The University of New Mexico

Agenda for Excellence in Undergraduate Education

Department of Mathematics and Statistics

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1 Introduction

To paraphrase an ancient saying, *living* is owed to one's parents, but *living well* to one's teachers. Recruiting New Mexico's youth and providing them with the education and growth that will give them a good life is our primary mission. As president Caldera has pointed out, improving undergraduate education is the single most important thing we can do to increase public support for UNM.

Mathematics and Statistics forms the foundation of all science and engineering curricula. The department teaches more student credit hours each year than every college on campus except Arts and Sciences itself. Since we are one of the "3R's" we constantly strive to mesh our courses with the evolving engineering and science courses. Besides conducting several introductory courses with many sections and large, cross-campus enrollments, we must also ensure that the level of our remaining courses is accessible to students from other departments and colleges and that the course content is appropriate. This means that every step we take to improve our program must be compatible with the diverse sets of goals and requirements of the campus community. But it also implies that our success in teaching and outreach will ripple across a large part of the campus.

2 Our ideal of Excellence

The Mathematics and Statistics curriculum has an intricate structure that gradually rises from a strong base. Our students require rigorous and complete training in the basics if they are to succeed in grasping the more complex concepts that follow. Any gap in the structure and it cannot continue to grow. Therefore our main courses should always be staffed by experienced faculty and their content needs to be well coordinated and up to date. Moreover, we must ensure that our students are carefully monitored through personal assessment by our staff advisor and their individually assigned faculty advisor.

We see our majors as budding professionals. Their career choices are as diverse as the individuals and illustrate the enormous opportunities open to our graduates. Examples include computer pro-

gramming and animation, forecasting and modeling, cryptography, data analysis quality assurance, and careers in the military, government or in the private sector. Some are headed for graduate research in abstract or applied fields, in a university, research center or government laboratory or in the industry, in this country or abroad. Many will seek a Masters' degree and work as actuaries, as secondary educators, or as resident statisticians in hospitals.

However the majority of our students at all levels are not majors in the department: they are engineers, physicists, education or business majors, to mention but a few, coming to us both for required courses and electives. They seek skills that will afford them a deeper grasp of their engineering or science courses or will allow them to better prepare for graduate school or a successful career.

We consider ourselves successful if our students succeed, indeed thrive, in their pursuits, whether in postgraduate education, in finding desirable employment or in the careers they choose. And we define as our students not only the select few dozen that earn a degree from us, but all the students that we serve.

3 Our Strengths

The undergraduate program in Mathematics and Statistics is stronger than ever. Our recruiting efforts, advising, and curriculum design and enrichment over the past decade have helped us recruit and guide students to a successful graduation in larger numbers than ever before, see Fig.(1a). Often a strong mentor relationship is formed between the faculty advisors and their advisees, and the benefits of having this support can be felt throughout our program. A mathematics honors society, *KME*, has been one of the venues for creating and cultivating a spirit of camaraderie among the students. We have many concentration areas for majors: Pure Mathematics, Applied Mathematics, Computational Mathematics, Statistics, Mathematics Education, and the recently added Distributed Mathematics major. These options provide the flexibility to meet the diverse interests and needs of our students.

Our students now also enjoy opportunities to participate in undergraduate research: 15 did so in the last 5 years, two through our newly formed honors program and the number of faculty involving undergraduates in their research is growing. A pending collaborative grant by Professor Salter with the Biology Department is requesting funding for 3-4 math/stat undergrad research projects over a five-year period.

In response to demand in emerging research areas, several new courses were added to the curriculum. These include Nonlinear Dynamics and Chaos, Fluid Mechanics (Professor Nitsche), Fourier Analysis and Wavelets (Professor Pereyra), Nanotechnology (Professor Putkaradze), Scientific Computing (Professor Warburton), SAS programming (Professor Justin Kubatko), Bayesian Statistics (Professors Hanson & Huerta). Also possibilities exist for internships at Sandia and Los Alamos Labs, or in the Health Sciences Center. Several of our students have participated in NSF REUs (Research Experiences for Undergraduates) and internships at a variety of Universities and Institutes (The Ohio State University, National Center for Genome Resources, Institute for Social

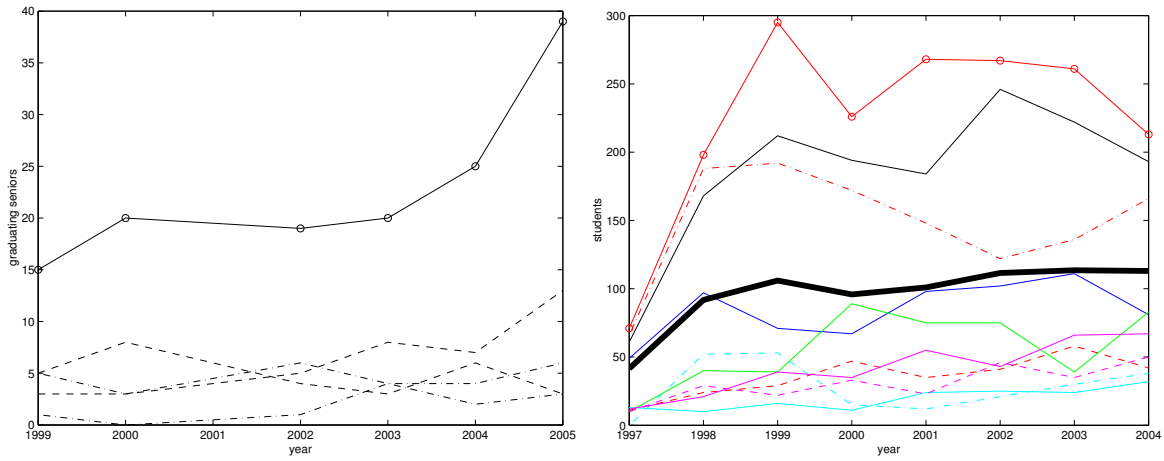

Figure 1: (a) Mathematics and Statistics graduates for the past five years. Numbers of graduates per category (broken lines) fluctuate, showing trends in cohort preferences but total shows a solid growth. (b)Students completing select 300+ courses over the past 8 years. Only the ten courses with highest enrollment are shown. The circled entries correspond to Math 316, the course with highest enrollment. The bold line gives the average enrollment for these 10 courses.

Research, Los Alamos, NASA, NSA among others).

Enrollments in our mainstream courses have also grown. Fig.(1b) shows the enrollment figures for our 10 courses at the 300+ level with the highest enrollments for the last 8 years for which we have **SIS** data. These courses are either required by one of our subdisciplines or by other departments or are popular electives. The average enrollment in these representative courses is also shown. To make the comparisons meaningful, we only show numbers of students that successfully completed these courses with a grade of C or better.

The increase in students attending and successfully completing our 300+ courses parallels the growth of graduates in our own program, as shown in Figs(1a,b). We believe that the time lag between the major upswing in Math 316 (ODEs), Math 314 (Linear ALgebra) and Stat 345 (Introductory Statistics), the three courses with the highest enrollments since 1997, and the upswing in present-time Math-Stat graduates is indicative of the importance of these courses as a gateway of attracting students to our own programs.

The quality of our courses is an issue of great importance to us. But so also is their relevance in the wider university arena. We maintain regular channels of communication with colleagues in other departments. Several of us have flourishing collaborations or hold joint appointments in other departments, and are actively involved in the research projects and/or advisement of graduate students outside Mathematics and Statistics. These contacts and experiences with other fields feed directly into the design of our courses.

Besides these informal communications pathways, our undergraduate committee has pursued regular contacts with its counterparts in other departments, especially Physics, C/NE, ME, the College of Education and others, to discuss and synchronize the curriculum in key required courses in Math-

ematics (316, 311, 312, 314, 321, 375, 401) and Statistics (345, 427, 428, 445) and the mathematics for secondary teachers sequence (Math 305, 306, 308) so that these sequences better serve students' needs. Through advising, we continuously monitor our students' progress, especially those with minors or double majors, so that we can achieve optimal synergy with the curricula for our intended clientele across campus.

4 Developing the Curriculum

The number of majors has been increasing, as has the number of students in our key service courses. However, our research faculty numbers have declined through attrition and loss of young faculty to competing institutions. At present we estimate that we are short by at least 8-10 faculty, as is evident if we compare the sizes of our department and our student credit hours to those of peer institutions. It is customary and essential that students in 300+ courses be taught by research faculty, with the knowledge and experience required by students at this level. Of these, our introductory Ordinary Differential Equations course, Math 316, is of special concern to us, as it is the highest level course required by several engineering departments. Many of the students in these programs may have had their lower level mathematics training outside UNM; thus, Math 316 is our one chance at introducing them to effective problem solving and modeling skills as taught by a specialist in the field, and taught in a way as to set expectations for skills across the disciplines at UNM. We believe Math 316 to be an excellent focus for adapting our curriculum to the needs of the community we serve. Other such courses are our new Calculus sequence for the Life Sciences designed by Professor Sulsky and the new Statistics for Biology course, an adaptation of Stat 345, proposed by Professor Salter. In the area of Mathematics Education several courses are planned by Professor Umland working with faculty from the College of Education. We are always interested in finding new ways to adapt our advanced undergraduate courses (such as Partial Differential Equations, Methods of Applied Math, Probability, Scientific Computing, Nonlinear Dynamics, Wavelets) to mesh with new programs, such as the proposed Nanotechnology Degree.

One of the strategies that we have used to deal with our critical faculty shortage in a way that would mitigate its short term impact on our 300+ courses has been through employing"Teaching Postdoctoral Fellows." So far we have employed 2 TPF's and they have been a positive addition to our program, as compared with part-time instructors. In other areas our shortage in faculty has forced us to cancel activities, such as our participation in the prestigious Putnam mathematical competition, in which in the past we had a strong presence. Professor Hillman began the tradition here in the '60s, founding at the same time the New Mexico Math Contest for High School students. Training a team for the Putnam requires a dedicated faculty coach, which we have not been able to afford in recent years. We also do not have the staff to expand pilot courses into full offerings. Therefore, more permanent solutions are required if our strong growth in quality and numbers is to be maintained.

At the present moment, we are involved with several changes as we adapt to the ever expanding information revolution. It has become apparent that the traditional approach of introducing students to the computer (a required programming course introducing a high level language which over the

years has changed from Fortran to C to C++) is ineffective for general instructional purposes. We have recently been exploring, in discussions with colleagues from other departments, a new course introducing freshmen to Matlab, a full, high-level mathematics programming environment, which will be offered experimentally as CE/ME 439 this Fall. While the transition is planned, we would like to introduce a 1 credit introductory Matlab course. We could offer this course utilizing 1 or 2 TA's, with close faculty supervision at first. In the long run, our courses currently using the computer (Math 314, 316, 375, Stat 345) would greatly benefit from setting an entry standard for the students' computer skills, and other creative uses of the computer could be contemplated in courses such as Partial Differential Equations, Nonlinear Dynamics, Wavelets and Differential Geometry. Most of our upper level Applied Statistics courses also use computing. Several courses use computing intensively, such as Stat 425/525 (SAS programming) and Stat 590 (Statistical Computing) or to a significant degree (Stat 440/540, 445/545, 427/527, 428/528, 474/574).

In the past, Stat 145 and Stat 345 have used computing, but at present the use of computing is limited, primarily due to the difficulty in teaching these students programming techniques when they aren't sitting in front of a computer. The same limitation hinders our use of computers in Math 316 and 314 and prevents its introduction in additional courses, such as Math 312, 412 and 437. A better classroom for teaching with computers is needed. Hopefully in collaboration with other units in the College, we can acquire a computer instruction room similar to the new Computer Lab in Mechanical Engineering, designed for effective integration of instruction with computing resources.

We see our involvement with the teachers of New Mexico as a critical part of our mission. In addition to our traditionally strong role in providing mathematical content to K-12 teachers, we have recently increased our articulation efforts with high schools from around the state. We have created extensive materials that are available on the department's website for high school teachers and prospective students. We have had significant participation by department faculty in the UNM summit for math and English teachers. We have been working to develop a teacher sabbatical program where secondary teachers can come teach at UNM and take courses for a year.

Even with the limited resources that are available, we continue to work closely in collaboration with the College of Education. With new federal directives to retrain the majority of the state's middle school mathematics teachers, we need to revamp our program for teacher training. Building on the current grant-funded work with in-service mathematics teachers, new courses need to be designed to truly help the incoming pre-service teachers deepen their understanding of mathematical concepts and improve the skills that they will bring back with them to the classroom. We will need to continue our modest but steady investment in better facilities for our teacher training program. A grant application is planned by Professor Umland for setting up a diverse collaborative team to pursue the design of a comprehensive training program for mathematics teachers. We believe that well trained teachers graduating from our program can be our most effective means of reaching the state's youth and attracting them to our department and our University.

New efforts are under way for a BA/MD program, and we are making contributions to that through designing special courses, as mentioned above. Here again, teams need to be formed and grants planned to pursue these ambitious new directions successfully. We can have a similar approach to the new Nanotechnology effort, and we plan to remain in close contact with its designers and offer our help where it is needed.

5 Ideas for improvement

Our plans are always tempered by limited resources. In that regard, we have identified a few areas that could benefit tremendously from special funding from the College.

- Seed funding for designing various interdisciplinary courses, such as a course sequence for middle school teachers and Statistics for the life sciences. Seed funding would help to form teams possibly in collaboration with other Universities in the State, to pursue outside funding. We request $1,000 for each, mainly to support travel for grant planning meetings.
- Funding for refurbishing our Education Instruction Room. We need to make a permanent installation for grant-acquired equipment (cost $3,000) and to refurbish the closet so it can be securely locked ($5,000).
- A classroom for integrated computing instruction (possible area of pooling resources with other departments in college). The figure we have for this was what a similar adaptation cost the School of Engineering ($60,000).
- A new programming course to prepare students for using the computer in upper level courses in Mathematics (316, 314, 312, 375, 412, 434, 472) and Statistics (145, 345, 425, 427, 428, 440, 445, 474). Funding is requested for 2 TA's and initial design costs (2 TA's per year, and a one-time course release for faculty).
- An experimental mathematics laboratory: we have held discussions with Sandia Labs colleagues on designing an undergraduate laboratory for experimental demonstrations of advanced mathematical concepts. This would work best as a synergistic effort with others (physics, engineering). Several of our courses (ODEs, PDEs) would benefit from the ability to hold demonstrations of key physical phenomena, such as vibrations, waves, symmetry and bifurcation as concrete examples of abstract mathematical concepts ($20,000 for equipment).
- Creation of KME club room where students can meet and study.
- Funding to organize an Honors Seminar, to expose students to research at an accessible level and encourage more participation in the honors program (approx. $3,000 for two distinguished speakers per year, refreshments to be served at each seminar).
- Personnel so we can better prepare students for state-wide and national contests and field a Putnam team again.
- A program to encourage mathematics graduates to consider teaching at the secondary level, either as a career path or as a temporary, 2-3 year commitment on the way to graduate school.
- Funding for materials to advertise our program ($2,000). Possibly creation of a road show we can take to high schools around the state ($50,000).
- Pursue a focused hiring effort over the next 5 years to hire 8-10 research faculty so that we can staff all of our key undergraduate courses and have enough people on board to effectively pursue the above improvements as well as new ideas that may arise (**priceless!**).