

NCSU Math Department Wins AMS Award

Allyn Jackson

In May 2009 the mathematics department at North Carolina State University moved into its new building, SAS Hall. Named in honor of a donation from the statistical software company SAS, the new building provides an exceptional environment for faculty, students, and staff. "It is a great place to work, with quiet corridors for students and faculty," said Michael Shearer, one of the faculty members who worked to convince the university that the department needed a new home. "With modern and spacious visitor, teaching, conference, and seminar spaces, we have the physical environment that is already attracting leading scholars." The building is not just functional but beautiful as well. The entrance is a four-story atrium with a spectacular fabric mobile incorporating the golden ratio, designed by a team from the world-renowned NC State College of Design. SAS corporation lent the university around fifty works of art that decorate the hallways and public spaces. A logarithmic spiral begins on the floor inside the building and extends to the outside plaza.

The new building is a symbol of the department's creative spirit and a bellwether for its future. Even while in its old building, the department trained its focus on the essentials: stimulating excellent research and bringing out the best in students at all levels. As a result, by the time SAS Hall was ready for occupancy, the department had become a dynamic, thriving enterprise that could really capitalize on the new facilities. In 2010 the AMS chose NCSU to receive the annual Award for Exemplary Program or Achievement in a Mathematics Department.

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The Seeds of Success

The seeds of the department's current success were sown about fifteen years ago, when it decided to emphasize bringing domestic students into its graduate program. One motivation was that some grants held by NCSU faculty had come from defense agencies or other sources that required students supported on the grants to be U.S. citizens. "But in part it was really a cultural change," explained the current department head, Aloysius Helminck. The faculty "really felt this was important and that we needed to make a difference." Because the domestic students were talented but came with varied backgrounds for graduate school, the department realized that it had to provide careful mentoring and a supportive environment. It also realized that the students would benefit from education and training that prepared them for a variety of career paths both within and outside of academia. The department began to structure vertically integrated activities for students, even before VIGRE formally began (VIGRE stands for the influential National Science Foundation program Vertical Integration of Research and Education).

The NCSU mathematics department really took off about five years ago, when Helminck became department head. He secured several substantial grants that gave the department the means to fulfill its aspirations in education and research. Helminck's leadership has helped to build a cohesive vision for the department that the entire faculty can rally around. "You have to create a culture in which people believe this is the right direction for the department so that there is broad faculty participation," Helminck said. "You start with a few people and you show that a program is successful, then one by one you have faculty start to participate...They can totally change their minds. Those who were initially opposed are the biggest



Participants in the 2009 NC State REU in Mathematics (shown in the main lobby of the new mathematics/statistics building, SAS Hall).

supporters now, because they see the programs really make a difference.”

One of the distinctive characteristics of the NCSU mathematics department is the way it blends interdisciplinary research with foundational research, said faculty member Michael Singer. “The research aspect is very interesting but for training students it really makes a big difference that we are able to offer students both a basic foundation in mathematics, as well as the possibility to be trained to pursue a host of careers in the mathematical sciences,” he said. “We have enormous breadth and depth. I think this attracts a lot of different students and yields well-trained mathematical scientists. The diversity that you see in the research is translated into diversity of course offerings and research experiences for our students.” There is also an unusual level of cooperation between theoretical and applied mathematics, Shearer noted. “The applied side is unusually broad, including specialists in scientific computing and modeling who do not prove theorems, but relate models and simulations to practical applications,” he said.

Research Experiences for Students

The blend of interdisciplinary and foundational research has allowed the department to launch extremely successful research-experience programs for its students. At the undergraduate level, the department has two programs: Research Experiences for Undergraduates (REU), which is one of the largest REUs in the nation, and REU+, aimed at students traditionally underrepresented in the mathematical sciences. Both take place over the summer and are aimed at students from

outside NCSU (the department’s math majors are encouraged to apply to REUs on other campuses). Students work on a wide range of problems, such as ultrasound imaging in cardiovascular tissue, gravity quantization, and data mining. Many projects result in research papers, and one, in electron gun design, even led to a patent application. The active participation not only of faculty but also of researchers from industry makes for a rich, vibrant atmosphere. “The students who come out of the [REUs] are all highly invigorated, and they want to keep on working” in mathematics, Helminck remarked. “A lot of them want to apply to NC State for graduate school... They really feel that it is a life-changing experience.”

One measure of the success of the NCSU REU programs is the percentage of students who have subsequently entered graduate programs. From the 2005, 2006, and 2007 REU and REU+ groups, 100 percent, 77 percent, and 79 percent, respectively, have gone on to graduate school. The REU programs have serious participation by NCSU faculty and also give graduate students early experience as mentors of undergraduates—experience that has proven useful on the job market later on.

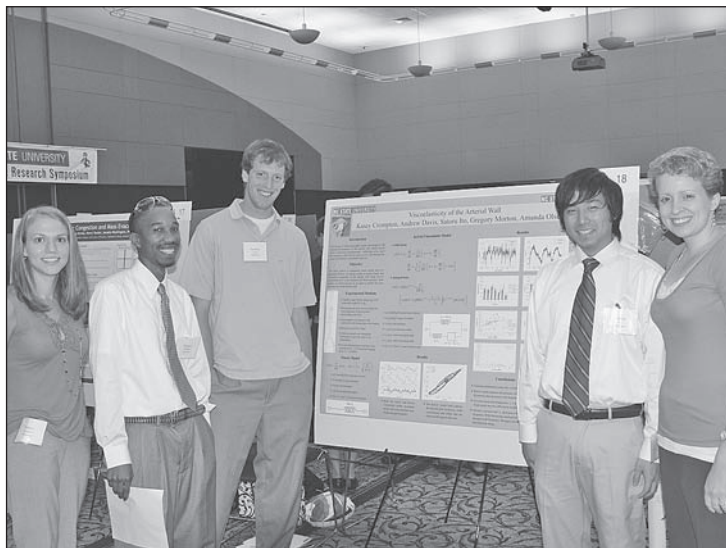
The department also has a counterpart program to the REUs called REG, Research Experience for Early Graduate Students. Students typically participate in this 10-week summer program at the end of their first year in graduate school, while still engaged in coursework but before taking qualifying exams. In the REG, a student might work solely with a faculty member or be part of an interdisciplinary team. Projects are typically

designed to be completed by the end of the summer, and in some cases they result in a publication for the student. Students learn background for the research as well as research strategies and critical oral and written communication skills. In many graduate programs, students are so consumed with coursework that “they lose sight of why they went to graduate school, which was to do research, to become a research mathematician,” Helminck said. The REG “seems to invigorate a lot of students... They study harder and become very motivated.” Students begin to form collegial groups with others interested in the same research areas, and they form ties to faculty early on, easing the path to choosing an advisor. The REG has also improved the retention rate: 96 percent of participating students have gone on to take and pass all three qualifying exams, whereas before the program began, this rate was roughly 70 percent.

The department’s qualifying exam structure is quite unusual: There are fifteen exam topics in all, and more are to be added. The department wanted the exam structure to reflect the increasingly interdisciplinary nature of mathematical research. So, for example, a student interested in biomathematics might take qualifying exams in that subject as well as in partial and in ordinary differential equations. Background in such core subjects as algebra, analysis, and geometry is provided through coursework. “All the students still get to see a broad spectrum of math, but [the exam structure] helps them focus on studying the subject in which they are going to do research,” Helminck explained. “We have found that this really helps in cutting down the time to degree.”

Emphasizing Professional Development

Graduate students are offered a variety of professional development activities. For example, the university has a scholarship program through which a student can observe a professor teaching a course one semester and then teach the course solo the following semester, under the guidance of the professor. Some students in the program have even taught upper-level undergraduate courses. Graduate students participate in seminars in which they give talks and receive supportive critiques of their presentations. There are also “Research Training Modules” that provide a forum to discuss a range of professional issues, such as how to apply for a job, how to find an advisor, and what to do at a conference. These modules were developed as part of an NSF Research Training Group grant on mathematics of materials, but they are advertised and available to all students and postdocs. The department makes efforts to send its students to conferences, and a former graduate student even endowed a travel fund for graduate students. The professional development activities are useful not only for those



In the REU program, teams of students work with faculty and graduate students to solve real-world problems. In this 2008 photo are (from left to right) Kasey Crompton (University of South Carolina-Columbia), Gregory Morton (Morehouse College), Andrew Davis (Clarkson University), Satoru Ito (NC State University), and Amanda Olsen (LaGrange College). This project was led by Dr. M. Olufsen and graduate student D. Valdez-Jasso and was named one of the poster session prize winners at the 2009 JMM.

who embark on academic careers but also for the increasing number who take positions in industry or in laboratories.

There are various opportunities for graduate students to get a taste of industrial and applied research. The newly established Center for Quantitative Sciences in Biomedicine facilitates project-oriented research in the biomedical sciences and provides a basis for novel graduate and postgraduate training at the interface of the quantitative and biomedical sciences. In addition, each year several graduate students participate in off-campus internships at institutions including Merck Pharmaceutical, the National Institute of Environmental Health Sciences, Harvard Medical School, MIT Lincoln Lab, Lawrence Livermore Lab, Boeing, the Hammer Institute, and Aerospace Corporation. These internship experiences are important in preparing students for the job market and often lead to postdoctoral and employment offers.

Students are also encouraged to participate in summer activities such as the Industrial Mathematical and Statistical Modeling Workshop, which is held annually at NCSU. This workshop is cosponsored by the Statistical and Applied Mathematical Sciences Institute, one of the seven national mathematics institutes supported by the NSF, and NCSU’s Center for Research in Scientific Computation (CRSC), which brings together mathematics faculty members, faculty from other

departments on campus, and disciplinary scientists from industry and government laboratories. Founded in 1986 and currently directed by H. Tom Banks, the CRSC is a great asset to the department and has helped support various departmental programs.

Inspiring Commitment

All of this attention to students demands great commitment on the part of faculty. How does the department inspire this commitment? One way is through tangible rewards. "It factors into promotion, into tenure, into raises," Singer said. "It is part of what [faculty members] are evaluated on. You get what you measure." At the same time, changes that made the department more student-centered have also stepped up faculty commitment. For example, about a decade ago the department revamped its honors program, so that talented undergraduates were matched with outstanding mentors, and this change raised the faculty's enthusiasm about its students. Mathematics is a popular major at NC State, attracting diverse and high-quality students; about sixty-five students graduate with a B.A. or B.S. each year, and about one-third attend graduate school. "The faculty cannot help being inspired by our best students, who go on to graduate work at top-rated universities, in mathematics and related fields," Shearer remarked. At the graduate level, the professional development programs provide a forum in which faculty give advice and answer questions about careers, applications, organizing the final year of graduate study, and so on. "The faculty are inspired by seeing the students benefit from these sessions," he said.

There is no question that faculty morale is also raised by such tangible benefits as the new building and the grants the department holds. In addition to those held by individual faculty members, the department has grants from such NSF programs as Research Experiences for Undergraduates, Mentoring Through Critical Transition Points, Research Training Groups, and S-STEM, as well as from the National Security Agency. Monetary support for graduate students, including through the summer REG program, helps the students feel valued and included. Many graduate students are supported on research assistantship positions from faculty grants. Those who are supported on teaching assistantships are not simply let loose in front of a classroom but are given careful guidance in developing their teaching skills.

On top of all the achievements mentioned so far, the department also excels in the recruitment and retention of students from underrepresented groups. One indication of this success is the percentage of female graduate students, which has steadily increased from its historic average of around 33 percent to its current level of

49 percent. In addition, in the last ten years more than ten African-American students earned Ph.D.s in the department. If that number sounds low, one must consider that between 2002 and 2007 the number of African-Americans receiving mathematical sciences Ph.D.s across the nation has ranged from ten to seventeen each year. The department has also awarded Ph.D.s to several students of Hispanic origin, as well as to two students of Native American origin. The picture is similarly impressive at the undergraduate level, where approximately one-quarter of the graduates come from underrepresented minorities. Among schools that are not historically black institutions, the NCSU department consistently ranks high in producing graduates who are from underrepresented minorities.

The department is stepping into the national arena to increase diversity in the mathematical sciences. Helminck spearheaded a new program, funded in late 2009 by the NSF, to provide postdoctoral positions specifically for minority Ph.D.s. The program allies the NSF-funded mathematics institutes and seven universities with good track records in producing Ph.D.s drawn from underrepresented minorities. The program will provide four three-year postdoctoral positions consisting of two years at one of the universities and one year at one of the institutes. "We believe this program will be very important in getting more minority faculty in Group I and Group II institutions," Helminck said.

This is a department that manages to do it all—research in a broad range of areas, outstanding teaching and mentoring, strong ties to industry, and a welcoming environment for underrepresented groups. A recent evaluation called the department "a nationally and internationally visible jewel". What is the secret to its success? There is none, said Singer. "It's not something magical. It's commitment and hard work."