External Review Report
Department of Mathematics
University of La Verne
April 2011

Prepared by
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Introduction

On February 24, 2011, Professor Christopher Towse of Scripps College visited the University of LaVerne for the purpose of conducting an external review of the Department of Mathematics.

First, I would like to thank the Math Department for the warm welcome I was given during my visit to campus. Faculty members and students alike were generous with their time and thoughts regarding the Math Program.

Definitions

Throughout this document, "the department" refers to the Mathematics Department at the University of LaVerne. "ULV" refers, of course, to the University of LaVerne. "The program" refers to the mathematics program at ULV. "The self-study" refers to the *Mathematics Program: Program review for the 2008-2009 Academic Year* report prepared by the department and received by me on February 12, 2011. The "MAA" refers to the Mathematical Association of America. "CUPM" refers to the Committee on the Undergraduate Programs and Courses in Mathematics, a committee of the MAA. The "CUPM report" refers to the *CUPM Curriculum Guide 2004*, a report by the CUPM that is available through the MAA. "The MAA Guidelines" refers to *Guidelines for Programs and Departments in Undergraduate Mathematical Sciences*, a report updated and published by the MAA in 2003.

Purpose

The purpose of the visit was to assess the current state of the mathematics program of the department and to provide advice as the program moves into the future. The program offers a Bachelor of Arts and a Bachelor of Science degree, both in mathematics. They also offer a minor in mathematics.

This report, following the lead of the self-study by the ULV Math Department, is focused on the Core and Upper Division courses taught by the Math Department. That is, the so-called remedial courses and the general education portion of the responsibilities of the department were not studied during this review. The area under review here is the program of courses that would lead a student to major in mathematics at ULV.

I met with the following faculty members from the department:

Yousef Daneshbod
Michael Frantz (Chair)
Xiaoyan Liu
Rick Simon

In addition, I met with a group of four mathematics majors, with Robert Neher (Natural Sciences Division Chair), and Jonathan Reed (Dean of the College of Arts and Sciences). I ended my visit to campus with a wrap-up meeting with the mathematics faculty at which much of the information contained in this report was discussed.

Findings

The department should be commended for the thorough self-study they prepared. There is no question that the department has done more than its due diligence in creating this document. The department has done a remarkable job of analyzing their program, finding issues to address, and coming up with plans of action.

In particular, learning outcomes for math majors and minors and program goals and objectives have been well articulated. Regarding the question of whether the program meets generally accepted standards for mathematics, the self-study has included useful material in Appendix Q, comparing the ULV program to that of ten peer institutions. The program certainly falls within accepted standards. There are potential areas in which the department might be able to strengthen the program. Some of these are already mentioned as ideas for consideration in the Summary statement in Appendix Q. Other ideas will be mentioned below in this report.

The four full-time faculty members of the department are well-qualified mathematicians with appropriate degrees. They have areas of specialization that are both active areas of current research and also areas relevant to the students they serve. (See p. 5 of the self-study.) The self-study identifies two places in which the departmental facilities can be improved: a dedicated computer classroom and a student space. This issue will be addressed later in the section on Action Recommendations.

The department has done a thorough job of assessing the program through two senior exams (the GRE subject test in Mathematics, and an in-house exam), a senior project, and follow up surveys with alums. The department is considering dropping the required GRE exam and I would support that action. The in-house exam seems a better tool for assessment in that it has been designed to reflect the material actually determined by the department and in that it has the capability of being altered as the goals of the department change over time. The GRE has some notoriety in the overall math community in the way that it can overemphasize introductory material (calculus, in particular) and has a lack of focus in more advanced material (algebra, analysis, topology, etc.). For the department to rely on the GRE as a significant means of assessment runs the risk of having the program cater to an exam that has a lack of focus itself. Perhaps, in the future, if major changes are made to the in-house exam, the GRE might be used as a means to gauge the level of these changes, so as to prevent a “dumbing down” of the exam

(or the opposite effect). But the GRE, as direct means of assessing the success of the program, seems ineffective and redundant. The department should regularly reevaluate the in-house exam and continue to adapt it according to the expectations it has for its majors. Without seeing the exam itself, I cannot make any judgment regarding its content. I would say, however, that the department might want to place a greater emphasis on more advanced material (particularly Linear Algebra) and less on more introductory material (Precalculus, in particular). All math majors are required to take Math 305 Transition to Advanced Mathematics, so it would seem appropriate to include material from that course, if possible, in the exit exam. Of course, should major requirements change, the exam should be adapted to reflect that change.

The senior project is a critical part of the program, both in terms of assessment of overall growth/knowledge/expertise of the seniors and as a capstone experience for the majors. While it is difficult for me to rate the students general academic knowledge, I can say that the exam results look good and the senior project topics seem appropriate, interesting, and even impressive. Student satisfaction, as measured through the alumni survey, seems remarkably high, though, admittedly, the response rate for the survey was low. The department should continue to seek out opportunities for the majors to participate in research experience, perhaps through summer programs such as Research Experience for Undergraduate Sites. Many such programs are listed at the websites for the MAA and American Mathematical Society. The senior thesis projects should continue to be an opportunity for students and faculty to engage in meaningful undergraduate-level research activities. The faculty members should see this as an opportunity to teach in those areas that are specialized enough that regular courses cannot be offered. If it is at all possible for Analysis to be taught as a regular course, I would strongly recommend that students with the goal of proceeding to graduate studies take such a course *and also* participate in a senior research project/thesis. As a side note, I should clarify that it is entirely appropriate that such math theses be expository and should not require original research results. Nevertheless, the students should develop a sense of ownership of the material, and the writing and point of view should be original to them.

Action Recommendations

In this section, I will comment on some of the recommendations made by the department in the self-study. The numbering reflects the numbering of Action Items on pages 14-16 of the self-study.

11. Seek to obtain a computer lab dedicated to mathematics classes, so entire classes could be either taught in such a lab, or taken in as needed for demonstrations and work on sophisticated mathematical software. Also increase the available space (MA 54) for mathematics and physical science majors to gather and collaborate with each other with appropriate computing facilities at hand.

This is an excellent suggestion. The recommendation 2 of the CUPM report [p. 2] states that, “At every level of the curriculum, some courses should incorporate activities that will help all students progress in learning to use technology….” One significant departmental strength is its embracing of (appropriate) technology in the classroom. The dedicated computer classroom is likely to encourage continued development, and, as technology changes (it always does),

modification.

The dedicated student space is also of critical importance. Mathematics can be seen as an isolating field of study, but this view is contrary to the way most successful math is learned and understood. Given the fact that currently many ULV students do not live together in dorms, there is a need for institutional support in finding academic gathering spaces to enhance collaboration. The MAA Guidelines [p. 11] state that, "There should be dedicated space for use by mathematical sciences majors for conversation and study. It is desirable that this space be near faculty offices to allow opportunity for frequent contact between students and faculty."

12. Continue to apply for a full-time tenure track faculty position in Math Education who could teach all sections of Math 389 Developmental Mathematics for preparing K-8 teacher of mathematics, and a full-time non-tenure track position of instructor or lecturer to teach eight remedial mathematics classes per year (Intermediate Algebra, College Algebra, Precalculus) and organize and administer lab sections for said classes.

With the emphasis with which ULV puts on its Education program, there is no question at all this position in Math Education should be filled. In fact the link between the Math Department and the Education Department should be further enhanced, encouraged, and exploited. Related to this is action item 33.

33. Revisit the decision not to apply for the state subject matter program in mathematics, and either affirm the previous negative decision, or else start the application program.

It is to be hoped that the new faculty member in Math Education will be central to this discussion.

13. Introduce a mandatory structured Math 499 Senior Project class that would be taken for 4 units, but would only meet one hour per week, in order to force students to keep on schedule with their independent work and to give them a forum to discuss their work and practice presenting with other students. Publish a Senior Project Handbook in conjunction with this new course.

It is clear that there has been some dissatisfaction with the senior project as currently implemented. Students were confused about the requirements and expectations for their senior projects. In the exit interview with faculty, the department members seemed enthusiastic about doing what was needed to alleviate some of the confusion on the part of students. A Senior Project Handbook would be a welcomed first step. The suggested Math 499 course would be a clear help. The department might also consider a policy of having advisors meeting with their students weekly while they work on their senior project. And the University should compensate faculty members for this time (with credit toward their teaching loads). As mentioned above, the faculty should view the supervision of senior projects as opportunities to take advantage of this concentrated time with students to enjoy more advanced math.

14. Determine whether or not to continue requiring the GRE Advanced Subject Mathematics Exam for all mathematics majors, and whether to revise the in-house departmental exam.

As mentioned above, it would make sense to drop the GRE exam in favor of the in-house (revised or not) departmental exam. Action items 13 and 14 relate well to action item 25, as well.

25. Consider implementing some type of review course or workshop for students to help prepare for their senior comprehensive exam in order to boost scores and reduce first-attempt failures; also consider a workshop for CSET preparation.

Should the Math 499 course be implemented, it would make sense to include comprehensive exam preparation as part of that course.

Action items 20 and 26 are related to each other and the summary in Appendix Q.

20. Consider whether or not to require probability and statistics in some form for mathematics majors.

26. Determine whether courses such as MATH 315 Differential Equations, MATH 328 Abstract Algebra, MATH 410 Real Analysis, MATH 351 Probability, and MATH 352 Statistical Theory should be required core classes for all mathematics majors.

Summary: La Verne should give serious consideration to making one-semester courses in both abstract algebra and real analysis core requirements for all mathematics majors. Currently, students may opt out of abstract algebra if they complete a B.A. degree, and usually only take real analysis (and on a directed study basis) if they are applying to graduate school.

Consideration should also be given to establishing tracks if this could be done with no or very few new courses being introduced, perhaps three tracks in the areas of secondary math education, applied mathematics, and graduate school preparation.

Certainly all of the courses mentioned above would be reasonable requirements for a math major. Of course any program needs to balance standards with flexibility, paying close attention to the needs and demands of their own student population. Appendix Q reveals that nearly all of the math departments from the ten peer institutions listed require Analysis for the major. More than half require Algebra. The other courses are required to a lesser extent. The department may very well consider Analysis and Algebra (along with the already required courses in Calculus, Linear Algebra, and Transition to Advanced Mathematics) as part of the "standards." At least Analysis should be given more emphasis in the major requirements.

Analysis was mentioned frequently during my interviews on campus as an object of frustration in that it is not currently offered as a regular course at ULV, only as a Directed Study. One idea would be to run this course not as "directed studies" but as a seminar course. Perhaps full-on seminar-style courses (i.e. with students essentially running the classroom discussion while the faculty member facilitates) would be difficult to successfully implement, but some compromise might work well. (Indeed, the students I spoke to were enthusiastic about the idea of more self-determination at the senior level.) This would need to be sold to students correctly, and facilitated particularly well. The administration should consider making faculty development funds available for faculty members to seek out workshops and conferences that might help them to fit this into the culture at ULV. (In other words, this is a change that should not be taken lightly; this could involve significantly more preparation than any typical new courses a professor might teach.)

In order to lend more focus to the rest of the program, I would support the creation of "tracks." The idea of tracks within the math major can be done in different ways. In one approach, a student would have to satisfy all the requirements of one of the established tracks. In another approach, the minimal requirements for a major would be the same for all students, but departmentally published tracks would serve as guidelines for students as they decide how to (or whether or not to) plan their math major. By establishing a list of courses that a math major, who is interested in focusing on math education for example, should take, the department might attract some education students into those (and other) math classes. The other tracks (preparation for graduate school and applied math) also make sense for ULV. Courses of interest to science (particularly biology) and business or economics majors (e.g. linear algebra, financial math, or actuarial math) could also be developed and highlighted by tracks. Within Appendix U of the self-study ("Summary of and Responses to the 2003 External Review Recommendations"), there is the suggestion [Recommendation 27, p. 103] that, "Every physics major should be have a mathematics minor, if not a second major in mathematics. A mathematics minor should be encouraged for economics and computer science majors." While this statement may be hyperbolic, I would support the sentiment and expand it to far more disciplines. Perhaps informal tracks for a math *minor* would help more ULV toward this.

Lastly, I would like to highlight three more related action items.

18. Re-examine the Calculus II-III sequencing to make sure that it is serving our students as well as possible.

21. Reexamine all prerequisites for mathematics courses, particularly courses for majors, such as possibly recruiting MATH 311 Calculus III students for MATH 351 Probability.

32. Encourage faculty to seek out course release time from the administration for research projects and curriculum development during the year or summer.

There are two difficulties in designing the calculus sequence in any math department. The first is logistical: since not every student will take the entire calculus sequence, and some will need certain topics for their major, the department needs to determine a reasonable order in which to present material. The current order, particularly in Calculus II and III reflects a need for certain student to learn calculus in 2 and 3 variables without

going through all the material leading up to Taylor polynomials and series. I would strongly encourage the department to address action item 18 seriously. One alternative to consider would be a set of different calculus tracks for different cohorts of students. For instance, at Swarthmore the second semester Calculus is broken down into four half-semester courses: (a) Antidifferentiation techniques and applications of the Integral; (b) Series; (c) Multivariable Calc (for non-math majors); (d) topics. A typical math or physics student would take the a-b sequence followed by a semester of multivariable and vector calculus (Swarthmore's Calc III). A biology, chemistry, or economics major might take the a-c sequence and be done with calculus. An advanced student with BC Calculus credit typically takes the b-d sequence, followed by Calc III. While this particular set of half-courses might not be appropriate for ULV, a flexible approach similar to this might work.

The second difficulty in designing a calculus sequence lies in keeping the material current.

CUPM [p. 7] states that, "Mathematics programs have traditionally drawn heavily from the physical sciences for applications. In recent years, mathematics has come to play a significant role in far more disciplines, but many mathematics programs have not adjusted to this new reality."

I would encourage the department to take a critical, rigorous look at the topics throughout their calculus sequence. For example, has the topic of curve sketching in Calculus I been updated to address the fact that computer software that in use in this class can sketch a curve on its own? Is the topic of trigonometric substitution important enough (to whom?) to warrant the time in Calculus II? If not, then do trigonometric integrals need to be studied? The administration should support departmental work toward assuring that the calculus curriculum is up to date (perhaps in the form of release time or summer workshop support). And as the department evaluates this curriculum, it should keep in mind the prerequisites for both upper division math courses and courses in other departments.

Overall Health (strengths and weaknesses)

Clearly the greatest strength of the department is the faculty. The students I met and the students who responded to the alumni survey all appreciated the friendly, happy, welcoming faculty members. They mentioned the availability and openness of the ULV mathematicians. They appreciated the small class size and the great deal of personalized attention they received. The mathematical expertise of the faculty was also praised. The amount of work done in preparing the self-study was apparent. This is a department that has a healthy awareness of its goals and aspirations.

In my interviews with faculty and students, one theme appeared repeatedly. Faculty members and students alike had a desire for more upper division offerings coupled with higher enrollments in those upper division classes. All seemed aware that the frequency of classes such as Linear Algebra, Abstract Algebra, and particularly Analysis was limited by the fact that enrollments in those courses are sometimes quite low. In fact, Analysis is not taught as a regular course, but only as a Directed Study course. Many of the recommendations I bring forth, below, are directed

toward the goal of increasing the cohort of students taking upper division math courses. This group includes, but should not be limited to, math majors. Actions by the Math Department have already been made to encourage the number of math majors at ULV. (The NSF-CSEMS grant to "fund scholarships for students in mathematics and computer science" [p. 90 of the self-study] is an excellent example.) Yet the number of math majors and other students in upper division courses remains not up to the potential. The recommendations here center around the idea of creating and supporting a "critical mass" of mathematics students at ULV. Math majors at ULV are drawn from a student population around 1600-1800. Yet enrollments in courses above the level of Calculus III are small. This is a drag on the morale of the department.

First, I would suggest that the department try to design more classes that would address the interests of biology, education, and business students. The departments in question might not feel that they need such courses, but a dynamical systems course with significant biology applications might attract enough biology students to the math department to help that course and perhaps other courses run. Every biology major would have a much stronger transcript with a math minor attached to it. Biology students need to be told this by the math faculty. The CUPM report [p. 33] says, "…many recent developments in partner disciplines are based on mathematics that is not presently included in the required courses. For example, the report of the *National Research Council, BIO 2010: Transforming Undergraduate Education for Future Research Biologists*, notes that most biology majors study calculus, and some may take a statistics course. However, the report goes on to say that these students would benefit greatly from also studying 'discrete mathematics, linear algebra, probability, and modeling.' The report notes, 'While calculus remains an important topic for future biologists, the committee does not believe biology students should study calculus to the exclusion of other types of mathematics.'"

A similar sentiment might be said for economics students (who should all be encouraged to take linear algebra). Business students might be attracted to a financial math course and directed toward careers in actuarial math.

Second, I would encourage the department to take a serious look at the idea of offering at least one genuine upper division math course that does not require a calculus prerequisite. There is a great deal of interesting mathematics that can be done without the knowledge of calculus. If the only reason for requiring calculus is for the "mathematical maturity" of the student, then the department needs to rethink its position. Incoming students at ULV are not flocking to the math program. But, like in many departments, many students spend quite a few semesters taking math courses without ever getting a taste of upper division math. Give those students a chance to try out some real math before they move on to other disciplines.

Again, from the CUPM report [pp. 37-8]: "Mathematical topics and courses should be offered with as few prerequisites as feasible so that they are accessible to students majoring in other disciplines or who have not yet chosen majors. This may require modifying existing courses or creating new ones. In particular,
• Some courses in statistics and discrete mathematics should be offered without a calculus prerequisite; …
• Prerequisites other than calculus should be considered for intermediate and advanced non-calculus-based mathematics courses."

Third, the department should think about redesigning those calculus courses so that the applications (in, say, Calc II) are not entirely (or nearly so) physics applications. There may be some excellent, more recent, applications in other fields. This is difficult, of course, since most calculus textbooks do offer of view of calculus through the eyes of the physics of the 20th century.

Lastly, the department should work directly with Admissions, if at all possible, to try to recruit more potential math students (not necessarily majors) to ULV.

Conclusion

It has been a great pleasure to meet and talk with the dedicated professors, enthusiastic students, and supportive administrators at the University of LaVerne. The recommendations for departmental action made in the self-study are all excellent. The department has done an excellent job in its self-evaluation. It is important, as always, that a department never be entirely satisfied with what it is doing, but always looking for ways of improving how it serves its students. In my view, the university has a mathematics department of which it should be proud, and which, with continued support, can serve more students with wider interests to the benefit and satisfaction of all.