University of Washington Department of Mathematics
Ten Year Review, November 2004

Submitted by

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Executive summary

The Department of Mathematics has made dramatic progress since the last review. Reform of the calculus courses, which account for the bulk of the student credit hours delivered by Mathematics and are perhaps the most important interface of the Department with the university community at large, has been a big success. Failure rates are down, while student satisfaction with courses, retention rates, and enrollments are up. The number of students majoring in mathematics has more than doubled in the past ten years. The graduate program has grown in both size and quality, and students are finishing the doctoral program at increased rates. The Department has made excellent faculty hires despite the stringent financial constraints under which it operates. Its K-12 outreach activities are truly exemplary. Faculty morale is good, and faculty members are proud of these departmental successes. The Chair, leadership team, faculty, and staff deserve a lot of credit for these achievements.

All the indicators are pointing in the right direction. Consolidating and expanding on the gains and moving up in the rankings will require continuing efforts by the Department as well as (moderate) investments by the University. Concrete suggestions are summarized below and laid out in detail in the body of the report. *These suggestions, some of which emerged in discussions with Department members, should not detract from the overall very favorable impression gained in the review.*

Principal recommendations to the Department

Lower division teaching and undergraduate program

- Take steps to increase the sense of community and connection with the Department among majors, especially those in the standard BA and BS programs, and those who have not gone through honors calculus.
- Improve advising and information flow to undergraduates: Provide sample four year course schedules; find an effective way to publicize summer research opportunities; consider assigning faculty advisors to undergraduates.
- Review course scheduling and distribution of topics courses over the year. Implement senior capstone courses, at least for honors students, with a group paper or group presentation. Advise students to obtain a background in computing.
- Require student evaluations for every course and strive to make course content reasonably uniform from instructor to instructor.
- Collect exit surveys of graduating students and track where these students go after graduation.

Graduate program

- Consider creating one or more 5-year programs leading to a professional Masters degree. Such programs should be offered jointly by the Applied Mathematics, Mathematics, and Statistics and should build on the Applied and Computational Mathematical Sciences (ACMS) major.

Research

- Continue the commendable emphasis on collaboration with researchers in other fields.
- Build on the existing connections to Microsoft Research.

K-12 outreach

- Encourage efforts of faculty members to become engaged in outreach, and make sure that such efforts are properly rewarded.

Principal recommendations to the University

- Make permanent the temporary investments in the calculus reform program.
- Enlarge the space for the Mathematics Study Center so that it can support all the large, multi-section freshman-sophomore mathematics courses.
- In order to increase communication and create a sense of community among Mathematics and ACMS majors, provide a room where these students can congregate informally, hopefully near the Mathematics student services / counseling office.
- Assist the Department in its efforts to offer competitive stipends for graduate student recruiting.
- Provide a modest increase in faculty staffing sufficient to cover the increased demand for mathematics courses. This might be done, at least initially, by increasing the number of Acting Assistant Professors in the Department.
- Allow the Department to make at least some new faculty appointments at the Associate Professor level.
- Collaborate with the Department in maintaining its exceptional K-12 outreach program.

Introduction

Our review of the Mathematics programs extended over a period of roughly eight months, starting with the charge meeting on March 31, 2004, and culminating in the site visit on November 8-9, 2004. (The site visit was originally scheduled for May 6-7 but had to be postponed due to the sudden illness of a review committee member.) We carefully examined the Self Study document prepared by the Department. The UW internal committee members conducted about 20 meetings with the Department leadership, faculty, staff, graduate students, and undergraduates (individually or in groups.) They briefed the external committee members on the results of these conversations prior to the site visit. The site visit itself involved meetings with members of the Mathematics Department as well as representatives of other departments interacting with Mathematics.

From this broad base of information emerged a coherent picture of the Department that is presented in this report, which is endorsed by all review committee members. The report is structured into sections discussing lower division teaching, the undergraduate program, the graduate program, research, governance, K-12 outreach, and relations to other departments. Each section contains a set of recommendations; these recommendations are also gathered in the Executive Summary of the report.

Lower Division Teaching

The area of greatest change in the Department over the past decade is in the faculty's attitude toward undergraduate teaching, particularly in the lower division pre-calculus and calculus courses. The reform efforts of the Department have been a big success.

The introductory program has two major strands. The largest is the traditional pre-calculus/calculus sequence aimed at science and engineering students (120, 124/5/6) and the other is a two-quarter sequence, 111/112, which is pre-calculus/calculus for business majors. Accounting for the bulk of the student credit hours taught each year, these courses are perhaps the most important interface of the Department with the university community at large. Because mathematics is a gateway discipline for all science, engineering, and many other areas, it is crucial that the Mathematics Department be successful in offering high quality introductory courses that meet student needs.

Over the past decade, the Department has achieved great improvement in its delivery of these courses, to the satisfaction of both students and faculty. A first major step was the creation of the Mathematics Study Center in the early 1990's. Popular and heavily used by students, it provides a strong support platform for students in introductory courses. Its mode of operation is to group students from the same course together at tables where peer learning, assisted by undergraduate, graduate student, and faculty tutors, takes place. The Center is heavily subscribed and starved for space, so much so that the Department has to restrict the number of courses it serves. It seems clear that a small investment of resources in additional space and tutoring support would allow the Department to extend its vital support services to many more UW students.

The introductory sequence for business students, Math 111/112, was given high marks for being designed to meet student needs. Ongoing consultation with representatives of the Business

School ensures the curriculum remains up-to-date. Except for an oversight role, tenured faculty members seem to be relatively uninvolved with this course, which is coordinated by a long-term lecturer. Reduction of class size from 600 to 180 also has contributed to improved student satisfaction.

Most recently, the Department made major changes in its mode of delivery of the courses 120 and 124/5/6. The Department seems solidly behind this calculus reform effort which has led to improved student performance and satisfaction as well as an improved attitude of the faculty toward teaching the courses. There is an impression that students from the reformed courses are better prepared with fewer who have major gaps in their mathematical knowledge. Two common quantitative measures, failure rate and end-of-term student evaluations, show marked improvement. For example, the failure rate in pre-calculus, Math 120, was reduced by 40% and the number of students continuing to Math 124 and overall enrollments in that course increased. Representatives of other departments we met with reported that the introductory courses are appropriate for their students, and they were pleased with the improved communication with the Department. There has also been a truly remarkable increase in the number of students electing mathematics majors of some type. It is hard to connect these events directly, but it seems reasonable that higher student satisfaction with the calculus courses and positive faculty attitudes at least partially account for this increase.

The Department's self-study and the on-line report on calculus reform
(http:www.math.washington.edu/~m124/Reports/report_summer03_finalversion.html)
document the steps that led to the improvements. It is significant that many senior faculty members were involved with the efforts to improve the curriculum and pedagogy. The University invested in the reform by providing resources that helped reduce class size in both lectures and recitation sections of the courses. Departmental commitment to the reform effort was emphatically demonstrated by the fact that they voted an increase in their teaching load of about 10% to help provide the class size reductions. Important parts of the reform effort, many still ongoing, include:

- Survey of client disciplines, to be aware of their students' needs.
- Review of successful programs at other universities.
- Changes in the curriculum, to focus on the problem-solving and basic skills needed for student success in other disciplines. Use of a single textbook for several courses.
- Improved coordination between faculty teachers of the courses.
- Reduction in class size with increased opportunity for students to have active learning experiences.
- Building continuity for training and leadership by hiring Lecturers on longer term appointments.
- Collaboration with CIDR (Center for Instructional Development and Research) to improve training and provide formative assessment for TA's in the courses, as well as summative assessment of student performance and satisfaction.

As a part of the reform agreement with the College, the Department has established assessment metrics to evaluate its progress. The review committee endorses their plan to continue working with these tools and with CIDR to continually improve their courses.

Curriculum development has not been restricted to the freshman level. Perhaps work at this level has contributed to interest in curricular questions at the sophomore and higher levels. A new course, Math 310, introduced as a bridge course from calculus to more advanced level

mathematics also seems to be quite successful with a large increase in demand. No doubt, this addition to the curriculum is very much related with the large increase in the number of mathematics and math related majors.

We also recognize the excellent work being done with honors students in the small but highly successful honors sequence 134/5/6.

The Department should be congratulated on its success in improving the educational opportunities for freshman-sophomore mathematics students and encouraged to continue its efforts.

Recommendations to the Department

- Improve access to 310 for non majors.
- Make sure that the contributions of faculty who have played key roles in successful reforms are suitably rewarded in promotion and merit programs.

Recommendations to the University

- Make permanent the temporary investments in calculus reform.
- Expand the space for the Math Study Center so that it can support all large, multi-section freshman and sophomore mathematics courses.
- Reduce the teaching load of faculty who are active in research to its pre-reform level, in order to avoid damaging the Department's competitive position in the academic marketplace.

Undergraduate Program

The Department offers BA and BS degrees in mathematics, each with several options:

- *Bachelor of Science in Mathematics - Comprehensive Option.* For students who plan to do graduate study in mathematics or who just want a solid background in mathematics.
- *Bachelor of Science in Mathematics.* For students who want a general background in mathematics. Allows students the freedom to shape their program.
- *Bachelor of Arts in Mathematics - Standard Option.* Intended for students who are interested in a non-science degree in mathematics. Requirements for the degree are more liberal than those of the other options.
- *Bachelor of Arts in Mathematics - Philosophy Option.* Includes courses in both mathematics and philosophy. Promotes competence in abstract thinking, logical rigor, analysis, expository clarity, and critical writing.
- *Bachelor of Arts in Mathematics - Teacher Preparation.* Prepares students for teaching careers in secondary or middle schools. The majority of majors go on to obtain a Master's in Teaching.

There is also a minor in mathematics.

In addition, Mathematics is one of four departments (with Applied Mathematics, Computer Science and Engineering, and Statistics) jointly offering the seven year old interdisciplinary Applied and Computational Mathematical Sciences (ACMS) degree.

Many Mathematics and ACMS students are double majors. This seems healthy, although the committee questioned whether it made sense to allow students to double major in Mathematics and in ACMS, as a few do.

The most striking development in the Mathematics undergraduate program is the large increase in the number of majors, from 199 in 1994 to 300 in 2004. During the same period the ACMS program was started, which currently has 180 majors. Therefore the total number of Mathematics and ACMS majors increased in the ten year period from 199 to 480. The increase is particularly striking in light of the rigor of the course work and grading schemes. Possible factors accounting for this growth in the number of majors include the calculus reform, recruiting efforts by the Department, the ACMS major, the new honors calculus track, a nationwide trend, improved high school mathematics teaching, the increase in the undergraduate population, and the change in UW admission standards.

There are no hard data by which to assess the satisfaction of Mathematics undergraduates during their time at the University of Washington and their opinion about the program later in their professional careers. The internal committee members, as well as the review committee as a whole, met with groups of about 20 Mathematics and ACMS majors. Both groups were heavily skewed towards the cream of the crop; most of the students had taken honors calculus. They were enthusiastic and articulate about the beauty and power of mathematics, and their delight at having the opportunity to be exposed to advanced topics and research. When we asked them why they had chosen their major, most replied that they had liked mathematics from an early age.

Based on these (admittedly non-random) samples, it is the impression of the committee that at least the top undergraduates are both very impressive and well taken care of by the Department. Most of them liked the mathematics classes they had taken, and they said they felt highly involved in the Department. Those who had gone through the honors calculus program also mentioned that the smaller class size had allowed them to get to know a faculty member and develop a sense of community. Some described the influence of a mathematics research experience, or mentoring by a faculty member. There was a consensus that Jim Morrow is an important contributor to the great experience of many top students. He runs a popular Research Experiences for Undergraduates (REU) program, and he coaches student teams competing in the international Mathematical Contest on Modeling. Over the past four years, 11 three-person teams have participated in the contest; four teams have been Outstanding Winners and four have been Meritorious Winners. This success was recognized by a Seattle Times editorial in 2003 and by stories in the Seattle PI and Tacoma News Tribune in 2004.

We met only a tiny fraction of the many students who do not take honors calculus or are in the standard BS or one of the BA programs. The fact that so few of them chose to talk to us suggests that there may be many majors with little connection to the Department or sense of community. The few that we did meet expressed a need for help with forming study groups, more contact with faculty, and easier access to advice about course selection and career options. Currently all official advising is provided by two staff members. However, the top students felt they got more relevant advice about curriculum planning and career options from faculty members, while some of the others did not know how to get access to faculty advice. Several of them suggested that sample four year course schedules for their major option would be helpful. Not all the students felt well informed about research opportunities such as the REU program, REU programs at other

schools, graduate school options, career options, or seminars, nor did they know where to get such information.

Most of the students felt that undergraduate teaching was good, however a few had had bad experiences with some of their courses. The teaching problem appeared to be confined to a single faculty member. The chief complaint was about a syllabus which appeared wildly different from other sections of the course.

Both faculty and students report high satisfaction with math 310, a new course on mathematical reasoning, as a way of easing the transition from lower division towards more rigorous courses. The course is so popular that enrollment has had to be limited to majors.

The ACMS program

The ACMS degree is jointly offered by Applied Mathematics, Computer Science and Engineering, Mathematics, and Statistics. It has many different pathways or specializations: Biology and Life Sciences, Discrete Mathematics and Algorithms, Engineering and Physical Sciences, Mathematical Economics, Operations Research, Scientific Computing and Numerical Algorithms, Social and Behavioral Sciences, and Statistics. Initially a majority of the students chose the Discrete Mathematics and Algorithms option, because it has the largest computer science component, but recently the balance among the different options has been improving. Economics has become another popular option.

The inter-departmental cooperation manifested in the ACMS program has been an important contributing factor in the renewal of the VIGRE grant which, among other things, provides funding for undergraduate research and seminar series.

The ACMS program currently is struggling with the fact that it has no budget and can obtain resources only on an ad hoc basis. It has so far been unable to recruit a new director, and the web site needs a lot of work.

Recommendations to the Department

- Try and increase the sense of community and connection with the Mathematics Department for majors, especially those in the standard BA and BS programs, and those who have not gone through honors calculus. Some specific suggestions:
    - Encourage faculty to set up web-based chat groups for their courses, facilitating formation of study groups.
    - Create a photo wall and/or web site with pictures of math majors, which would help students become acquainted and help faculty memorize the students' names. Students could be asked their permission to have their photos posted when they sign up for a major.
    - Organize informal get-togethers of undergraduate majors, including a meeting to discuss graduate school and career options, and perhaps a departmental barbecue. Food should be provided to ensure participation.
    - Recruit a faculty member to advise majors on setting up a student society or math club. For instance, the club could meet weekly for a partially subsidized pizza lunch, on the same day as the colloquium, and the colloquium speaker could be invited to give an accessible introduction to the subject of the colloquium to the math club.

- Take exit surveys of graduating students and track where these students go after graduation, in order to find out how the education of majors can be improved,
- Consider implementing senior Capstone courses, at least for honors students, with a group paper or group presentation.
- Consider assigning faculty advisors to undergraduates.
- Review the number of credits for senior electives. Some students report doing 20 hours of work or more for 3 credit courses.
- Make course scheduling more convenient. The current concentration of courses on MWF 9:30-1:30 makes scheduling difficult for double majors. Also, more of the topics courses should be offered in Spring quarter.
- Provide sample four year course schedules for the various degree options.
- Offer a seminar on Math communications, including LaTeX.
- Advise students to obtain a background in computing.
- Find an effective way to publicize summer research opportunities, such as REU programs at UW and at other universities.
- Require student evaluations of every course and strive to make course content reasonably uniform from instructor to instructor.

Recommendations to the University Administration

- Provide some permanent resources to the ACMS program, funding release time for the director, maintenance of the web site, and the seminar series.
- Provide space for a student society or math club.
- Designate some suitable classrooms for the use of the Mathematics Department on a permanent basis, in exchange for a commitment by the Department to improve the flexibility of its class scheduling in order to make sure these classrooms are optimally used.

Graduate Program

The graduate program has seen a significant improvement in size and quality over the past five years. The most notable improvement is in student quality, with almost all students who accept admission to the Ph.D. program now coming from those ranked highest among the applicants. The success rate for graduate students, measured in terms of Ph.D.'s awarded compared to the number of students admitted to the Ph.D. program, is rapidly moving up from its previous, undesirably low level. The Department is now looking to graduate with a Ph.D. well above half and possibly up to 75% of those admitted to the program, a quite good level. We also note that the percentage of graduate students who are US citizens or permanent residents, approximately 75%, is well above the national average at US research universities, both public and private. The percentage of women graduate students, approximately 1/3, is good and slightly above the percentage at peer universities.

It is hard to identify the reasons for improvement in recruiting talented graduate students, particularly the impact of external forces such as the demand for technically skilled workers in the economy. However, some specific actions taken by the department in response to a decline in the quality of its graduate students have pretty clearly had a positive influence. First, the Department has very significantly ramped up its recruiting efforts, with many prospective

students now being invited to visit. Second, support from the VIGRE program, the ARCS program, and Microsoft Corporation has made it possible to provide fellowships that increase the stipend for outstanding applicants from the noncompetitive level of UW TA salaries to a level comparable with competitor departments.

There have been many other changes, connected or correlated with the Department's top-rated VIGRE program (jointly with Applied Mathematics and Statistics), that we believe have had a positive influence on the atmosphere for graduate students. The weekly seminar in which faculty members "advertise" their research gives students a better and earlier exposure to possible research problems. Graduate student mentoring has improved. The annual conversations with the graduate program coordinator for each graduate student who is not yet working on a thesis was mentioned by students very positively. An excellent "Handbook for Instructors and Advisors of First-Year Graduate Students" clearly explains the responsibilities of both students and faculty. Recent changes to the preliminary exam system that allow students more flexibility to choose specializations outside the core areas of analysis, algebra, and topology were welcomed by both students and many faculty members.

There was a high degree of collegiality and satisfaction with the department among graduate students. We heard only minor complaints. One concerned the lack of access to high-end computational equipment. A second complaint was that no faculty proctors are available during the written preliminary examinations. When there is a question regarding a possible mistake on the exam, students may spend an hour or more trying to get an answer. This seems unnecessary and easy to remedy. Third, we perceived a disconnect between graduate teaching assistants and course coordinators on the value of the weekly meetings intended to help TAs make effective use of the worksheet component of the courses. Such weekly meetings should be a valuable part of the team effort involved in teaching these large classes, especially since TAs do not normally attend the class lectures. We suggest, as part of the ongoing assessment for the freshman program, graduate student input be solicited on making effective use of the meetings.

We also suggest the Department investigate whether the preliminary exams should be given more than once per year. Doing so would certainly be popular with the graduate students. It would likely be unpopular with faculty members who have the responsibility for the major task of preparing and grading the exams. However, there are positive effects that we feel the faculty might consider. More opportunities to take the exam might provide faster entrance to research, allowing for an extra summer devoted to research instead of exam preparation. It might provide more flexibility for those students who, for whatever reason, leave with a Masters degree instead of a Ph.D. The masters program is designed to be completed in two years. If a student is to leave with a Masters degree, is it reasonable for him to know this in time to make a good choice of courses that will help him in his career after leaving UW? Is it the case that some students do not find out they have failed the preliminary exam until the very beginning of their third year? Is it a hardship for those students? Is the purpose of the exam to show proficiency in specific subjects or is it to demonstrate the ability to successfully complete a Ph.D. in the Department? Of course, UW faculty know their students better than our committee, but thinking about such questions may help the department decide if their recent changes are in the right direction and if more should be made.

Given the success of the ACMS program, the Department should consider creating a professional Masters degree to be offered jointly with Applied Mathematics and Statistics. This could be either a stand-alone degree or a combined 5-year degree with the ACMS degree program as a front end. For example the ACMS degree program might be an excellent feeder for a planned Masters program in Financial Engineering. Similar opportunities may exist for Masters programs

specialized in Statistics or Operations research. The skilled graduates of such programs should be in high demand in the greater Seattle area. Whether or not this is possible depends on collaboration between the ACMS departments.

We sincerely hope that the improvements made in the graduate program be continued.

Recommendation to the Department

- Provide faculty proctors during qualifying exams.
- Solicit student input on making better use of meetings between TAs and instructors
- Consider offering qualifying exams more than once per year.
- Look into the possibility of offering a professional Masters degree building on the ACMS program.

Recommendations to the University

- Help the Department in stabilizing stipends and fellowships support for graduate students at a level competitive with peer departments. The current situation, where the department is totally dependent on fragile funding from VIGRE, ARCS, and Microsoft, is unstable, and the consequences will be disastrous if it collapses.

Research

The Mathematics Department is an outstanding research department. Honors accumulated by the faculty in recent years include: Sloan Fellowships (Kovacs, Toro, Yuan), a Guggenheim Fellowship (Uhlmann), a Fullbright Award (Solomyak), an NSF Career Award (Kovacs), invitations to speak at a meeting of the American Mathematical Society (Zhang) and at the International Congress of Mathematics (H. Smith, Uhlmann), election to the European Academy of Sciences (Bube), the Chilean Academy of Sciences (Uhlmann), and as a Fellow of the Institute of Mathematical Statistics (Burdzy).

A majority of the faculty members are supported by grants from federal agencies. Given the overall funding picture for mathematics and the Department's attention to teaching and K-12 outreach, this is a very good record.

The visiting committee was impressed faculty's extensive contacts and collaborations with other units in the University, such as the Applied Physics Laboratory, Biochemistry, Finance, Geosciences, Industrial Engineering, Physics (via string theory), and the Medical School.

The Department has shown good judgment in setting priorities for hiring. The strategy of hiring into research groups and of maintaining competitive assistant professor salaries has worked well. Its younger faculty is especially strong: Recent hires are excellent, and the record of hiring women is outstanding.

At present, the Mathematics Department is ranked in the middle of its natural cohort, which consists of Group I public universities. Given the upward trends reported here, such as the quality of its recent hires, its successes in attracting majors and graduate students, and its congenial atmosphere, the Department is well positioned to improve its standing in the years

ahead. However, departments that are ranked above this one hire regularly at both the associate professor and the assistant professor levels, and they make occasional appointments at the full professor level. This gives them an advantage which will be difficult for the Department to overcome, especially when taken in conjunction with the Department's compressed salary scale.

Recommendations to the department:

- Continue the commendable emphasis on research outreach.
- Build on the existing connection to Microsoft research group.

Recommendation to the University Administration:

- When outstanding opportunities arise, allow hiring at the associate professor level.
- Provide for a modest increase in the staffing of the department, for instance by funding a few post-doctoral (Acting Assistant Professor) positions.
- The Department absorbed a 10% increase in its teaching load in order to staff its calculus reform, and did a commendable job. At the same time the number of majors doubled, the ACMS program had a large increase, and the graduate program has thrived. Further improvement will be difficult without some help from the administration.

Departmental culture and governance

The department has a two-tiered governance structure. Its committees are staffed by appointment. Appointments are made by the Chair, in consultation with department members. There are monthly meetings of the entire department, which votes on recommendations brought forward by the committees.

This system of governance is working well; the department reached agreement on controversial changes such as calculus reform and graduate students' preliminary examinations. Decisions are generally based on consensus. The department appears harmonious. We do not recommend fundamental changes in the governance.

The visiting committee did notice a difference in perception of mentoring between the junior faculty and the Executive Committee.

Recommendations to the Department

- Consider appointing a junior faculty member to the Executive Committee.
- Assign a faculty mentor to each new hire.
- Make expectations of junior faculty clear and unambiguous.

K-12 Outreach

The K-12 outreach activities by the Department are truly exemplary. They include a Mathematical Sciences Partnership, the GK-12 program that involves local public schools, various summer programs for teachers such as the Northwest Mathematics Interaction, the SIMUW program for high school students, and the very successful Math Day program that brings many, many students to campus. The committee knows of no other Mathematics Department at a research university that has so much involvement with the local K-12 teacher and school community. The University certainly receives much good will and has a positive impact on the larger community with these programs.

That is the good news. The bad news is that many of these programs are quite fragile, depending on the personal contacts and excellent work of a handful of faculty members, such as Ginger Warfield and Jim Morrow. Several of these faculty members are within a few years of retirement. If these outreach activities are to continue, expertise and contacts need to be transferred to younger faculty members. Success in outreach depends at least in part on having personal connections with, and understanding the problems facing K-12 teachers. There is much more involved than simply teaching good courses for prospective teachers.

We recommend that the Department encourage efforts of interested faculty to be engaged in outreach efforts. In particular, outstanding work in this area should receive recognition by both the Department and the University administration in promotion and merit considerations. It was not clear to our committee that this has been the case. It has been said that one difference between public and private research universities is that public research universities cannot fail to be involved with the great issues facing our society. The need for improvement in K-12 mathematics instruction and student performance is certainly one of our society's greatest educational issues, one the UW Mathematics Department is and should be involved with. It is unlikely that research mathematicians can take the lead in such efforts, but they can work together with teachers and supply resources that are unavailable outside the university. Programs like GK-12, Math Day, and the Summer Institute for Mathematics are ones the Department can be proud of.

At some point, the Department may be called upon to commit some of its own resources to maintain or develop new outreach efforts. These are a genuine extension of its mission beyond the University walls. The committee recommends, perhaps unnecessarily, to the University administration that it recognize the value this work adds to University's role in the State of Washington and support the Department in such efforts. We recommend to the Department that it be willing to make such a commitment in pursuit of this objective.

Recommendation to the Department and the University

- Encourage efforts of faculty members to become engaged in outreach, and make sure that such efforts are properly rewarded.

Relations with other Departments

Faculty members in the Mathematics Department collaborate with researchers in a wide range of areas, such as Applied Mathematics, Biochemistry, Computer Science, Finance, Geological Sciences, Industrial Engineering, Medicine, Physics, and Statistics, some of which are far removed from traditional pure mathematics.

The recent collaboration between the Mathematics and Physics Departments in assembling a group of young and promising researchers in string theory is an excellent example for bridge building that benefits the departments involved as well as the university as a whole. Mathematics should continue to seek out and take advantage of similar opportunities for connections with other departments.

Naturally, Mathematics' closest relationships have been with Applied Mathematics and Statistics. The three mathematical sciences departments have jointly been recipients of two consecutive VIGRE grants. Together with Computer Science and Engineering they are responsible for the ACMS undergraduate program. Mathematics and Statistics share in the teaching of undergraduate and graduate probability sequences.

The sometimes strained relationship between Mathematics and Applied Mathematics has improved significantly and become quite congenial over the last decade. Factors contributing to this positive development are the creation of the ACMS program, during which undergraduate course offerings were revised to be complementary rather than competing, and the highly successful joint work on the VIGRE proposals.

The review committee was specifically asked to consider the possibility of merging the Mathematics and Applied Mathematics departments. There is no clear and obvious demarcation line between pure and applied mathematics; there certainly are faculty members in Mathematics who could just as well be in Applied Mathematics, and vice versa. Starting from a clean slate one would probably not introduce a somewhat artificial division. Other possible motivations for a merger are potential financial savings, and improvement in the external perception of Mathematics at the University of Washington. However, a merger would also pose significant challenges.

First, there is the space issue. Providing space with which both departments are happy seems like an obvious pre-condition for a successful merger. With the upcoming renovation of their current office space in Guggenheim Hall, Applied Mathematics was given the option of moving to offices scattered through Padelford Hall. Understandably, they instead opted for an eventual return to Guggenheim.

Second, there are great differences in values and culture. For example, the Mathematics Department has a tradition of using detailed numerical formulas both in making its teaching assignments and as part of its process for annual merit evaluation. This approach requires agreement on the formulas and on the basis for assigning the weights assigned to different activities. It does not appear that faculty in Applied Mathematics would be comfortable with the use of such formulas or would be happy with the current weights. (As an example of a difference, the Mathematics Department has only recently begun to give small teaching credit for supervision

of graduate students, something that Applied Mathematics with its proportionally much larger graduate program has given greater weight for some time.)

A second example for cultural differences is the way in which research contributions are evaluated. Within the Mathematics Department, faculty members read and judge the quality of each others' theorems. While this approach can work well in evaluating pure mathematics where theorems are the primary "product", it is not necessarily well-suited for evaluating the quality of work in applied mathematics with its greater emphasis on methodology and algorithms. There already appears to be some uncertainty among Mathematics faculty members about how best to evaluate applied work by their colleagues; this is an issue that may need addressing even without a merger.

Because of the cultural differences discussed above, and concerns about diminished influence within a much larger department, the majority of faculty within Applied Mathematics is opposed to a merger. There is no particular desire for such a merger on the part of the faculty in Mathematics.

The only model under which a merger of the two departments might make sense would be the "MIT model" in which the pure and applied parts of the Department have a large degree of independence in appointments, promotions, teaching assignments, and graduate admissions.

At this time the upheaval of negotiating such a merger would be a distraction and seems to outweigh the potential benefits. We therefore recommend against a merger at this time. Some of the benefits, such as a more unified external perception of the mathematical sciences at the University of Washington, can be achieved without official merger.

Recommendations

- Mathematics should continue to work at strengthening its relationships with other departments.
- A push by the administration to achieve a hasty merger of the Mathematics and Applied Mathematics Departments would not be wise.

Organization of the Review

The committee received its charge on March 31, 2004; see Appendix A for a copy of the charge letter. Between March 31 and May 6 (the originally scheduled date for the site visit) the UW internal members of the committee (Paul Beame, Ann Nelson, and Werner Stuetzle) met, individually or as a group, with Mathematics Chair Selim Tuncel, the leadership team, and numerous faculty, staff, and students; see Appendix B for a list of names. The information gathered in these conversations was communicated to the external committee members (Michael Artin, Alan Taylor) prior to the site visit. The site visit took place on November 8-9, 2004; see Appendix C for the agenda.

The members of the review committee join in thanking the many participants in the review process for their contributions. It was a pleasure to review such a sound program, focusing on ways to further improve its quality.

Appendix A: Charge letter

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April 2, 2004

Department of Mathematics Review Committee
Werner Stuetzle, Professor, Statistics (committee chair)
Ann Nelson, Professor, Physics
Paul Beame, Professor, Computer Science & Engineering
Michael Artin, Professor, Department of Mathematics, Massachusetts Institute of Technology
Alan Taylor, Professor, Department of Mathematics, University of Michigan

RE: Department of Mathematics 10-Year Review

Dear Review Committee:
The purpose of this letter is to outline the Graduate School's charge to the Department of Mathematics Review Committee. The specific action needed at the end of your review is a recommendation regarding the continuation of the Department's BA, BS, MA, MS, and PhD degree programs. The range of possible recommendations runs from suspension of entry to continuation with a subsequent review in ten years. Shorter terms can be recommended if deemed appropriate. Perhaps more important than the specific recommendation of status and review period, your review has the potential to offer the Department and the administration an independent assessment of the health of the Department and its programs and advice as to how they might be improved.

The review is most likely to be successful if tasks are divided among the committee members effectively. It is suggested that the external reviewers be relied upon to serve as content experts with regard to degree programs. They also are likely to be the most able to comment on developments in the field that should be addressed. The internal reviewers are strongly encouraged to conduct some assessments and interviews prior to the day of the actual site visit. Indeed, it is impossible to conduct a review of the depth and rigor desired without doing considerable work before the site visit. It may not always be desirable or appropriate to function as a committee of the whole, for example in interviewing members of the Department. Also, the review is most likely to be successful if you engage in regular communication with the Department so that they know your interests and expectations, particularly for the site visit.

The site visit will culminate with an exit interview divided into two portions, the first with the Chair and perhaps other program representatives present, and the second without these program representatives. The College Deans will be present at both sessions, as will the Deans and Associate Deans of the Graduate School and the Office of Undergraduate Education. The

Provost will attend the first session. Please let us know what your formal recommendation regarding continuance is likely to be early in the second period of the exit interview. We hope to have your written report within 6 weeks of the site visit and to have the UW members of the committee attend a meeting of the Graduate School Council to present your findings and comment on the Department's response. David Canfield-Budde will provide you with a model report if you would like. Please call upon him for any assistance you may need in the course of this review.

The most important objective of your review is an assessment of the academic and educational quality of the Department and its programs. The important questions are: Are they doing what they should be doing? Are they doing it well? How can they do things better? How should the University aid them? Each question can be asked in each sphere of operation. The test to apply in deciding how to prioritize issues is to consider how important each is to scholarship or education. Listed below are several issues that may help you as you begin. This list is not intended to restrict your review; you should consider all issues that you deem to be sufficiently important and eliminate those of lesser importance in order to focus your energies.

The following questions emerged from an initial review of the School's self-study and discussion in the Charge Meeting. They are intended to serve as a starting point, although other questions surely will surface in the course of the review.

<u>General</u>

1. What is the quality of the Department's faculty, programs, and students? How does the Department compare to other institutions nationally?
2. Mathematics is an essential tool for research and education across the University and within the broader community. For the Department of Mathematics, it is also a focused area of research. How does the Department balance its narrow academic goals with its broader mission of service to the University and community?
    - The Department's non-major courses provide a valuable service to students in many disciplines. How are these service courses viewed by faculty and supported by the Department? How does the Department distribute teaching responsibilities for these courses?
    - Do faculty actively participate in collaborative, cross-campus work? Are such relationships structured through joint and adjunct appointments?
    - Are there future collaborations with other units, for example Medicine, Biology, or Computer Sciences, that ought to be developed by the Department of Mathematics?
    - The Applied and Computational Mathematical Sciences (ACMS) undergraduate major and the Center for Quantitative Science (CQS) provide opportunities for the Department to work in concert with other units. Has interdepartmental interaction through ACMS and CQS been successful?
3. What is the Department's intellectual and practical relationship to the Department of Applied Mathematics? Is the existing division between these two departments something that should be maintained?
4. The self-study says little about governance within the Department. Is the current structure and practice of governance appropriate and effective?
5. What is the role of teacher education, especially K-12, in the department? How does the Department integrate faculty, graduate students, and undergraduate students in its K-12 programs into the wider department?

6. The length of term for Department Chair, as well as the appointment process, have changed since the last review. What is your assessment of the effectiveness of the current model?
7. The Department currently focuses on gender as its measure of diversity. Looking towards the future, how can the Department support a broader approach to diversity? What tools might be effective in creating a more racially and ethnically diverse community of mathematicians at the University?
8. The Department has received regular non-permanent resources for its programs. How can the Department and University measure and project future demand for mathematics courses and majors? In this light, which temporary investments ought to be made permanent?

Strategic Vision and Plan

1. What is the intellectual trajectory of mathematics as a discipline? How does the vision of the Department compare to the direction of the field? How does the University Of Washington's department compare to the intellectual trajectory of the best mathematics programs nationally?
2. What structures are in place for the Department to be strategic and future oriented? How does the structure of governance and participation affect faculty engagement in shaping the future?
3. The self-study describes thirteen areas of research in the Department. Does this intellectual breadth strengthen the unit, or would a more narrowly focused department be better? If so, what areas might be the center of a more narrowly focused department?

Faculty

1. How do faculty members share responsibilities in teaching, advising, and mentoring?
2. How does the Department allocate resources, including promotion and tenure, among faculty?

Undergraduate

1. How have the recent changes in the undergraduate program, especially the calculus reform, affected students?
2. Students repeat some courses, such as calculus, at a high rate. What are the reasons for this? Should this be viewed as a problem?
3. How well does the current procedure for evaluating and placing incoming students work? Do more effective models exit at other institutions?
4. The demand for undergraduate mathematics courses has increased in recent years. How should the Department and University react to this change, especially regarding the distribution of resources (faculty, staff, facilities)?
5. What role does the Math Study Center play in departmental programs? Is there currently adequate investment in this facility?

Graduate

1. The self-study describes that much has been done since the last review to improve the experience of graduate students in the program.
    - How does the Department currently mentor students? Do students find this effective?
    - Is the "prelim" system now appropriate? Do students receive sufficient support before these exams?
2. What role does faculty play in graduate student admissions?

3. How does the Department facilitate the difficult transition from coursework to research that is necessary for a successful graduate career?

Thank you for your participation identifying these critical issues. I look forward to working with you as the review continues.

Sincerely,

Gail L. Dubrow
Associate Dean for Academic Programs
The Graduate School

Encl: Guidelines for Good Practice in Graduate Education

c: Elizabeth L. Feetham, Acting Dean, Graduate School
David B. Thorud, Acting Provost
Susan E. Jeffords, Vice Provost, Academic Planning
David C. Hodge, Dean, College of Arts and Sciences
Ronald S. Irving, Divisional Dean, Natural Sciences, College of Arts and Sciences
George S. Bridges, Dean and Vice Provost, Undergraduate Education
Selim Tuncel, Professor and Chair, Department of Mathematics
David Canfield-Budde, Assistant to the Dean, Academic Programs

Appendix B: Meetings or conversations with Department members prior to the site visit

Selim Tuncel, Chair

Senior leadership team
Ken Bube, Stephen Mitchell, Paul Smith, John Sylvester, Paul Tseng, Tom Duchamp (Graduate Program Director), Dave Collingwood (Undergraduate Program Director)

Mary Sheetz, Administrator

Advising staff
Julie Martinson, Brooke Miller

Graduate students (group lunch)

Undergraduates (group lunch)

KK Tung, Randy Leveque (Applied Mathematics)

Patrick Perkins (Director, Math Study Center), Dave Collingwood (Undergraduate Program Director; in charge of calculus courses)

Jim King, Ginger Warfield (Teacher preparation; K-12 outreach)

Jim Burke (ACMS Director)

Mina Aganagic (Physics)

Jennifer Chayes (Microsoft Research)

Tom Duchamp, Jack Lee (current and previous Graduate Program Director)

Ken Bube, Gerald Folland, Doug Lind, Jim Morrow, Hart Smith, Tatiana Toro (faculty members)

Leo Tzou (graduate student)

Appendix C: Site visit schedule

UNIVERSITY OF WASHINGTON
The Graduate School
Department of Mathematics Program Review
November 8-9, 2004

Sunday, November 7

6:00 p.m. Review Committee dinner: Ponti Seafood Grill (3014 3rd North)

Monday, November 8

Faculty Club - Music Room

7:45 - 8:30 a.m. Breakfast of external committee members with Selim Tuncel, Chair, Department of Mathematics

Padelford C138

8:45 - 9:30 Selim Tuncel, Department Chair

9:30 - 10:00 Undergraduate service courses and calculus reform:
Dave Collingwood
Patrick Perkins
Ken Bube
Jenni Taggart
Course coordinators of 124/5/6

10:00 - 10:30 Undergraduate Program Coordinators from other Departments:
Oscar Vilches (Physics)
Scott Hauck, Helene Obradovich (Electrical Engineering)
Greg Ellis (Economics)
Pete Dukes (Business School)

10:30 - 11:00 Break

11:00 - 11:45 Undergraduate BA and BS degrees:
Dave Collingwood
Jim Morrow
Ken Bube
James King
Ginger Warfield
Brooke Miller

11:45 - 12:15 Applied and Computational Mathematical Sciences:
Jim Burke
Brooke Miller
Dave Collingwood
Ken Bube
Hong Qian (Applied math)
Steve Tanimoto (Computer Science and Engineering)
Matthew Stephens (Statistics)
Galen Shorack (Statistics)

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Monday, November 8 (continued)

Communications
Bldg. 126

12:15 - 1:00 p.m.	Lunch with undergraduate students
1:00 - 1:30	Break

Padelford C138

1:30 - 2:15	Graduate Program: Tom Duchamp Jack Lee
2:15 - 3:00	Coffee with graduate students
3:00 - 3:30	Break
3:30 - 4:00	K-12 outreach: Ginger Warfield James King Jenni Taggart Jim Morrow
4:00 - 4:45	Assistant Professors and recently promoted Associate Professors
4:45 - 5:30	Department governance
5:30 - 6:00	Facilities tour: Selim Tuncel John Sylvester
7:30	Review Committee dinner: Nell's Restaurant (6804 E Green Lake Way North)

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Tuesday, November 9

Padelford C138

9:00 - 9:30 a.m.	Relationship with Applied Mathematics: Ka Kit Tung (Applied Math. Chair) Randy Leveque
9:30 - 11:15	Research
11:15 - 11:45	Research focus, hiring priorities, strategic plan. Selim Tuncel Executive Committee
11:45 - 12:15	Break
12:15 - 3:00	Lunch (catered to meeting room); Review Committee executive session
3:00 - 4:00	**Exit Interview** (**Faculty Club Conference Room)** Selim Tuncel, Chair, Mathematics Tatiana Toro, Associate Chair, Mathematics David B. Thorud, Acting Provost Susan E. Jeffords, Vice Provost for Academic Planning, Office of the Provost George Bridges, Dean and Vice Provost, Undergraduate Education David C. Hodge, Dean, College of Arts and Sciences Ronald S. Irving, Divisional Dean, Natural Sciences, College of Arts and Sciences Elizabeth L. Feetham, Acting Dean, The Graduate School Gail L. Dubrow, Associate Dean for Academic Programs, The Graduate School Augustine McCaffery, Assistant to the Dean, The Graduate School
4:00 - 5:00	**Exit Interview** (**Faculty Club Conference Room**) As above; no departmental representatives.