

Strategic Planning: Department of Mathematics & Statistics

Undergraduates Mathematics undergraduate research is enjoying increased exposure nationwide and renewed momentum at UNH. A recent UNH undergraduate research poster features photos of two Math undergraduates who shed light on a thirty year old conjecture of I. Kaplansky. Other undergraduate majors are involved in research projects with faculty guidance. Some of these projects are likely to lead to joint publications. The Department launched a program to increase student awareness of and involvement in research. Initial program steps introduced freshman majors to faculty mentored research and undergraduate thesis opportunities and provided guidelines. Also, the Department organized an on-campus meeting of the Mathematical Association of America (MAA). The MAA program included undergraduate presentations (UNH students participated) and faculty research lectures aimed at undergraduates. All majors were invited to participate and present papers. The Department expects to hold meetings with majors from each class rank and to discuss opportunities for research and multidisciplinary learning.

Departmental student advisors are encouraged to lead advisees to research exploration and also to go beyond courses and try to learn something from each individual faculty member; to ask not “what does professor X teach?” but rather to ask “how does professor X think about mathematics?” The Department will continue to revise and fine tune majors programs and, in particular, to establish new and more effective ways to study applied mathematics and statistics in keeping with modern trends and expectations. It will also raise awareness of Honors-In-Major, thesis project and multidisciplinary collaboration opportunities.

Graduate Students Department graduate programs have been recognized both for research accomplishments and teaching achievements. The first Graduate School Award for Graduate Student Research was won by a PhD student of Professor Liming Ge. In the same year, another Department Ph. student received the CEPS Outstanding Graduate Teaching Assistant award, and a Department Masters student was among the Graduate School’s first Graduate Student Teaching Award winners. The Department has established a steady flow of quality graduate students and has earned an international reputation for its programs. To build on this success the Department will broaden its recruitment effort through posters, direct mailings, exchange of graduating seniors lists, renewed web postings, and continued emphasis on onsite recruitment by faculty who travel to conferences, both nationally and internationally. (Present faculty efforts in this direction are already benefiting the program.) To improve the quality of current offerings the Department is developing a program to offer increased support for TA activities in the form of mentoring, classroom visits, and increased recognition of good instructional performance with internal departmental awards. To enhance graduate learning and research the Department will aim to offer closer faculty mentoring opportunities at an earlier stage in a graduate student’s career, and to make more salient presentations of the opportunities for and benefits of multidisciplinary research and study. To sustain relations with its past students the Department will work to form a graduate alumni association.

Core Mathematics The Department has an international research reputation that has been recognized through invited addresses at prestigious professional meetings, publications in leading journals, and grants. The Department must support and retain its faculty by maintaining an attractive scholarly environment, by bringing in exciting speakers and long term visitors, by recruiting strong graduate students, and by providing recognition and support for distinguished achievement. Further, the Department should continue to build on its existing strength, to recruit new faculty of outstanding caliber, especially promising recent Ph.Ds, and thus to increase its international prominence. In a time of tight budgets this will be challenging, but not impossible: student enrollment and staffing cycles can be managed creatively to generate new

resources for both research and teaching. A continuous lookout effort for such opportunities for resource generation is essential and should be coupled with ongoing faculty recruitment.

Applied Mathematics (AM) AM activity is gaining momentum. One new faculty member was hired recently and is contributing actively on several fronts. New applied courses were developed and increasing student interest and participation has been observed, among both undergraduates and graduates. An international workshop on aircraft flutter, held in the Department recently, was well received and will likely lead to new campus conferences. The interdisciplinary Center for Dynamics Research was created to build connections between mathematics, science and engineering. It has received industrial support, for equipment and student work, from BAE Systems, Northrop Grumman, Chaoticom Tech, and the NHIRC. Student participation in Center activities has been strong from the start and will increase. Opportunities for additional funding and new collaborations abound and include dynamics of capillary flow (Chemical Engineering), fluid dynamics of centrifugation (Biochemistry), flutter analysis and aircraft wing design, information theory, noisy communication, multiplexing and secure communication and nonlinear prediction, e.g., seismic detection. The undergraduate AM curriculum was revised recently to enhance program effectiveness and a revised graduate track is undergoing active discussion with a multidisciplinary perspective. The plan is to sustain and build on the existing momentum, to increase the breadth and depth of AM programs, promote new collaboration with other departments, colleges and centers, to gain additional external funding, to recruit a broader group of strong students and to add faculty members to support these activities and contribute distinction and strength in specialty areas.

Statistics The new information economy demands ever greater statistical analysis and support, in medicine, ecology, manufacturing, commerce, and essentially all other aspects of society. Recent Exploring Mathematics Night panelists unanimously commented on the strong employment opportunities in statistical sciences. Indeed, a sound statistical background is now considered essential in many disciplines and forecasts point to ever increasing needs for statistics expertise and research. We're well positioned to support these needs on several fronts.

First, we can provide the entry level foundational instruction that serves the common needs of all disciplines, one that can be tailored to fit the preparation of students, e.g., calculus-based instruction that is required for engineers and many scientists, or non-calculus based instruction for majors with less mathematically demanding curricula. Secondly, at a more advanced level, the department can provide instruction on new and emerging methods, such as Data Mining and Knowledge Discovery, that are rapidly becoming the norm in a multitude of fields. Undergraduate research opportunities abound. Professional opportunities, such as those available in actuarial science, benefit from current faculty in mentoring and professional exam oversight.

Despite this clear resurgence for providing statistical education the department has been challenged with the loss of tenure track faculty. With reduced statistical staffing the department has struggled to maintain its commitment to offering its statistics option in the MS degree program, a dissertation option for the PhD degree program, as well as a popular graduate certificate program in Industrial Statistics. Some success for this program might be attributed to providing its courses on-line via CEPS' FarView program, which has led to a steady stream of professional, self-supporting part-time students from near and far.

The lack of sufficient permanent faculty can create uncertainty, instability and excessive demands. Because science discovery relies increasingly on data exploration, statisticians are in constant demand from across the UNH campus. While statisticians have traditionally served on MS/PhD committees from many disciplines, this role has changed from serving as a statistical overseer or consultant to that of being a true collaborator. The level of statistical methodology used by scientists is advancing from standard to cutting-edge. Many newly emerging inquiry

fields are statistics driven, e.g., remote sensing, imaging, bioinformatics, genomics, proteomics, and nanotechnology. Commensurate with this trend is the senior statistician's increasing level of involvement in interdisciplinary research. The clear indication is that this need for involvement is just beginning and is likely to increase exponentially.

The biggest challenge in this regard is to match resources with increasing opportunities and expectations. The Department would be better positioned to address these needs with permanent faculty in place of temporary instructors. UNH has attracted lecturers with PhD degrees in statistics, who are strongly qualified to compete for permanent positions. Indeed, recently a lecturer left our staff to take an outside tenure track job. He had taught important foundational courses and collaborated with faculty on research for several years. It was fortunate that we were able to attract a strong (temporary) replacement into the position, but it is unclear if we'll be able to do this again as the need re-emerges.

To maintain momentum in the developing statistics program (both undergraduate and graduate), the department must develop a more effective and visible program structure, improve its recruitment and retention practices, provide a wider range of PhD level courses, increase the number of potential thesis directors, and organize a structure that can respond to growing demand from the UNH community as well as regional industries and groups for statistical expertise. The department has long recognized the need for creating a statistical consulting center that could formalize student involvement in funded research, improve the visibility of statistics and help strengthen the research mission. Current human resources are not sufficient to initiate this activity so new faculty recruitment is essential.

Mathematics Education (MaE) The MaE program at UNH is housed in the Department of Mathematics & Statistics and is thus distinguished from most MaE programs nationwide, which are not generally in such departments, and which typically do not provide as strong a mathematics background as ours. Program graduates, both at the Bachelor and the Doctoral level, have earned the Department a strong reputation. As elementary and secondary mathematics teachers find rising expectations for in-discipline majors, the Department is well positioned to attract future teachers and provide them with a strong background. Statistics instruction is increasingly prominent at the secondary level and here too the Department is well positioned in its offerings to future teachers.

Faculty have been actively involved with externally funded projects and outreach activities and support of allied disciplines. (These are elaborated in a separate section.) The Department will soon aim to recruit new MaE faculty members and will strive to build on its already distinguished reputation through the search. This is not only an opportunity to add to existing faculty strength, but also to incorporate new and emerging specialty areas which are particularly well suited for UNH, e.g., *statistics education*.

Named Instructorships Leading mathematics departments nationwide offer named instructorships that allow new or recent Ph.Ds to spend a few years collaborating with senior faculty on research, building teaching experience, and preparing for a permanent position, typically in another institution. These positions can bring in fresh ideas and energy and enhance a department's image. A prestigious named instructorship adds value to a young mathematician's CV. We have been able to attract some highly qualified faculty into our Lecturer positions. Some of these followed the model described above, establishing high powered collaborations with permanent faculty while providing outstanding instruction. The Department can derive greater benefits from these positions by establishing a formal named instructorship program coupled with a (slightly) reduced teaching load and a national image campaign. Graduate students will benefit from exposure to outstanding scholars who are moderately ahead of them on the career time-line. Resources such as funds from faculty buy-out, leaves and external grants can help support this program. Named instructors may be successful in generating their own funding and thus add to the program's resources.

International Collaboration The Department will leverage its strong international ties and pursue establishing international exchange programs with notable institutions, e.g., the Chinese Academy. This could include research institutes, such as the forthcoming Center for Noncommutative Analysis, as well as comparative mathematics education programs, e.g., a bi-national variant of our ongoing Master of Science for Teachers (MST) program.

NH K-12 Outreach The Department strives to be highly connected to and visible within the NH K-12 system. We expect to take a more active leadership role in mathematics education in the state. Currently faculty specializing in MaE serve on state committees, in the NHTM and its conferences and provide some in-service education to public school mathematics teachers. Nonetheless, we remain separate from the day-to-day operation of providing for and guiding the learning of mathematics by K-12 students. We envision the entire Department taking a more active and intensive role. Future activities could include regular seminars in MaE and mathematics for *all* K-12 teachers, a supervisory role in determining the content of the school mathematics curriculum, provision for middle and high school students to do intensive work in the mathematical sciences (MathSci) with university faculty on realistic research problems or studies, provision of information on careers in MathSci and related fields, demonstration classes, graduate programs in mathematics and the MathSci for teachers, and provision of materials and technology to the public schools through the mathematics resource center. These activities benefit UNH by providing more and better prepared undergraduates seeking degrees and careers in MathSci and related fields, reduction in remediation needs for entering calculus students, and students more informed about and committed to education in the MathSci. Naturally, continuing collaboration with the Leitzel Center is expected.

Collaborative Opportunities with Allied Departments and Colleges

Engineering and Physical Sciences. The Department has strength in areas naturally suited for multidisciplinary collaboration with other CEPS departments. These areas include, but are not restricted to applied mathematics (especially dynamical systems, partial differential equations and asymptotic analysis), applied and mathematical statistics, operator theory, non-commutative analysis, and science education. The Department will maintain and enhance collaborative activities, creating new opportunities for joint research projects (both for students and faculty) and new course and degree offerings that benefit a broad base of students and leverage resources.

Life Sciences (LS) and related Physical Sciences . It is said that the basic mechanisms governing biological systems are now understood and that the challenge is to learn how manifold small scale processes are pieced together and interact to produce large scale phenomena. Thus the contemporary study of LS depends in essential ways on mathematical and computational analysis. Departmental strengths in areas such as nonlinear dynamics, applied partial differential equations, statistics and mathematics education will be paramount in pursuing and developing collaborative opportunities in the LS and related areas in CEPS.

Collaboration can begin at the freshman level. Students planning to major in science or engineering must master at least one calculus course which is prerequisite for their upper level courses. Many entering freshmen are not ready to take calculus upon arrival and must first take a pre-calculus course. Success in this course is believed to correlate with overall undergraduate success. The Department has allocated considerable effort to the development and refinement of the basic pre-calculus course “418”. While fine tuning of 418 continues, it appears already to be serving CEPS students well: students who perform well in 418 are likely earn a good grade in the calculus “425” course. LS students, on the other hand, aim for a different calculus sequel, “424B”, and may find the 418 pre-calculus suboptimal for their needs. In this area the Department has launched a major effort to produce an LS parallel to 418 and considerable activity is already underway: many COLSA freshmen now go into pre-calculus

after a placement process and this will become a permanent part of the curriculum. In the coming years we must work to develop and fine tune this initiative and thus contribute directly to improving student retention, achievement and success rates in another college. This can be done in conjunction with other CEPS departments, especially Chemistry.

Beyond the pre-calculus level, it is natural to build on Studio Calculus success, and collaboration with Studio Physics, to develop a Studio Calculus-Biology track, or even a Calculus-Biology-Chemistry course. The Studio course experience has been cited by students as among the most exciting of their academic career. It should be expanded, and one can be hopeful that Federal agencies such as NIH may support the development through grants.

At the upper undergraduate and beginning graduate level one can find two directions of collaboration potential with LS. Advanced LS students often encounter mathematics beyond their basic course preparation and must acquire advanced skills as they pursue research and publication efforts in their own field. The Department has begun providing advanced background courses at this level, but preliminary discussions indicate that a considerably larger group of students could be served, and that this can be manifested through faculty guidance and mentoring early in students' careers. Coordination with LS faculty and allied CEPS departments is, of course, essential for success. In the other direction, advanced mathematical sciences students can contribute to projects in the LS and related physical sciences such as chemistry, and generate mathematical results of biological interest but may not have the appropriate science background and multidisciplinary mentoring to make the connection. The challenge then is to create a forum for advanced math and LS students to interact and support one another's growth and development.

In all these areas activation energy has been expended and we have gone beyond initial discussions. We must sustain and expand this activity, get more faculty and more students involved (undergrads and grads), arrange for distinguished scholars to visit and speak on the connections between math and LS, and organize campus symposia and conferences. Initiatives such as internal grant proposals have already started and should be followed by, e.g., external proposals and outreach efforts modelled on the Exploring Mathematics Night . This planning direction strongly overlaps several others, including statistics and mathematics education.

Data Mining: Collaboration with Civil Engineering, Business Management, NH and Local agencies Traffic safety research has revealed that this important concern has not yet received the full benefit of analytic and objective study that is now salient in some fields. At UNH the "Car 54" project provides a unique opportunity to mine traffic data and shed light on such questions as: how does one quantify the safety of an existing road system? What is the safest geometry for building a new road system? A multidisciplinary team was assembled which includes faculty investigators from Mathematics and Statistics, Civil Engineering, and Business Management, along with local and state agencies contacts. A group NSF grant was funded which includes student research assistant support. The challenge now is to build on this initial success, sustain regular seminar activity, promote local involvement of, e.g., high school students and teachers and law enforcement professionals, involve undergraduates through the creation of inquiry-discovery courses, and expand the scope of the program to national and international levels. One imagines quantitative safety tools (software, handbooks), emerging from this activity and leading to a research and education center. New courses in this area are particularly well suited for *Inquiry* and *Discovery*.

Health and Human Services The Department is working with HHS faculty to reintroduce foundational mathematics courses into some HHS departments' curricula. Preliminary discussions have taken place and responses have been positive. Soon we will see increased HHS student representation in our courses. This opens an additional opportunity to serve a segment of the UNH campus in new ways, including broadened and expanded offerings in applied mathematics and statistics.