and degree programs. Show how and where math is applied. This takes more collaboration across departments, which academia is not good at.
- Deal with pedagogy. We have 40 years of data that shows the power of active engagement in learning, which is able to train poorly prepared students. If every class incorporated an element of active learning, it could transform math education in all groups, especially underrepresented groups, who are becoming the dominant population in colleges.
- She closed by reminding the audience of the importance of the “profoundly gifted,” who often drop out but could have a high impact if cultivated by teachers.

Joan Leitzel chairs an ad hoc Mathematics Steering Committee for the Ohio Board of Regents. The Committee’s charge is to develop expectations and processes that result in each campus offering pathways in mathematics that yield increased success for students in the study of mathematics, a higher percentage of students completing degree programs, and effective transferability of credits for students moving from one institution to another.

Additional points:

- This is “one of those exceptional times” to revisit at least the lower division part of our post-secondary programs, especially in light of the changes we hope to see in K-12 mathematics as a result of the Common Core State Standards.
- This will require working with teachers and schools, and “lots of adult re-entry students will need to be accommodated.”
- While engineering and the physical sciences were once considered the mathematics-intensive fields, mathematics is now also central to the biological sciences, many of the social sciences, areas of business, and other fields. Perhaps we are “victims of our own success.” In some fields, math is no longer just a tool, but more like an essential foundation piece of the discipline, so we must work with colleagues in these fields to align mathematics courses with their needs.
- Because not every student will enter a mathematics-intensive field, not every student needs calculus, or hence traditional college algebra. “We must consider other entry-level options.”
- Fortunately, people across the country are doing very creative things. We can and should borrow and improve on what they are doing.
- This is also a time to look at new instructional delivery options to support student learning – not only for students in mathematics classrooms, but also for those in dual-enrollment courses in high schools.
- Departments need not and should not undertake these questions in isolation. Networking with others has many advantages. “Different perspectives lead to better solutions.” Much can be learned from those who got an early start.
- Even when we have clarity about what needs to be done in mathematics, there will be obstacles. It helps to speak with one voice. In Ohio, we find many critical players: chairpersons, institutional administrators, state and regional higher ed systems, national professional organizations, funding agencies. “Success will require us all.”

Michele Cahill described herself as an “outsider,” not being a professional mathematician, but saw “a moment of opportunity for math leadership.” Mathematicians can address the “democracy problem” of loss of social mobility by helping more young people move “from fear of failure in math to connection and mastery.” Quantitative capacity in math is the driver of earnings, underpinning jobs that pay at or above median wages. Also:

- She challenged the math profession to problem-solve, improve, invent new solutions. “We have to do something that’s never been done.” When she started as Senior Counselor to NYC Department of Education Chancellor Joel Klein in 2002, more than half of 400,000 public high school students did not take algebra. Her brief was to raise graduation rates while raising standards including algebra taking. Little was known then about how to prepare teachers to teach algebra to students who had major gaps in their math knowledge and skills or how to invite students to think of themselves as capable. “Now that problem has moved up to undergraduate education, where only 7 to 15% of students who start remedial math ever get credit in math. We need to change the notion of math as something to be feared to math as something as basic as reading. You don’t not learn how to read.”
- She issued a challenge to the mathematics community to raise its voice in support of higher standards. “The voice of higher ed has been very soft in advocacy for this.”

- “This is the moment.” Advances in learning sciences and pedagogy can now be connected with advances in technology. The students’ mindset is key: Statway has shown that students who think they don’t belong in a course do worse even if they have higher skills when entering. With technology, diagnostic tools can now promote customized tutoring and experiential learning.
- Pathways of study are not the same for all. All students benefit by having a concept of where this struggle can take them.
- Push factors are coming and must be anticipated. The mathematics community must engage with the completion agenda; it is a blunt instrument, but 31 states have set targets for degree completion. Completion agendas will be linked with outcome-based funding.
- In a STEM education initiative she supports, “100k in 10,” 150 partners have joined in the goal of recruiting, preparing and supporting 100,000 capable STEM teachers in 10 years. “There is a lot of great work going on out there.”

Congressman **Jerry McNerney**, the only member of congress to hold a PhD in mathematics, underscored the importance of “making math departments relevant in today’s complex world.”

“Math departments are fairly well positioned to increase their relevance because math has so many real-world applications. Math makes our society more sustainable because it is used to increase efficiency and solve challenges in technology, transportation, genetics/ biology, and communications. Mathematics is, indeed, transforming these fields.

PhD students who want to work in the private sector and return to academia can be reluctant to do so because they fear losing their academic standing. Mathematicians shouldn’t be penalized for pursuing a career in the private sector. In fact, they gain valuable experience and perspective that can often be an asset to math departments.

Now more than ever before, it’s important that we get students engaged in math at an early age. This can be difficult because of the current culture in primary education that says “it’s not cool to be smart.” We must reverse this notion and ensure that students have a strong foundation in math before they reach high school – if they don’t, their opportunities to pursue and excel in fields such as engineering and science, will be extremely limited.”

Can legislation help? Yes. The Congressman invited feedback and said he would review any legislative ideas. “Let me know. I love to hear ideas.”

Phillip Griffiths challenged the mathematics community to adapt to these challenges and to “make the contributions that only we can.”

A participant said he had heard the call to action – to change the way we teach, and change what we teach. “The first is easier. For the second, there are constraints in the curriculum. We can think of small changes, but we need some other national mechanism to change pre-calculus and calculus.”

Brit Kirwan agreed with the dichotomy, that changing the way we teach can take place, while changing what we teach is “more evolutionary.” He said that the college board is now under new leadership, transformation is going on, and significant changes are coming.

Jo Handelsman said that in biology, statistics has become far more important, and that calculus “used to be. Two tracks may be one solution; students choose one of them.”

Joan Leitzel said that in one large university, all students take same first semester of calculus, but then diverge into different branches (for engineering, physical sciences, biological sciences, social sciences, etc.) where examples and context come from those fields.

Brit Kirwan asked Prof. Handelsman about the drivers for change in biology teaching. **Jo Handelsman** said it was incremental, with content driven by the research world. “The way we taught hasn’t changed enough. Some places slashed old courses; most added new content and dropped older content.” Teaching evolution has changed because the “five kingdom model we studied is now irrelevant,” even though some high schools still teach it. “Sometimes a single discovery can drive new curricula.”

She added that probability is the most important skill “for any person on earth, in dealing with modern life; certainly in biology. But we struggle to teach it. The concept of frequency is so difficult to teach to college students. I’ve proposed moving it back into K-12 to start earlier.”

Jim Gates, a co-author of the PCAST *Engage to Excel* report, said that the mathematics community does have the capacity to respond to national need. “I hope you will become national leaders. I commend Dr. Leitzel for what she is doing in Ohio. We need all of you to do that. Please join us to save the American dream; that’s what it boils down to. The American dream can die, and I would hate to bequeath to my children a different kind of America.”

Carlos Castillo Chavez, Arizona State University, saw several problems: (1) “A lot of grade school teachers hate math – who changed them? We must take ownership of that problem.” (2) The skills to prepare for college: most students get discouraged, drop out. Who takes responsibility for that? (3) A large number of students do not go to good schools – do we wait for someone else to fix them? We can’t waste any generation of students. (4) Some barriers: a lot of people thought you can’t do research in college; you can. We have to take ownership of the problems.

Phillip Griffiths said that in responding to changing times we need help from the institutions, and asked Prof. Kirwan’s advice to math departments in dealing with administrations.

Brit Kirwan noted some myths. First is that an administration “has a mint and can print money,” making all problems go away. In reality, all universities are resource-constrained. At the same time, they are under enormous pressure from state and national leaders to improve college completion rates. “This is in many ways the social equity issue of our time. One statistic haunts me: if you are a child in the lowest quartile, you have a 9% chance of

getting a college degree. A child in the upper quartile has an 85% chance. Among leading societies, we are tied for bottom with England for social mobility. I can't imagine a university administration not being receptive to ideas that can help improve the quality of learning."

Joan Leitzel seconded this statement, saying that college completion and student success are very much priorities for college administrations. "Don't hesitate to explain changes in mathematics to those who make budget decisions and to those who speak on behalf of an institution and want to say things that resonate with the public."

Joel Cohen, University of Maryland, said that for colleges and universities, the "problem really is in K-12: what is being taught, and who is teaching it." At the University of Maryland, SAT scores of entering students are lower for those who will be high school teachers. "We have two courses in modern algebra. One is for serious mathematicians; the other baby version is for future high school math teachers. In Finland only the best students are allowed to become teachers."

Uri Treisman, University of Texas-Austin, urged caution in suggestions about K-12. "The U.S. has improved tremendously. A quarter of students are going with AP courses in math." He warned against a "rhetoric of failure."

In biology education, he said, change was incremental, but it was also hastened by "exquisite" textbooks by Bruce Alberts and others aimed at narrowing the gap between old and new. He urged retraining of mathematicians, few of whom know what's done in social science or biology.

Jo Handelsman suggested NSF put out an RFP for innovative textbooks that could drive change. "Old books are a major barrier to transformation."

Peter Loeb, University of Illinois, said that when he began teaching, class sizes were only 25 or so. "And when teaching mathematics, we were teaching a language. With classes of 300, it's much different. No administration would have a French class for 300." In small classes the teacher can see when a student is having trouble, but seldom in large classes.

Paul Zorn, past president of MAA, encouraged people to direct attention to the "INGenIOuS" project (INvesting in the next Generation through Innovative and Outstanding Strategies), which is supported by MAA, SIAM, ASA, AMS, and NSF.

Phillip Griffiths closed by observing how many parallel efforts are underway or planned around the country to transform postsecondary mathematics education. He urged all stakeholders to pool their efforts and speak with one voice to increase the chance of being heard.