Recruitment and Retention

Martha Siegel, Towson University, chair
Sylvia Bozeman, Spelman College
James Epperson, University of Texas at Arlington
Pao-sheng Hsu, Association for Women in Mathematics
Elizabeth Mayfield, Hood College
Joanne Peeples, El Paso Community College
Kay Somers, Moravian College
David R. Stone, Georgia Southern University
William Yslas Vélez, University of Arizona

Introduction. President Obama, Education Secretary Arne Duncan, the National Academies of Science and others have made producing more STEM graduates a top national priority. While one need not be a mathematics major to enter a STEM field, most of the STEM disciplines require a solid background in the mathematical sciences. Recruitment and retention of students who major in the mathematical sciences is thus a national priority.

Mathematical sciences departments need to become “pumps, not filters” in the STEM pipeline. There is some good news. The November 2013 U.S. Department of Education report *STEM Attrition: College Students’ Paths into and out of STEM Fields* finds that attrition in other areas (health science and education) exceeds that in STEM fields. In addition, more students graduate with a major in mathematics than express that intention when they enter our colleges and universities. Among all the major STEM disciplines, moreover, only mathematics picks up majors. Nevertheless, the challenge to mathematics departments is substantial: to cultivate and excite students who come to us with a keen interest in mathematics, and to adequately prepare students who arrive with interest in a related discipline that relies on collegiate mathematics.

Affirming diversity. We emphasize the importance of intentionally welcoming and including diverse populations to the major. Department-sponsored activities like seminars and guest speakers, contests, picnics, and field trips help build community. Study groups create bonds between students while helping them learn. Many of these activities, especially when encouraged for students early in their college careers, may also attract students to mathematics by highlighting the rewards of choosing mathematics as a first or even second major. Alumni engaged in interdisciplinary careers are particularly helpful as mentors or speakers.

In classrooms we aim to create communities in which diversity is respected. We try to develop a classroom culture that is inclusive, motivates students towards excellence, encourages them to support each other, and promotes persistence on difficult tasks. For students with deficits in learning or performing, we ensure that resources are provided. We pay attention to the cognitive

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1 *Intended* majors are entering full-time freshmen at 4-year institutions who list Math or Stat as their first choice for an intended major. (See the [American Freshman Survey](https://www.nse.org/).) *Actual* majors (as measured by [National Center for Education Statistics](https://nces.ed.gov)) is the number of students for whom Math or Stat was their primary or first listed major.
and the affective (attitudes, beliefs, values, and motivations) dimensions of learning, because both influence what students will learn by the end of a course. Whether students enroll as part of a program in the mathematical sciences or to fulfill a general requirement, what they retain from a course may contribute to their life-long view of mathematics, and thus to the public image of our discipline. Some of our students will become parents, teachers, and political leaders; all of them will become citizens and decision-makers.

**Who recruits whom?** Not all mathematics faculty see it as their responsibility to recruit mathematics majors. Some departments are reluctant to recruit students who perform below A-level in mathematics. We reject these views. Professors who find their discipline exciting should communicate that excitement to students. Almost any student, regardless of major, can benefit from taking mathematics. Every student who enjoys the subject and is reasonably good at it should be encouraged and invited to continue.

**Different students, different strategies.** Intentional outreach can greatly increase the number of students taking advanced courses in mathematics. Letters of welcome from a mathematics department can encourage incoming students with strong mathematical backgrounds to enhance their careers—regardless of major—by adding mathematics courses to their programs. Students who succeed in a first course in mathematics often decide to continue. Mathematics departments should actively invite students who score A’s and B’s in a given course to continue. Many students become math majors “by induction”: taking a first course, doing well, continuing to the next course, and so on.

Beginning college and university students present many different stages of mathematical preparation and maturity. To meet each at her or his level is a challenge. Talented students who arrive with advanced credits in mathematics (e.g., through Advanced Placement or International Baccalaureate programs) may need encouragement to take any mathematics in college. Retaining these students in the discipline requires interesting and challenging courses. At the same time, we should not assume that students who arrive with less mathematical experience are incapable—or unworthy—of completing a mathematics major program. We need to design mathematics curricula that serve a wide range of students, with courses that meet students where they are, advancing them to the next level and beyond.

This curricular challenge has spawned various strategies, some more effective than others. For students who begin below precalculus we have offered remedial courses. Precalculus courses themselves may receive college credit. Many institutions offer “stretch” or “supplemental instruction” courses, with extra class meetings and remedial topics introduced “just-in-time”. Course redesigns may include in-person help clinics, drop-in classes, and remedial uses of online homework systems. Modular materials may be offered to remediate particular topics, again “just-in-time,” combined with in-person tutoring or coaching.

At the other extreme are incoming students who have already accumulated college credits in mathematics. Some of these prefer to avoid further mathematics; others dig right in. College graduation requirements may obligate these students to take some further mathematics, but we should offer courses—required or not—that challenge and excite these students and encourage them to continue in mathematics, no matter their ultimate majors. Attractive course possibilities
may be distinct from or independent of calculus; they might focus on discrete mathematics or on special topics such as number theory, voting theory, and knot theory. Such courses can attract students to mathematics by revealing more of what mathematics really is, without repeating material already seen in high school.

**Efforts of other organizations.** Both AMATYC and CUPM’s subcommittee on Curriculum Renewal across the First Two Years (CRAFTY) have looked closely at developmental mathematics, college algebra, and general liberal arts courses. In particular, the Curriculum Foundations Project has addressed the needs of beginning students in various other disciplines.

More recently, *Transforming Post-Secondary Education in Mathematics (TPSE Math)*, a new program, sponsored jointly by the Carnegie Corporation of New York and the Alfred P. Sloan Foundation, aims to effect constructive change in mathematics education at community colleges, 4-year colleges and research universities. Among the areas of inquiry for TPSE Math is to determine what areas in mathematics students really need to know. Then the task is to align the curriculum to address these needs. One challenge is to supply a route to the major for students who begin in precalculus or courses designed for non-majors.

**Recruitment strategies.** Mathematics faculty who want to recruit students can begin by offering courses appropriate to students’ needs and mathematical maturity. Promising students in service courses in statistics, applied calculus, or finite mathematics should be individually encouraged, regardless of major, to take the next course or the first course in the major sequence. A necessary next step is to assure that students who begin in service courses or precalculus can indeed complete a major. Minority students and women who start below the standard entrance point (calculus) for majors may be particularly reluctant to continue in mathematics.

Warm and welcoming personal invitations can encourage students beyond what we expect. Coupling initial words of encouragement with departmental tutorial and social support can help students learn to study and to succeed at every level. Even when a curriculum is structured to allow alternative entry points to the major, many students need advisors, coaches, professors, and peers to help clear the way. This structure should be built into the organization of the department by building a corps of faculty who intentionally reach out to students.

**Building community.** Establishing a supportive and encouraging learning community is crucial to attracting new majors and to nurturing them as mathematics learners. As a first principle, a department must show that it respects and values students, recognizing needs of different student populations—residential, commuter, full-time, part-time, underrepresented minorities, men, women, those from different cultures—and working to ensure that all feel welcome.

Student-led groups (math club, MAA student chapter, Pi Mu Epsilon, Mu Alpha Theta, Kappa Mu Epsilon) allow students who like mathematics to find each other and learn more about math. These groups need active and committed student leaders, meaningful activities and programs, and departmental support.

When mathematics departments cultivate good working relationships with other departments, especially in STEM fields, students follow their example. Student clubs from several
departments should be encouraged to jointly invite speakers who can point out how the various disciplines are used in their research or job-related responsibilities. It is equally important to be sure that invited speakers are diverse in gender, culture, race, and undergraduate major. Students respond well to such visitors because they want to see how their education will be integrated into their careers. They need to be able to see the possibilities for themselves in their life after college. They also benefit from seeing that gender and racial stereotypes can be overcome.

Technology can be used in various modes to foster community: email, web pages, Facebook, Twitter, blogs. And we should pay close attention to the department’s physical space as it can enhance the sense of community, by providing spaces where students can gather in small or large groups to work (or play, or eat lunch) together; by placing comfortable seating areas near faculty offices; by providing blackboards, journals, a coffee pot, and refrigerator in student areas.

A critical mass of department faculty must be committed to and involved in the process of creating and sustaining community. The department must value faculty time (including in the tenure and promotion process) spent on community-enhancing activities and must commit resources to them. Forming a vibrant student community begins with the department's conscious commitment to this effort.

**Orientation.** Several schools have found that an orientation program for potential majors that might have been developed in connection with various federally-funded STEM-scholarship and support programs proves interesting and inviting for first-year students (freshmen and transfer students). In addition to introducing students with similar interests to each other and forming a cohort that might also be formally organized into a learning community, a good deal of information can be transmitted. One possibility is to offer a course meeting one or two hours a week. The syllabus for such a course should emphasize degree requirements, possible career paths, suitable double majors or integrated majors, and alumni success stories.

The course should encourage participation in professional organizations (everyone is invited to an MAA Section meeting) or in the campus mathematics club or Pi Mu Epsilon by requiring that students attend a meeting or two and write a short paragraph about the experience. Students should be introduced to possible undergraduate research experiences for mathematics majors and told what they will have to do to prepare for professional examinations (Praxis, GREs, or actuarial exams, for example) or for graduate programs. Having librarians, financial aid experts (including those who can help students to make reasonable budgets), tutoring coordinators, and peer mentors speak with students can make the department seem accepting of and interested in them. Food and informal conversation among students and faculty encourage community and a feeling of professional identification.

**Different paths to, through, and beyond a major.** We should pay attention to the provision of diverse paths through the major. This Curriculum Guide has presented some new paths for those interested in mathematics. Traditionally the upper division courses in mathematics, abstract algebra, linear algebra, analysis and complex variables, prepared students for graduate study in mathematics. Designing “options” that allow for a different selection of upper division courses that lead students to the workforce or graduate programs in the life sciences, engineering, or business can increase interest in the mathematics major.
Students appreciate opportunities to learn off campus. The mathematical and scientific establishment can be harnessed to deepen mathematics majors’ experience. Research positions in scientific labs, REU programs and summer internships integrate students into the academic culture and expand their career choices. Communicating mathematics through conferences, tutoring, and school outreach activities give mathematics majors an opportunity for personal and professional growth.

Many beginning college students see a mathematics major as leading to only one profession: high school teaching. While we do indeed need more teachers, college departments should educate students early about the full range of careers available to mathematics majors. The mathematical community should also support high school mathematics teachers in informing their own students of mathematical career opportunities.

**Conclusion.** Successful programs around the country demonstrate how a few simple strategies can dramatically increase the number of students studying mathematics. While all of the diverse ideas laid out here have worked for some colleges and universities, the common thread is that successful departments are intentional in their efforts to get more students interested in, thriving at, and majoring in mathematics.