Undergraduate Students Experience Research Firsthand at Nipissing University

Andrew Dean and Murat Tuncali
Nipissing University, North Bay, ON

Nipissing is a university in Northern Ontario where the development of synergies in the mathematics department has led to unusual strengths in research, teaching and student involvement.

It is the smallest university in Ontario. Situated in North Bay, about 3.5 hours north of Toronto, it was founded in 1967 as Nipissing Liberal Arts College affiliated with Laurentian University in Sudbury. On its silver anniversary in 1992, the Nipissing University Act was signed into law and it received its charter as a university. At this time, it was quite small and operated without academic departments. The disciplines were grouped into four broad divisions: Humanities, Social Sciences, Geography/Science and the School of Business and Economics. Not until 2001 did Nipissing University's Faculty of Arts and Science adopt a formal departmental structure and the Department of Computer Science and Mathematics come into being.

The university has a long history of educating teachers and the majority of students who attend as undergraduates plan to go to teachers' college. But in the past few years, the university has seen substantial growth in all areas of arts and science. Many students are planning to go to graduate or other professional schools. There has also been a major increase in research, and plans are underway for Masters degrees in a number of areas.

Just as Nipissing is small, so is the mathematics department. There are four fulltime permanent faculty, one limited term contract faculty and a number of part-time teachers. But the department has a healthy number of students with over 70 majors, most of whom are doing honours degrees. The department offers nine different degrees, including a concurrent degree with the Faculty of Education.

The department is very research-focussed and has established a well-known research cluster in the area of topology. From his initial arrival in 1991, Dr. Murat Tuncali has kept an active research program in this area, mainly in continuum theory. He organized workshops and seminars in North Bay, and in 1997, Nipissing hosted the international Twelfth Annual Seminar Conference on Topology and its Applications. Since this conference, Nipissing has partnered with Auburn University in publishing the journal *Topology Proceedings*.

When the time came to add another faculty member in mathematics in 2002, an important strategic decision was taken. Rather than hiring someone from a different area as would have been normal, a conscious choice was made to establish a niche area in topology. This resulted in the appointment of Dr. Vesko Valov. With the introduction of the Honours Mathematics Program in 2003, Dr. Alex Karassev was added to the department, further consolidating the topology research cluster. Last year, the department became the only mathematics department in Ontario without a graduate program to become an affiliate of the Fields Institute. Plans are underway to hold workshops on topological methods in algebra, analysis and dynamical systems in May, 2008 that will be partially funded by the Fields Institute.

For three years, using NSERC grant money and support from the University, Professors Karassev, Valov and Tuncali were granted full course releases and brought in visiting scholars: Taras Banakh in 2004/5, Andriy Zahorodnyuk from Lviv, Ukraine in 2005/6 and Pawel Krupski from Wroclaw, Poland in 2006/7. These scholars enhanced the research culture and exposed students to new ways of thinking, showing them how universal mathematics is.

The undergraduate program

The increased focus and dynamism of the department inspired the students. With the introduction of the honours degree in 2003, more students have been heading off to graduate school and winning NSERC scholarships. Because the course offerings are relatively limited, the faculty have made special efforts to involve upper-year students in research projects. Each summer, the department uses USRA (NSERC Undergraduate Student Research Awards) funding and internal research grants to employ a number of them.

Each honours student must complete two three-credit courses of independent research. The students apply for them in third year and are expected to do some preliminary research on a topic before submitting their application. Once the topics have been agreed upon, the students are paired with professors as mentors, whom they usually meet once a week during the term.

At the end of the term, students submit written reports and make twenty-minute oral presentations of their work to their fellow students and professors. The grade is based on work done during the term and the quality of the presentations and the report. All mathematics majors are invited to the presentations and refreshments are provided. Last year, with the double cohort graduating, there were 21 projects completed in the fall term and 17 in the winter term. Presentations occupied two days in each term.

Topics of the projects last year included generalized Fibonacci sequences, applications of topology in chemistry, quantum mechanics, area-preserving transformations and map-making, and voting systems. The expectation is that each student study a topic not covered in any course and be able to internalize and present it. In 2005, the department went through a standard external review. The reviewers spoke very positively about the research experience of the undergraduate students: "The department runs regular seminars that upper year students attend. It was clear in talking to the students that this had a significant positive impact on their understanding of the nature and spirit of mathematics."

The students

The mathematics program has a good reputation locally; some of the best students have come from the vicinity. Last year's winner of the Governor General's Silver Medal (highest graduating average from an undergraduate degree) was Nick

Mailloux from a rural community near Sudbury. He obtained an NSERC graduate scholarship and is pursuing a Masters in Cryptology at the University of Ottawa. Nick writes:
The faculty members are truly dedicated to helping the students succeed. Although the professors are specialized in their own particular areas of preference, they are well educated in many areas of mathematics. With such a broad range of knowledge, they can accommodate the research interests of all the students. In my personal experience, my research supervisor was not completely familiar with my particular area of study. With my best interests in mind, he studied the topic on his own, ensuring that he could offer me the best possible assistance in my research. This shows a level of dedication that is rarely seen in larger universities.

Natasha May is from Huntsville, ON, 100 km south of North Bay. She completed her undergraduate degree in 2005 and finished her Masters degree at York University in 2006. She is now enrolled in a doctorate program also at York.
At Nipissing, there was much exposure to the research of math professors and other great mathematicians from around the world, through seminars and workshops. I benefited from the wide array of research covered because the introduction to different areas of research in mathematics helped me to discover my interests and abilities.

Kaitlyn Church, from the small nearby community of Powassan, is pursuing a Masters degree at the University of Ottawa in category theory.
In creating a welcoming environment for students to attend weekly research seminars, which focussed on current research, more students were exposed to higher-level mathematics in a supportive environment, which is crucial to learning and creating a desire to participate in research. In addition, all students were welcome to attend the yearly topology conference held at Nipissing, where we could see the benefits of conducting and sharing ideas and research areas. Through inviting outside mathematicians who were collaborating with the professors, students were exposed to the community aspects of research, and how outside collaboration greatly benefits research.

Jill Lazarus started her undergraduate degree with the intention of going into the consecutive B.Ed. program upon graduating. She was involved with a research project, jointly supervised by mathematics and education faculty, that analyzed the current high school mathematics curriculum. Upon graduation, she was accepted into the M.Ed. program at Queen's University. Jill reports:
All of the research experiences, and particularly my work with curriculum analysis projects, have influenced my decision to pursue graduate studies in mathematics education.

Outreach

In 2005, the mathematics department, the Faculty of Education and local mathematics teachers collaborated on a project, *NUMERIC* (*Nipissing University Mathematics Education and Research Information Council; see http://www.nipissing.ca/numeric/index.asp*). The purpose is to develop a community of mathematics in North Bay. Council activities include mathematics competitions, mathematics fairs and talks aimed at the high school level. In October, Dr. Karassev delivered a talk to about 25 students entitled, "Why do we need four dimensions?" *NUMERIC* keeps a database of students who are willing to volunteer their time to work with local high school students in any area of mathematics. Our students have been actively involved in helping teachers maintain their mathematics clubs.

The department has operated a mathematics drop-in centre since 1992. Similar to those at other universities, it is staffed by upper-year students and is used mainly for tutoring and help with assignments. On any given day, there may be as many as twenty-five students seeking assistance. But the room has taken on a life of its own; it has become a "home" for mathematics students, and many majors simply stay put there. There are chess and Go sets, and a small set of reference books and journals. Almost all seminars and upper-year classes are held in the room. While the room is officially known as A223, it is usually just called the "math room" on campus.

Conclusion

Many students graduating from the mathematics program will become high school teachers. Fundamental research in mathematics may not be important in their future. But the department believes strongly that by having seen and experienced research as students, they will have a greater appreciation of mathematics that they will be able to pass on to their own students. The research component in their degree lets them see that mathematics is a continually evolving subject related to many diverse areas. Moreover, because of *NUMERIC*, it would be possible to provide an opportunity for those students who are going to be teachers to do research projects related to mathematics education. Some of the ideas for collaboration among mathematicians and education faculty were presented at the conference on "The Mathematics Education into the 21st Century Project"[1]. We are currently in the process of implementing these ideas.

As Nipissing University grows, so does the mathematics program. The department works closely with its colleagues in computer science; new courses in computational geometry and game design are being introduced and cross-listed between the two departments. Preliminary plans are underway to develop a Masters program.
The department feels very fortunate to have had so many good and keen students over the past five years, and believes that an active research component is essential for an honour degree. Both professors and students have created a dynamic department in which doing mathematics creates new opportunities for research, teaching and further study.

Footnote

[1] Douglas Franks and H.M. Tuncali, Building a relationship between undergraduate mathematics and mathematics teacher education: innovation in teacher education. The Mathematics Education into the 21st Century Project, Seventh International Conference, "The Future of Mathematics Education", June 26 – July 1, 2004, Ciechocinek, Poland.

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FROM THE VICE-PRESIDENT'S DESK

Gordon MacDonald
University of Prince Edward Island, Charlottetown

"My math teacher says a square is not a rectangle," said my niece last year, once again complaining about her teacher's grasp of basic math. I had heard similar comments for the previous two years as she had the same math teacher in both Grade 7 and Grade 8. This time she wanted some action taken: she wanted me to write her teacher a letter explaining why a square is a rectangle. The word of a math professor at UPEI would surely carry some weight.

After some cajoling, I agreed to write the letter. I kept it friendly, explained that if we agree that the definition of rectangle is a quadrilateral with four equal interior angles (hence each of 90 degrees), then a square is obviously a rectangle. I prefaced my discussion by saying that I thought this was probably just a misunderstanding and concluded by saying that if he wanted to discuss the issue further, feel free to contact me.

I thought that would be the end of the matter, and was quite surprised when I got a phone call from the teacher a week later. Our conversation

Math Education on PEI

was very cordial; he told me that he thought my niece was an excellent student, but in this case she had misunderstood, and that he indeed knew that a square was a rectangle. Just as we were wrapping up our conversation he said: "While I have you on the phone, I have a question for you. How many axes of symmetry does a rhombus have?"

I was very careful in responding, since I was not sure if he was trying to trip me up to exact some small measure of revenge for the letter. "My definition of rhombus is a quadrilateral with sides of equal length," I began. He agreed that was a good definition.

We then agreed on the definition of an axis of symmetry of a planar object: *a line in the plane about which the object can be reflected without changing shape of the object*. "So a square is a rhombus," I said. (I was stalling for time looking for any errors in the answer which was forming in my head.) He agreed a square was a rhombus.

"Excluding that special case, the answer is obviously two ... the two lines which extend the diagonals of the rhombus."

"OK," he responded. "The reason I asked is that the answer in the back of the book is one, but when I called the math expert at the Department of Education, they said the answer is three."

If you modified the definition I could see how three was possible, but I could not think of any definition which would allow one as the answer. "But if you agree with our definitions, the answer is clearly two ... right," I insisted.

There was some hesitation and then "yes, I see that now... thanks for your time."

That was that, or so I thought. A few days later I saw my niece again and asked her how math class was going. She told me that there had been little fall-out from my letter, but that the teacher had taken her aside and told her that she had misunderstood him, and that a square was indeed a rectangle.

Moving on, I asked her, "So, how many axes of symmetry does a rhombus have?"

"Well, I think the answer is two," she said. "*But the teacher says the answer is one, two, or three!*"

What is the problem?

Last Fall, the latest PISA

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