

ENHANCING MATHEMATICS TEACHER PROGRAMS AND RESPONDING TO THE SHORTAGE OF MATHEMATICS TEACHERS

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ABSTRACT

Through the Department of Mathematics the author has spearheaded many innovative courses and programs to improve the mathematics education of future teachers at all levels. This work has been recognized by a joint appointment to the Brock Faculty of Education. As co-chair of the Mathematics Education Forum of the Fields Institute for Research in the Mathematical Sciences, he has motivated strategies to address the shortage of mathematics teachers in Ontario. This presentation will consider the following: Too many middle school teachers in Ontario show a lack of understanding of and enthusiasm for mathematics. In 1990 the Mathematics Department, with the collaboration of other Science Departments and the Faculty of Education, instituted a unique program for middle school teachers. To teach at the secondary level in Ontario an individual must present two subjects, a first teachable (a minimum of six university courses) and a second teachable (minimum of three university courses). Half of the teachers in Ontario teach mathematics with a second teachable qualification and with mathematical experiences gained in Service Courses. The Department of Mathematics has reviewed its programs and opened appropriate courses to students wanting mathematics as a second teachable. Teacher education in Ontario is principally consecutive, namely, teacher candidates apply to a Faculty of Education after a first degree. There are no mathematics requirements to qualify for elementary school teaching in Ontario. The author has instituted a mathematics course for future elementary teachers who did not complete their high school mathematics. This course is now required by the Brock Faculty of Education.

Ontario is facing a shortage of mathematics teachers. For three years, the Mathematics Education Forum of the Fields Institute has been developing strategies to address this concern. It is hoped that the sharing of these developments will help others to implement changes within their own educational systems.

Introduction

In Canada education is a provincial responsibility and in Ontario teacher education follows a consecutive model, where future teachers first complete a university degree and then apply to a Faculty of Education. Therefore the normal pattern is a three or four year undergraduate degree followed by one year in a Faculty of Education after which one is certified to teach in the Province of Ontario. Admission into Faculties of Education is based on a number of criteria including marks achieved in the undergraduate program, a portfolio, and undergraduate discipline requirements. For most programs in these Faculties there are far more applicants than positions and students must present an average of at least 75% in their undergraduate program. A portfolio outlines experiences with children, in schools, in camps, in tutoring situations, etc., and this can account for as much as 40% of the admission mark. Undergraduate discipline requirements depend on the school level certification. For the purpose of this presentation we shall summarize and simplify these requirements into elementary, middle, and high school certification. There are no subject specific requirements for elementary school certification and teachers are home-room teachers responsible for most disciplines. A minimum of three courses¹ in one subject taken from a list of 'teachable' subjects is required at the middle school level. These 'teachable' subjects include those that one would normally expect. Teachers at this level also teach across most disciplines. At the high school level candidates must present a minimum of six courses in one of a list of 'teachable' subjects and at least three courses taken from another subject from that list.

The consecutive teacher education model carries with it a number of implications for university mathematics departments and for groups interested in mathematics education. At the elementary level, mathematics departments need to be pro-active and offer a specially designed mathematics course, otherwise the present situation will continue where the great majority of elementary teachers enter their teaching career with very little understanding of mathematics, and how to teach it as a living discipline. Mathematics departments should be even more concerned about the mathematics background of teachers at the middle school level. Unfortunately very little has been done. In middle school students start to make the transition from arithmetic to algebra, in geometry they move from the visual/observational to the descriptive/analytical/relational, and they start their experiences in probability and data analysis. Middle school teachers need understanding of mathematics beyond an ability to perform a set of algorithms. At first sight undergraduate mathematics programs for secondary school teachers appear to be less problematic. But are they? Are mathematics teachers taking appropriate mathematics courses for their future career? Are they getting a breadth of experience in mathematics? What about future teachers who have a major in another discipline and have a minor of three courses in mathematics? Now that Ontario is experiencing a shortage of graduating teachers of mathematics, future teachers with mathematics as a minor will surely end up in a mathematics classroom. Are these future teachers selecting courses that provide a breadth of experience in mathematics and that present mathematics as a living discipline? Or is their mathematics a compendium of techniques? Do they understand what mathematics is and what

¹ A course in this context is a full year course.

mathematicians do? In this paper we present some of the initiatives that the Department of Mathematics at Brock University has implemented to address these many concerns.

Ontario has always had a shortage of middle school teachers who have any undergraduate background in mathematics. Recent data shows that Ontario is starting to experience a shortage of mathematics teachers at the high school level. Over the next five to ten years, and at the present rates of graduation, the number of new teachers is projected to meet only forty four percent of the demand for new mathematics teachers. This has implications for the government, for faculties of education and for departments of mathematics. The Mathematics Education Forum of the Fields Institute for Research in the Mathematical Sciences has undertaken a number of initiatives to address this concern.

Initiatives at Brock University

Brock University is a publicly funded university with just over twelve thousand undergraduate students. The Department of Mathematics plays a fundamental service role to many disciplines in the university and has an Honours program which attracts between twenty and thirty first year students each year. It also has joint programs with other disciplines and plays an active role in teacher education. In all courses and programs, students and faculty make extensive use of technology. Maple is used starting in the first year. In Statistics, Minitab and SAS are used. “Journey Through Calculus” and Geometer’s Sketchpad provide learning tools in appropriate courses. The Honours Program is called MICA – Mathematics Integrating Computers and Applications. Within this Program students may select concentrations in Pure Mathematics, or Statistics, or Teacher Education, or others.

In the late eighties the author turned his attention to teacher education, especially to the education of future middle school mathematics teachers. Middle school mathematics plays a pivotal role in the the development of individual’s understanding and progress in mathematics. Students start their transition from arithmetic to algebra, in geometry they move from the visual/observational to the descriptive/analytical/relational, and they begin experiences in probability and data analysis. To enhance the education of future middle school teachers in mathematics a Concurrent Program was developed on collaboration with members of the Faculty of Education and other members of the Faculty of Mathematics and Science.

In 1990 thirty students were admitted to this special program where they would do mathematics, science, and education concurrently. From the point of view of attracting students the timing was perfect. Mathematics and science graduates were finding it difficult to get places in Faculties of Education, because these Faculties had reduced the weighting on undergraduate program marks and had increased the weighting on the portfolio – evidence that applicants have worked with children or peers. In the Ontario context a Concurrent Program is attractive to students who aim to become teachers because the program guarantees them a place in Brock’s Faculty of Education provided they continue to meet certain conditions involving marks, course selection, and so on. As expected the Concurrent Program continues to attract very good applicants, students who are interested and motivated in mathematics and science, and students who have a real desire to become teachers. Admission is done on the basis of marks and a letter that outlines the applicant’s interest in teaching as demonstrated by activities with children or peers. The Program is highly structured and is demanding in its diversity of emphases. Students’ have access to a Program director and a Program coordinator. The formation of peer groups is, for some students, the major reason for their success in the Program.

Professors report that concurrent education students form a real identifiable community, not only because they know each other and take most of their courses together, but also because they are proud to be in the Program. Members of faculty enjoy the dynamics that these students generate in their mathematics classes. They are eager to share their knowledge and are ready to ask questions. The Program consists of six (full year) courses in mathematics, three in different sciences, a number in education, one in child and youth studies, one in psychology, and one selected from the humanities. It aims to provide a breadth of experience while it retains a concentration in mathematics. Students must maintain a 75% average. In mathematics the students are exposed to different areas of mathematics, that include calculus, linear algebra, discrete mathematics, combinatorics, probability, statistics, geometry, applied abstract algebra, geometry, history of mathematics and teaching/learning mathematics at the middle school level.

There are many enrichment possibilities. Students can instruct in the annual Brock University residential mathematics and science camps organized for over 2000 middle school students in May and June. They can instruct in an annual camp for Aboriginal students, and in a camp for top Ontario grade 9 and 10 mathematics students. They can help in local and regional Science Fairs, and can participate in a government-sponsored program called "Tutors in the Classroom". Parents from the region can draw for assistance from the list of mathematics tutors maintained by the Department.

Over eight hundred students have graduated from this Concurrent Program and school boards are approaching the University specifically for these graduates. Because these students have completed enough mathematics and science courses to qualify for high school teaching a small number upgrade their teaching certificates. In general however most of them are teaching at the middle school level and are rapidly taking leadership roles with other teachers in their schools.

I believe that this Program is an example where a small but consistently implemented change can produce quite an effect in the educational system as a whole. I have tended to shy away from innovations that will not be sustained by the Department of Mathematics. When I started introducing technology in the mathematics courses in the mid-eighties most of my time was spent getting other faculty on board. There are too many examples of innovative courses and programs in departments of mathematics that have collapsed when the sustaining faculty member has moved out of them.

The Concurrent Program for future mathematics teachers at the middle school level suggested that the Department should play a more important role in the preparation of future mathematics teachers at the high school level. The Department extensively advertised the shortage of mathematics teachers and developed appropriate packages of mathematics courses for them. Finding an appropriate set of courses for majors was not difficult. What was a challenge was the selection of appropriate courses for those students who would be majoring in another discipline and would be seeking to complete three mathematics courses. The looming shortage of mathematics teachers would make it certain that these graduates would be placed in a mathematics classroom. While doing this, the Department of Mathematics also identified three appropriate courses for future middle school teachers, not in the Concurrent Program, who would be selecting mathematics as their 'teachable' subject. Whereas for high school teacher preparation it would make sense to require calculus and linear algebra, for the middle school level it would not be appropriate to allocate one and a half courses out of three to these two areas. The prerequisite structure of upper year mathematics courses made this a real challenge. Students without Calculus and Linear Algebra would not have access to courses in the history of mathematics nor to courses in geometry, two essential areas of mathematics for future teachers at the

middle school level.

Three years ago the Department of Mathematics decided to completely review and restructure its curriculum. Although technology was the main, opening up courses to more students was another reason. The review had three objectives. It analyzed the impact that the availability of technology in every course had on curriculum and sequencing of mathematical concepts. It seriously explored what it meant to teach mathematics in this new environment, and it made every effort to open up the prerequisite structure of courses. The impact for future teachers was the splitting of both the geometry and the history of mathematics course with their first half not requiring calculus and linear algebra. The history of mathematics course at Brock is particularly useful for future teachers as it is sequenced historically and students do mathematics within the mathematical constraints of the time. Although one can always improve the content and approach in courses if they were only for future teachers, the Department of Mathematics believes that it has done the best it can with the resources it has.

The focus on future teachers at the elementary level is very much the author's interest and is informed by his cross appointment to the Faculty of Education. For the past two years I have been teaching a mathematics course for students who have not completed their high school mathematics but are hoping to teach at the elementary level. The prerequisite for this course is failure or an incomplete program in mathematics at the high school level. The course runs as a set of workshops using hands on materials and using Mason (1) type problems that the class works on until everyone is able to explain to a peer how they have completed the activity and understood the mathematics. The students are encouraged and coaxed to ask questions, to make hypotheses and not to get emotionally attached to them, to look for generalizations, to explore the nature of mathematics, to do simple mathematics in different ways, to consider how mathematics at the elementary level empowers students to do mathematics at higher levels, and to do explorations in a non-threatening environment. I get a lot of satisfaction from the noticeable progress of the majority of these students. By the end of the course most of them are able to work on substantial mathematical problems and they are capable to translate their understanding of mathematics as a human endeavour to the mathematics they will be teaching.

Initiatives by the Fields Mathematics Education Forum

The Fields Institute for Research in the Mathematical Sciences has mathematics education as one of its mandates. It achieves this responsibility through a Mathematics Education Forum that brings together individuals from universities (both from departments of mathematics and from faculties of education), from colleges, schools, industry and from business. The Forum is Chaired by the author and it has developed and completed a number of mathematics education initiatives both at the Provincial and National levels. One of the initiatives was to address, through the work of a Task Force, the looming shortage of mathematics teachers in Ontario. Because the Forum has a wide representation, it has a certain standing among communities that can impact the problem. The Task Force identified a number of aims. The first was to make Faculties of Education aware of the problem so that they may increase the intake of students who present a concentration of mathematics courses in their undergraduate degree. The second aim was to encourage departments of mathematics to reflect on their responsibilities for the education of future teachers. The Ontario consecutive model of teacher education will be most effective when departments of mathematics, within their programs, provide opportunities for future teachers to reflect on their learning of mathematics and when they offer

environments that model good teaching practice. Future teachers benefit from a diversity of mathematical experiences that arise in courses from a variety of mathematical areas. They also benefit from the experience of different assessment practices. If these undergraduates have opportunities to tutor, to work in groups, and to assist teachers in schools, they will develop a better understanding of what teaching is all about. The third aim of the Task Force was to develop an advertising campaign directed at students in schools, colleges and universities. For this a Website (2) was developed and a poster advertising this site was sent to every Ontario high school, college and university.

Conclusions

The consecutive model of teacher education in Ontario provides opportunities for university departments of mathematics to influence and improve the mathematics preparation of future teachers. However to do so departments have to be proactive and have to consider what mathematics courses are most appropriate for future teachers at different school levels. Unfortunately few university departments of mathematics have been proactive and the number of applications to faculties of education by students who have mathematics in their undergraduate degree is insufficient to meet the demand for teachers of mathematics. The Department of Mathematics at Brock University has developed some innovative courses and programs for future teachers. The Mathematics Education Forum of the Fields Institute for Research in the Mathematical Sciences has and continues to address these concerns.

REFERENCES

1. Mason John, with Burton Leone, and Stacey Kaye, "Thinking Mathematically", Addison-Wesley, 1982
2. Web site of Mathematics Education Forum of the Fields Institute for Research in the Mathematical Sciences www.fields.toronto.edu/programs/mathed/ and the site advertised to students interested in becoming teachers www.daretocount.org/