Enhancing Mathematics Programs for Future Teachers

Eric Muller
Brock University

Abstract

Innovative mathematics courses and programs for future teachers at all school levels are presented. These include a course for future elementary school teachers who have no confidence in their ability to do mathematics, specially designed mathematics minor and major programs for future teachers in consecutive education programs, and concurrent education programs that integrate the undergraduate and education components. An initiative to address the shortage of mathematics teachers in Ontario is also described.

Teacher Preparation Models

In Ontario, teacher education is normally based on a consecutive model, where a student completes an undergraduate degree and follows it with one year in a Faculty of Education for a B.Ed. degree and teacher certification. Admission into Faculties of Education is based on a number of criteria, including grades achieved in the undergraduate program, a portfolio, and discipline requirements. A portfolio describes experiences such as helping teachers in schools, summer camps, and tutoring. Undergraduate discipline requirements vary and depend on the school level for which certification is being sought. For the purpose of this paper we shall classify these requirements into elementary, middle, and high school certification. There are no subject-specific requirements for elementary school certification, as teachers have the same students for most of the school day and teach a majority of school subjects. At the middle school level, teachers also teach across most subjects. However, for certification they must have at least three courses taken from a list of “teachable” subjects (subjects

Eric Muller is a Professor of Mathematics and Education at Brock University, as well as a Fellow of the Fields Institute for Research in the Mathematical Sciences. He has contributed greatly to elementary education by assisting teachers to overcome math phobias and to understand the nature of mathematics.
E. Muller

designated as part of the official curriculum). Teachers at the high school level are subject specialists and normally have six courses in one teachable subject and three courses in another.

The consecutive teacher education model assumes that subject-specific education is part of the undergraduate degree and therefore, for mathematics, the responsibility falls on university departments of mathematics. The great majority of Ontario elementary school teachers have no university mathematics experience. To change this situation, departments of mathematics need to be pro-active and offer specially designed courses. Because many future elementary school teachers find mathematics scary, courses have been designed to develop not only their understanding, but also their confidence and enjoyment of mathematics. At the middle school level as well, few teachers hold mathematics as a teachable. What can departments of mathematics do to change this situation? What set of mathematics courses would be attractive and useful?

At first sight, undergraduate mathematics programs for secondary school teachers appear to be less problematic. But are they? Are mathematics majors taking appropriate mathematics courses that provide a breadth of experience in mathematics? What about students who select mathematics as their second teachable; are their mathematical experiences sufficiently rich?

The Department of Mathematics at Brock University has addressed these many questions by developing packages of mathematics courses offered within concurrent teacher education programs.

**Mathematics for Future Middle School Teachers**

In the late eighties, the mathematics education of future middle school teachers became a concern, because few of them were selecting mathematics as a teachable. Furthermore, the middle school years are particularly important because it is during this time that students make a transition from arithmetic to algebra and are introduced to probability and data analysis, while in geometry they move from the visual/observational to the descriptive/analytical/relational. Without excellent teachers, many of them flounder. From a practical point of view, we needed a middle school mathematics-teaching program that would attract students. Moreover, while we were developing this program, admission requirements in Faculties of Education were changing and a greater emphasis was being placed on a portfolio showing teaching or related experience. Mathematics graduates were finding it more difficult to compete with graduates of other disciplines who had experience with children as a component of their undergraduate programs. For this reason, a program that carried some
guarantee of admission to the Faculty of Education would likely be attractive to future middle school teachers. With the collaboration of the Faculty of Education, a concurrent education program was established and launched in 1990. This concurrent program intertwines the undergraduate and teacher education components and therefore allows future teachers to reflect both on the discipline and on its teaching and learning. It appears that the time was right and that the rewards were sufficiently enticing as the program attracted, and continues to attract, very talented high school applicants, students who are interested and motivated in mathematics, and who have a real desire to become teachers.

The concurrent education program consists of six and a half full-year mathematics courses, three in the sciences, several in education, one in child and youth studies, one in psychology, and one selected from the humanities. The students are exposed to different areas of mathematics that include calculus, linear algebra, discrete mathematics, combinatorics, probability, statistics, geometry, applied abstract algebra, history of mathematics, and teaching/learning mathematics at the middle school level. The last four courses were designed to give the students a breadth of mathematical experience.

The program has demanding cross-disciplinary requirements, and many good mathematics students have difficulty with the content and expectations of courses in other disciplines. Furthermore, they feel the pressure of marks as they must maintain a 75% average. Two factors appear to contribute to a high retention rate. When the students arrive at Brock University, the Department works with them to form peer groups, and during their time at the university, an Office of Concurrent Education Programs initiates and provides continuing guidance and support. Professors report that these 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 this program. Faculty also note that these students are eager class participants. This is reflected in their success, as every year approximately 80% of them appear on the Dean’s Honours list.

Many enrichment activities have been developed for concurrent education students. They can instruct in the annual Brock University residential mathematics and science camps, which consistently attract over 2000 middle school students in May and June. Concurrent education students can instruct in an annual camp for Aboriginal students, and may provide leadership in a camp for top Ontario Grade 9 and 10 mathematics students. Opportunities are available to help in local and regional Science Fairs, and to participate in a government-sponsored program called “Tutors in the Classroom.” Many of
these students place their names on a tutors’ list maintained by the Department of Mathematics for parents from the Niagara region.

Over the years, more and more students in other programs have requested permission to take mathematics courses designed for concurrent education students. These requests were from students who did not have a background or interest in the sciences, but who knew they would be expected to teach mathematics in middle schools. The Department wished to do more to help these students achieve their goal. A second concurrent education program was therefore developed for students aiming for a middle school teaching career. This “generic” program is substantially different from the one previously described with its emphasis in the sciences. The Department of Mathematics had previously struggled to define a trio of courses for future middle school teachers. In a package of three courses for high school teachers, one can provide arguments for a full-year calculus course and a half-year linear algebra course. However, these arguments are far less convincing in the case of middle school teachers. In addressing this problem the Department was forced to look at the prerequisite structure of its courses. The review had three objectives. It analyzed the impact that technology has on curriculum and sequencing of mathematical concepts. It explored what it meant to teach and learn mathematics in this new technological environment, and aimed to open up the prerequisite structure of courses. One of the many consequences of this review was the splitting of the full-year geometry and history courses into half-year courses and with their first halves not requiring calculus and linear algebra. This opening up of the prerequisite structure has worked well. Students in the middle school concurrent program select six mathematics half courses covering such areas as discrete mathematics, geometry, history of mathematics, statistics, and teaching/learning mathematics at the middle school level. There have been strong benefits. For example, the number of inquiries to take mathematics courses by students in other teacher education programs has increased substantially.

Preparing for High School Mathematics

Meanwhile, the McIntyre (1998, 2001) studies were predicting that Ontario would soon be facing a shortage of high school mathematics teachers. This situation motivated the development of a generic concurrent education program for future high school teachers, with ten and a half courses in the first teachable, usually mathematics or sciences. The Department of Mathematics fit easily into this model with two packages of mathematics courses, one for students
choosing mathematics as a first teachable and another for those selecting mathematics as their second teachable.

**Preparation for Elementary Teaching (K-6)**

Recently, my focus has turned to mathematics education for the elementary school level. For the past four years, I have offered a course for future elementary school teachers who have had little success in mathematics and who have no confidence in their mathematical abilities. Even in the realm of mathematics courses for elementary school teachers, this course is non-traditional in content and approach. It runs as a set of in-class workshops where students use hands-on materials and work on substantial mathematical problems of the type developed by Mason, Burton, and Stacey (1982) in their book *Thinking Mathematically*. Most of the time, students work in groups. They are encouraged and coaxed to ask questions, to make mathematical hypotheses and to not get emotionally attached to them, to look for generalizations, to reflect on the nature of the mathematics they are doing, to do arithmetic, geometry, probability and data management in different ways, to consider how elementary mathematics empowers students to do mathematics at higher levels, and to explore mathematics in a non-threatening environment.

The students’ journals show a real progression. They start the course with a fear of mathematics that for some is quite intense, and they finish the course having built up their confidence to work on substantial mathematical problems, and with a new view of mathematics as a human endeavour in which algorithms play a role that is to be subsumed in understanding. In 2002/2003, one of the 49 students who started the course withdrew, one failed and the great majority did very well. Their performance was assessed on the basis of attendance, a journal, two class presentations, two tests, and three assignments taken from the course textbook. Starting in the fourth week of class, students are assigned readings and problems from the text and although this content is not explicitly covered in class, it is encountered in many of the class activities.

Students who successfully complete this course will be ready to contribute to the most recent Ontario mathematics initiative at the elementary level. They will have experienced and worked through many of the situations highlighted by an Expert Panel Report (2003) *Early Math Strategy*. As individuals, they will have reflected on the prior knowledge they brought to their group and to the class, they will have looked for connections to this knowledge, and they will have developed their new mathematical knowledge by doing and talking. Each one will have made the transition from negative to positive attitudes and beliefs in mathematics. As a class they will have built a
community of mathematics learners. They will have experienced an environment that provided sufficient time to solve problems and where they used concrete materials to aid understanding.

To conclude, let me briefly describe an initiative that I was involved in and which aimed to increase the number of mathematics teachers in Ontario. One of the mandates of the Fields Institute for Research in the Mathematical Sciences is mathematics education. It has established a Mathematics Education Forum that brings together individuals from universities (from departments of mathematics and from faculties of education), colleges, schools, industry and business. Through a number of mathematics education initiatives at the provincial and national levels, the Forum has gained the respect of those communities that impact mathematics education at all levels. One of the Forum’s Task Forces addressed the shortage of mathematics teachers in Ontario and developed the following actions. Faculties of education were made aware of the situation and it was suggested that the intake of future mathematics teachers should be increased. Departments of mathematics were encouraged to explore ways to motivate mathematics students to become teachers by providing them opportunities to reflect on their learning of mathematics and by offering them environments that model good teaching practice. To complete its work, the Task Force ran an advertising campaign directed at students in schools, colleges and universities. A “Future Teachers” (2001) website was developed and copies of a poster advertising this site was sent to every Ontario high school, college and university.

Programs instituted by the Department of Mathematics at Brock University and those undertaken by the Fields Institute’s Mathematical Education Forum are examples of small but consistently implemented changes that do have an impact on the educational system as a whole. The Ontario teacher education system requires the students to complete an undergraduate degree where they have developed their subject specialization. It is my view that the teaching and learning of mathematics in schools will be enhanced when departments of mathematics develop courses and programs specifically for future teachers.

References


