MATHEMATICS PROGRAM
External Review

Janet Beery, Professor of Mathematics, University of Redlands
Alan Knoerr, Associate Professor of Mathematics, Occidental College
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The present review of the Mathematics Program at the University of La Verne is based primarily upon 1) careful consideration of the Mathematics Program Review prepared by Program Chair Michael Frantz, and 2) a site visit on Monday, May 5, 2003, that included interviews with mathematics faculty members Michael Frantz, Xiaoyan Liu, and Rick Simon; Natural Science Division Chair Robert Neher; Dean of the College of Arts and Sciences John Gingrich; and seven ULV mathematics majors, as well as informal conversations with ULV Physics Program faculty members David Chappell and Sarah Johnson. Our review is informed also by our experience at our own institutions (a small private comprehensive university with a liberal arts emphasis and a private liberal arts college, respectively); by our participation in discussions of undergraduate mathematics education at regional and national conferences and in professional publications; and by recent recommendations from the Mathematical Association of America, the National Research Council, and other leading voices in undergraduate mathematics education.

Observations

The University of La Verne mathematics faculty, science faculty, and administration have a clear and well-articulated view of the importance of mathematics within a liberal arts education. The mathematics faculty strives to organize its work to meet its goals of providing meaningful mathematical experiences for all university students, from those who need to learn basic mathematics skills to those who wish to major in and pursue careers in mathematics.

The mathematics faculty is extraordinarily hardworking. The teaching load is substantial, with each faculty member teaching at least three courses and (usually) three preparations each semester, often including an extra course (often an extra preparation) taught as an overload. Faculty members are available for many hours for individual consultation with students, in their offices and via telephone and e-mail. They offer many directed study courses to individual students, with no compensation or reduction in other teaching responsibilities. They frequently design new courses or modify existing ones, and they rotate courses amongst themselves with each faculty member teaching virtually every course in the curriculum over an 8- to 10-year period.

Both full- and part-time mathematics faculty members, in courses ranging from the pre-college level to upper division, work very hard at and are very skilled in helping weak to average students succeed in a notoriously difficult subject. They attempt to meet all students in all courses "where they're at" and then to work closely and carefully with students to raise their level of understanding, thinking, and execution. Instructors provide a variety of classroom experiences, from group work to student presentations to computer laboratory instruction to traditional lecture. They employ mid-term evaluations to gage students' satisfaction and success with classes. The overall quality of mathematics

classroom instruction seems to be quite high, with teaching and learning most accurately described as "student-centered".
Full-time mathematics faculty members give an extraordinary amount of individual attention to students, both in and out of class, and students appreciate the faculty's efforts to meet their individual needs. Students majoring in mathematics describe the three mathematics faculty members as demanding and challenging, yet extremely caring and accessible. In addition to the faculty's many office hours, students appreciate activities the faculty organizes for them, such as trips to local mathematics conferences. Students also value their dedicated study space in Mainiero Hall, including its computers and its proximity to mathematics faculty. There seem to be just as many, if not more, women as men majoring in mathematics.

The mathematics program offers courses for underprepared students (Math Workshop and Intermediate Algebra). It offers general education courses designed to illustrate both the beauty and the applicability of mathematics (Mathematics in Society, The Mysterious Dance of Art, Mathematics and Music) and to impart specific skills to students in specific majors. It offers courses especially for the future elementary school teachers majoring in liberal studies (Developmental Mathematics) and for business and economics majors (Mathematical Methods for Business and Economics). Finally, it offers a calculus sequence (Calculus I, II, and III, Differential Equations, and Vector Calculus) tailored to meet the needs of students majoring in biology, chemistry, computer science, and physics, as well as mathematics.

While the majority of its course offerings consist of the service courses just described, the mathematics program also offers a fairly broad curriculum for mathematics majors, exposing them to many areas of mathematics and to both pure (theoretical) and applied mathematics, albeit through infrequently offered courses and/or directed study courses. Besides topics courses, course offerings for mathematics majors include the Transition to Advanced Mathematics course and the Senior Project, which currently is completed as a directed study. The majority of mathematics majors intend to become high school mathematics teachers, with a few preferring to pursue careers in industry or government. A few mathematics majors pursue graduate study in the mathematical sciences, but not always immediately after graduation from ULV.

The mathematics faculty is committed to using technology (primarily computer algebra systems) in mathematics instruction, but currently teaches only about one third of its classes in "smart" classrooms. Instructors can schedule computer laboratories for class sessions only occasionally. Otherwise, instructional spaces seem adequate. Faculty offices also seem adequate, as do the study spaces for science students in Mainiero Hall.

We observed a high degree of collegiality between mathematics and physics faculty members (we didn't speak with any computer science faculty members) and between mathematics/physics faculty members and their division chair, Robert Neher. Mathematics program faculty and, more generally, science division faculty, appear to have close, cordial, and effective working relationships with one another. The mathematics faculty also appears to have a friendly, open, and effective relationship, based on mutual respect, with Dean of Arts and Sciences John Gingrich.

Despite their heavy teaching loads, mathematics faculty members engage in a fair amount of scholarly activity, grant-writing, service to the mathematical community, and service to the university. Their dedication to teaching, their grant-writing efforts, and their committee work on campus are evidence of their commitment to the success of the university. They represent the university well off campus by their involvement in the local section of the Mathematical Association of America, their participation in national and international conferences, and their work in administering intercollegiate athletics.

The mathematics program already has in place a planning and assessment process. Indeed, the majority of our recommendations are intended to achieve goals articulated in the program review prepared by Program Chair Michael Frantz.

Recommendations and Rationale

Staffing and Compensation

The mathematics program's reliance on part-time faculty is far too high. The two part-time instructors we observed seemed very competent, but part-time faculty members generally have little commitment to a university and its students. At the currently low level of compensation, retaining good part-time instructors is difficult, making recruiting and managing these faculty very challenging for the Program Chair.

Part-time faculty members should be paid at least $3000 per course, perhaps with a requirement of a minimal number of office hours. They might be contracted for $2500 per course plus $500 for a specified number of office hours.

Since part-time faculty members are used primarily for lower level courses, the university might consider hiring a full-time instructor or lecturer to teach 8 sections of these courses per year with a certain number of office hours and possible committee expectations. The mathematics faculty should plan to make this instructor an integral member of the program, participating in departmental, division, and university decision-making and social activities.

Ideally, the university would hire an additional tenure-track faculty member who could help teach and invigorate major offerings as well as service offerings. Even more ideally, the university would hire both a tenure-track mathematics professor and a mathematics instructor.

In scheduling, the Program Chair should attempt to reduce the number of preparations for each faculty member by, for instance, assigning two sections of a course to the same faculty member. Faculty should stop taking on overloads, especially those that involve extra preparations. The university should increase faculty pay and program staffing so that faculty do not feel obligated to teach overloads. Directed studies should be counted in faculty teaching loads. Two directed studies should count as one course, but, perhaps, as a starting point, six directed studies could count as one course (or one overload).

Support for the Mathematics Program and Faculty

The university administration should continue to appreciate the special demands of teaching in a discipline that requires such a large amount of contact time with students both in and out of class. We recommend that mathematics faculty members be among the first to receive work-study assistance (for tutoring, paper-grading, and office work), assistance with grant-writing, support for travel to workshops and conferences, and even differential pay. We particularly recommend that the administration provide (and that mathematics program faculty members take advantage of) course releases for curriculum development. Participation in curriculum development should be regarded favorably for promotion.

We appreciate faculty initiatives to require scholarship for promotion, but caution faculty to include teaching-related professional activity as an acceptable form of scholarship. This would help ensure that all faculty can relate their scholarship to their teaching and that teaching remains the faculty's primary mission. Faculty and administrators should recognize that faculty teaching loads are not uniform across campus. In order to give all faculty the opportunity to engage in scholarly activity, the university should take steps to reduce teaching loads in programs with very heavy teaching loads, including mathematics.

The university should continue to expand and improve classroom technology by making more classrooms "smart" and by providing adequate computer laboratories. The university should set up one classroom computer laboratory in which mathematics courses could meet regularly.

Service Courses

The mathematics program should continue to offer interesting and exciting service courses, such as The Mysterious Dance of Art, Mathematics and Music; Mathematical Methods for Business and Economics; Mathematics in Society; and, of course, Calculus I, II, and III.

We encourage the faculty to carry out its plan to design and offer a "thinking" statistics course featuring collection and interpretation of real-world data sets. This course should be marketed to biology majors as well as to business and social science majors, with the eventual goal of having these programs require the course for their majors.

We hope that the interesting and exciting Mathematics in Society course survives; however, if it ends up being supplanted by the statistics course, the business course, the mathematics and the arts courses, and/or an applications-based College Algebra course (see below), then so be it. In order to encourage students to take Mathematics in Society, mathematics program faculty might bar students who have placed solidly into Precalculus or Calculus I (or higher) from College Algebra but not from Mathematics in Society.

We recommend following national curriculum recommendations for College Algebra [9] by integrating real world modeling and problem solving into the course. (Also see [13].) We very much like Professor Frantz's suggestion of an approach drawing on

environmental problems and modeling. This should appeal to many students, fits in with wider university curricular themes, and may be supported by recent textbook development.

These recommendations should make College Algebra more interesting and relevant, and certainly much less like the standard high school courses students may be repeating when they take College Algebra. Students frightened by such an approach (and there will be some) may flee to Mathematics in Society or another general education course, but this would be a desirable outcome. Whether Mathematics in Society gains in popularity or continues to be overshadowed by College Algebra, the result of modifying College Algebra should be that all ULV students would complete a concepts- and applications-based mathematics course – again, the desired outcome.

We also recommend that mathematics faculty investigate ALEKS [1] or another web-based mathematics tutorial system. Such a system may be very helpful in assisting students with skills development and concept mastery in elementary courses such as College Algebra. With less class time needed for fundamentals, more emphasis could be placed on the higher-order thinking skills the revised course would demand. We caution, however, that such tutorial systems are not magic; some students may also need human tutors.

While offering an even broader range of general education and other service courses would be desirable, we believe program faculty already are stretched too thin in offering existing courses. Unless program staffing is increased substantially, service courses beyond those discussed here should not be added to the curriculum.

Curriculum Revision for the Mathematics Major

The Mathematical Association of America's Committee on the Undergraduate Program in Mathematics (CUPM) is a good source for information on mathematics curriculum revision. In particular, the Curriculum Foundations Project of its Sub-committee on Calculus Reform and the First Two Years (CRAFTY) has produced a number of reports with recommendations for the preparation of mathematics majors, as well as for the mathematical training of students in other disciplines [10]. More comprehensive guidelines from the CUPM are forthcoming [9]. In addition, the California Commission on Teacher Credentialing has recently adopted new standards for the single subject credential in mathematics [2] and will require all colleges and universities to re-submit credential program applications within the next two years.

While curriculum revision should be informed by recommendations from these state and national organizations, it should be driven primarily by the mathematics program's mission and resources. We believe current resources can support only a very focused program. By deciding which courses are most important and focusing on them, the mathematics program should be able to offer fewer upper division courses overall, but offer more upper division courses as classes rather than as directed studies.

Since most mathematics majors plan to become high school mathematics teachers, it seems to us that the core of the major should be those courses within the credential program. These courses should be required or at least highly recommended for all

majors, not just those intending to teach high school mathematics. The new standards for the single subject credential in mathematics issued by the California Commission on Teacher Credentialing, together with the Commission's requirement that all colleges and universities re-submit credential program applications within the next two years, give the ULV mathematics faculty an ideal opportunity to redesign major requirements and upper division course offerings around credential program goals. It also is important that regular course offerings include at least one course that each full-time faculty member would be really and truly excited about teaching, e.g. courses in biological or environmental modeling or in numerical methods.

The net result of centering the mathematics major around courses required for the teaching credential should be that the same number of courses are offered as regular courses (we don't see how to reduce this number), but that fewer courses are offered as directed studies. We acknowledge that reducing the number of courses offered does have some disadvantages. It reduces student choices, and the soon-to-be-released recommendations of the Mathematical Association of America [9] advocate wider variety in courses with closer attention to individual student interests. But, again, we believe current faculty and student resources at ULV can support only a very focused program.

The primary resource allocation goal should be to make sure there almost always are four or more students in each upper division course, and that each student in the course is prepared to take the course. Nevertheless, the administration should support the occasional course with only two or three students in it, recognizing that the mathematics faculty has done everything possible to streamline course offerings while keeping the program attractive to potential majors.

Directed study courses should be reserved only for students intending to pursue graduate study in the mathematical sciences. Depending on their intended programs, these students would need from two to six additional courses.

The Senior Project should be offered as a yearly spring course, perhaps jointly with physics and/or other programs. It might instead be offered during fall semester or, less ideally, January term if that would help increase the number of students in it and other courses. Another option would be a 1- or 2-unit seminar taken throughout the senior year. Career information could be included in the Senior Project course.

In redesigning the mathematics curriculum, it may be possible to retain a few choices for majors and to distinguish between the B.A. and the B.S. However, it may not be necessary to offer these two degrees. Redlands offers only the B.S. and Occidental offers only the B.A. We note also that the two main features of the highly successful mathematics program at SUNY-Potsdam are its close faculty attention to individual students and its single-track mathematics degree [5].

The mathematics faculty at Potsdam believes that a compassionately taught, fairly traditional, relatively barebones curriculum that emphasizes the development of mathematical thinking skills is the best way to provide students with the knowledge and intellectual skills they need in order to succeed in careers in teaching, industry or government, and/or in graduate study. The ULV mathematics faculty will have to convince their students that a good grounding in mathematical thinking skills should be

an excellent preparation for any career or course of graduate study, that the courses required in the program do offer quite a bit of breadth in mathematics and its applications, and that their senior projects will give students an excellent opportunity to get experience in areas of particular interest to them.

While we appreciate the mathematics faculty's support of the computer science and physics programs through course requirements in these areas for mathematics majors, as well as its message to mathematics majors that being able to apply their skills in other areas is important, the mathematics faculty may wish to allow students to choose between the two or to design their own "emphasis" or application of mathematics. Perhaps all mathematics majors would complete a computer programming course but only students earning the B.S. degree would complete the physics courses.

We recommend dropping the GRE as one of the two exit examinations, as we suspect it is demoralizing for weak to average mathematics majors. Other "outside" exams available include those taken by prospective mathematics teachers (currently, the SSAT or Praxis exams) and a more general mathematics assessment exam offered by ETS. (Note: One of the reviewers is an ETS consultant.)

Especially since most mathematics majors intend to become high school teachers, the mathematics faculty should be sure to continue to model a wide variety of instructional styles and to involve students actively in learning, both in and out of class. Opportunities for tutoring and peer mentoring in mathematics [12] should be expanded for qualified students.

Recruitment and Retention of Majors

With most major courses offered only every other year, it is not possible to maintain viable enrollment levels and meet students' needs to progress through the major while requiring the customary sequence of prerequisites for these courses. Rather, it is important to make sure that most of these courses are accessible to most mathematics majors, meaning that some must be offered at a lower level than might be considered ideal. The Transition to Advanced Mathematics course should be very helpful, especially if offered when all students can take it. However, this course will not magically prepare all students for all upper division courses. Many students will need several semesters of "transition" to higher order thinking skills.

At the same time, faculty and students must be realistic about prerequisites. For example, students will have a much greater chance of success in the probability and statistics sequence if they take Calculus III first.

We hope these measures will help reduce the high number of Incomplete and In Progress grades assigned in upper division mathematics courses. While it is commendable that faculty offer such flexibility in order to help students succeed, neither they nor the students have time for this luxury.

In our focus group with students, they expressed a desire for more help with homework. Help in class was preferred, but an outside-of-class homework session with a little more structure than office hours (much like a recitation section at a larger university) also was

attractive to them. They also expressed a desire to be able to re-do homework assignments, a request which seems worth accommodating when possible. As for student complaints that mathematics courses are challenging and time-consuming and that taking more than one of them per semester is unrealistic, the faculty should continue to encourage and help students---and to help them plan schedules containing no more than two mathematics courses per semester! Again, students are unanimous in praising the availability of the mathematics faculty for help and guidance.

Students were also unanimous in expressing appreciation for their study space in Mainiero Hall. Maintaining and improving this space should be of highest priority. Seating might also be provided outside faculty offices so students can wait for faculty there.

Students' already strong sense of community might be further improved by a Math Club and activities, and by additional program-related employment opportunities for students as tutors, peer-led workshop leaders, graders, or even office assistants. Program alumni should be invited to share career information with current students, by visiting campus or via e-mail.

In addition to the improvements already made in the advising of mathematics majors as a result of better college records, mathematics faculty members might use a little class time each registration period for general advising about upcoming courses and to encourage students to meet with them for further advising, and/or hold general meetings for intended mathematics majors (with food as well as advice as incentive) to dispense information. One-page checklists of mathematics major requirements and recommended course sequencing should be distributed to prospective mathematics majors whenever and wherever possible, including in class. Ideally, ULV students would declare their majors by the end of their sophomore year to help ensure better advising and degree completion.

The mathematics faculty should pay even more attention to the calculus sequence, especially Calculus I, as the primary place where they will recruit mathematics majors and minors. Calculus courses must be stimulating and rewarding. The faculty might encourage or even require students who place solidly into Precalculus or Calculus I to take that course rather than College Algebra to fulfill general education requirements. Unless articulation really has become a big problem, we encourage the mathematics faculty to continue to design its calculus curriculum based on the needs of various ULV programs rather than on external norms.

The faculty also should identify other courses, such as Discrete Mathematics or Bridges Between Art and Mathematics, from which to recruit mathematics majors and minors. Every physics major should have a mathematics minor, if not a second major in mathematics. A mathematics minor should be encouraged for economics and computer science majors.

In addition to encouraging the Admissions Office to recruit strong students, capable of and interested in majoring in mathematics, ask Admissions to identify the best incoming students, regardless of intended major. Encourage these students to take Calculus I early in order to keep open their science and mathematics major and career opportunities.

We hope that all of these actions would increase the number of mathematics majors over the next few years. The university should recognize that increasing the numbers of majors in demanding disciplines such as mathematics depends on increasing the number of high-achieving students it attracts to campus.

Carrying Out Curricular Change

Good collegiality and program management are evident. However, carrying out the curricular changes we recommend will require an even higher level of coordination and mutual inspiration. We note that the mathematics program is planning a faculty retreat for Summer 2003 to discuss our recommendations. We wish to encourage this kind of activity, which strengthens the faculty's sense of community while also addressing program goals.

Here are some other specific recommendations that may be helpful:

- Consider having adjacent offices. This can improve collegiality within the program, though reducing interaction with other science faculty might be a concern.

- Select one to three goals on which to focus for a given year, using importance and feasibility as criteria. After further discussion, have each faculty member in the program commit to specific tasks needed to achieve these goals. Then meet on a regular basis for the sole purpose of making progress towards these goals, excluding discussions of other program or institutional business from those meetings.

- Take a look at some of the recent literature on organizational change ([6],[7],[8]) and faculty learning communities ([3],[4]); consider the applicability of this work to your situation.

Conclusion

The University of La Verne Mathematics Program does a very good job with modest resources. However, a greater focus on its core mission of preparing future mathematics teachers, together with some additional resources from the administration, should enable the program to improve, attract more majors, and be of even greater value to other programs in the university.

References and Resources

[1] ALEKS Corporation, 400 North Tustin Avenue, Suite 300, Santa Ana, CA 92705 http://www.highedmath.aleks.com/ (714) 245-7191

[2] California Commission on Teacher Credentialing, *Single Subject Matter Standards: Mathematics* (February 2003). http://www.ctc.ca.gov/profserv/progstan.html

[3] Cox, M. (1999). Peer consultation and faculty learning communities. In C. Knapper & S. Piccinin (Eds.), *Using consultation to improve teaching* (pp. 39-49). San Francisco, CA: Jossey-Bass.

[4] Gabelnick, F., MacGregor, J., Matthews, R. & Smith, B. (1990*). Learning communities: Creating connections among students, faculty, and disciplines.* San Francisco, CA: Jossey-Bass.

[5] http://www.potsdam.edu/MATH/Math%20Dept%20Home%20Page/Index.html, http://www.potsdam.edu/admissions/departments/math.html

[6] Kotter, John. *Leading Change*. Harvard Business School Press, 1996.

[7] Kotter, John. "Leading Change: Why Transformation Efforts Fail." *Harvard Business Review,* March-April 1995.

[8] Lucas, A. F. & Associates. (Eds.) (2000*). Leading academic change: Essential roles for department chairs.* San Francisco: Jossey-Bass.

[9] Mathematical Association of America, *Undergraduate Programs and Courses in the Mathematical Sciences: A CUPM Curriculum Guide, Draft 5.1* (July 2003). http://www.maa.org/cupm/

[10] Mathematical Association of America CRAFTY-CUPM Curriculum Foundations Project, *Recommendations on the Preparation of Math Majors in the First Two Years* (May 2001). http://www.mathsci.appstate.edu/~wmcb/CFF/

[11] Preparing Mathematicians to Educate Teachers (PMET) http://www.maa.org/pmet/, http://www.maa.org/pmet/focus.html

[12] The Peer-Led Team Learning Workshop Project http://www.sci.ccny.cuny.edu/~chemwksp/

[13] Center for Problem-Based Learning, Samford University http://www.samford.edu/pbl/