American Mathematical Society
Committee on Education Meeting
October 29-31, 2015
Washington DC

Summary Report

The focus of the meeting was on preparing undergraduate students for the next steps. Presentations included a wide variety of perspectives, including an update on the MAA's study about students' progress through calculus, a discussion of proof comprehension in advanced mathematics, and an overview of the American Statistical Association's work on the Statistical Education of Teachers. Also covered were access to graduate programs, the role of internships in mathematical training, the transition from academia to industry, and increasing the participation of students from underrepresented groups.

Building bridges to broaden and deepen representation
Federico Ardila (San Francisco State University-SFSU) spoke to the group about the SFSU-Columbia Combinatorics Initiative, his online mathematics course for students at SFSU and the Universidad de Los Andes in Bogota, Columbia, as well as from the University of California-Berkeley. This program brings together a very diverse group of students to complete mathematical research projects and exchange ideas.

Ardila's initiative is funded through the SFSU research office and a NSF CAREER grant and is born out of his own educational experience in his native Columbia. The program utilizes technology to create videos of Ardila's classes at SFSU and broadcasts them to Los Andes. In this way, he is able to create a sense of community among these students who then collaborate to produce high level mathematical work. In addition, the funding has allowed him to take some SFSU students to Columbia to work alongside their peers, to attend conferences and collaborate on research.

Since Ardila launched the initiative seven years ago, it has reached 200 students – 60% Columbian undergraduates, 40% SFSU undergraduate and master's students (of which 30% are underrepresented minorities and 50% are women). The online resources are readily available including all videos, lecture notes, homework and projects

Lessons learned in building diversity
Ulrica Wilson (Morehouse College) spoke to the group about women and minorities' access to the mathematics profession. She spoke about problems with diversity in the mathematics community and her own experiences. She noted with particular interest the institutional factors, funding practices and market forces that create barriers.

Wilson talked specifically about the Enhancing Diversity in Graduate Education (EDGE) program for women pursuing careers in the mathematical sciences. This program, primarily funded by the National Science Foundation (NSF) in the past, is now also relying on a sponsorship program to help fund some critical components of the program.

The EDGE summer session is a four week residential program held each June that includes workshops and problem solving, formal mentoring, mini-courses, guest speakers and social activities. This summer program has been held at a number of different locations and typically supports students from liberal arts colleges, although not exclusively.

Wilson also mentioned the Research Experiences for Undergraduate Faculty (REUF) workshops, sponsored by the American Institute of Mathematics (AIM), ICERM and NSF.

Challenges and opportunities for graduate school bound liberal arts students
Cristina Ballantine (College of the Holy Cross) and Steven Miller (Williams College) talked about the difficulty that liberal arts students have experienced in being admitted to top graduate programs in pure mathematics over the last 10-15 years. They explained that these students are no less qualified than others applying to graduate schools and discussed some ways in which the mathematics community might help to address the issues creating barriers for these students.

Barriers to students' comprehension of proofs in mathematical lectures
Keith Weber (Rutgers University) presented research, mostly funded by the NSF, on how well aligned students learning was in comparison to what instructors were trying to convey. He reported on several case studies where presentation of a proof by the instructor versus note taking and learning by the students was examined.

Weber discussed the importance of note taking, but pointed out that it can be challenging for students to take effective notes for various reasons. Instructors felt that the most important aspects of their proof presentations were given orally, therefore, students who relied on what was written on the board in taking their notes were not able to recall the most important parts of the presentation.

Other important factors for students in understanding proofs include their differing beliefs about learning from proofs (i.e. what students think the role or function of a proof is and what they think their responsibilities are as they read a proof), and *colloquial* mathematics, or the expression of a technical mathematical idea using informal English to aid in student comprehension.
Weber summarized that although students did learn useful information, they did not generally recognize the points the instructor highlighted as essential to convey.

Industrial mathematics opportunities and career pathways for undergraduate and graduate students
Rachel Levy (Harvey Mudd College) spoke to the group about preparing math students for careers in business, industry and government (BIG Math). She reported on the increasing number of math PhDs being produced and how the insufficient number of tenure-track jobs now requires students to look outside academia for jobs.

Levy emphasized the importance of starting early in preparing students for BIG math careers and noted a number of programs and competitions in math modeling. She also discussed the skills required for a successful BIG math career and training opportunities outside of curriculum to prepare students for jobs in BIG math (i.e. internships, study groups, embedded research in labs and clinic programs).

She also discussed the importance of creating a network (faculty ambassadors, BIG partners, department chairs and graduate directors etc.) to prepare students for BIG Math jobs and offered other ways in which the mathematics community can help in this endeavor.

Preparing math students for careers in industry: perspective from a career changer
Paul Koester (Allstate) began his presentation by providing information about his own career history and how he became a data scientist at Allstate insurance. He explained the term 'data scientist' and talked about the work he and his peers engage in and what their backgrounds are. He also discussed the challenges in adapting to work in industry, particularly for mathematicians.

Koester went on to talk about preparing students for jobs in industry and emphasized the communication and problem solving skills necessary to be successful. He suggested that improving these 'soft' skills could be done directly in math courses in a way that strengthens the current curriculum.

Update on the MAA's studies of calculus
David Bressoud (Macalester College) presented an update on the Mathematical Association of America's (MAA) studies of calculus. He spoke specifically about two large studies the MAA has been conducting on the study of calculus – *Characteristics of Successful Programs in College Calculus* (a five year NSF/EHR-DRL grant with two one year extensions, wrapping up next summer) and *Progress through Calculus* (just beginning).

He presented a summary of some of the data from the *Characteristics of Successful Programs in College Calculus* study, including grades; career goals; gender differences; student attitudes, confidence, enjoyment, and desire to continue; and, case studies of institutions with 'successful' Calculus I programs. Information on this study has been published by the MAA in a notes volume entitled "Insights and Recommendations from the MAA National Study of College Calculus," which was mailed to department chairs this week and available on the MAA website at www.maa.org/cspcc

His presentation on the *Progress through Calculus* study summarized the focus of this second study that began in January 2015, including the types of departments to be included, the Pre-Calculus through Calculus II sequence, multiple outcome measures and a focus on networking and observing departments that are reforming one or more courses in this sequence. Next stages in this study include a workshop immediately following this AMS COE meeting and a conference in St. Paul, MN in June 2016.

ASA education and outreach programs
Donna LaLonde (American Statistical Association) began her presentation by explaining that the American Statistical Association (ASA) has identified *education* as a strategic goal for their organization and identified four areas of focus to impact this goal: curriculum guidelines development; advocacy and dissemination; professional learning for K-16 teachers, statisticians, and journalists; and, student engagement in the practice of statistics. She went on to discuss these initiatives in more detail.

She spoke in more detail about curriculum guidelines development and mentioned several reports endorsed by ASA – *Curriculum Guidelines for Undergraduate Programs in Statistical Science* (2014), *Guidelines for Assessment and Instruction in Statistics Education* (GAISE) PreK-12 Report and College Report, and *Statistical Education of Teachers* (SET). She also spoke about programs and resources focused on professional learning and student engagement.

NSF and undergraduate mathematics education
Jim Lewis (National Science Foundation) began his presentation by discussing the current national and federal interest in improving STEM education. There have been a number of reports on this subject and efforts to broaden participation in prioritizing STEM. It is recognized that mathematics is essential in the preparation of the STEM workforce.

He summarized the STEM goals of the NSF Directorate for Education and Human Resources (EHR), including: 1) the preparation of the next generation of STEM professionals and attracting/retaining more Americans to STEM careers; 2) the development of a robust research community that can conduct rigorous research and evaluation to support excellence in STEM education; 3) increasing the technological, scientific and quantitative literacy of all Americans; and 4) broadening participation and closing achievement gaps in all STEM fields.

Lewis presented some statistics on NSF-EHR funding and key areas of opportunity for impacting the improvement of STEM education, including active learning strategies. He also discussed proposal pressure for funding dollars and briefly presented some tips on submitting a successful grant proposal, mentioning the free grant proposal writing session held by the AMS and NSF prior to the start of the Joint Mathematics Meetings each year.

General Discussion
The meeting was organized purposefully to allow discussion on topics of general concern and interest. These discussions resulted in conversations related to providing research experiences for students, redesigning first year mathematics programs, the importance of supporting and rewarding instructors, and providing information and resources on how to improve student learning.

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