

## **Forming Partnerships to Improve Mathematics Teaching** **Rose Elaine Carbone, Clarion University of Pennsylvania**

At Clarion University of Pennsylvania, teams of mathematicians, mathematics educators and experienced secondary high school teachers are working together to develop thirteen new courses for an innovative graduate program in mathematics education. The partnerships that are being formed between Clarion University and the teachers in the surrounding local school districts model the suggestions of the Conference Board of Mathematical Sciences (CBMS) that mathematicians and mathematics educators should collaborate to improve the teaching of mathematics. [1] This graduate program offers a model for graduate study on national and international levels that can be achieved by forming local working partnerships.

The results of the Third International Mathematics and Science Study [2] show that a radical change in the content and methods of teaching mathematics will be necessary before United States mathematics students are able to be internationally competitive. The TIMSS study reveals that United States mathematics teachers are presently emphasizing procedural knowledge rather than conceptual knowledge in their daily routines of lecturing and assigning home work. This traditional approach to instruction in which students memorize rules and perform algorithmic procedures to solve routine problems is in contrast to the reform view of mathematics learning in which thinking, reasoning, communicating, and employing advanced technological methodologies are emphasized. In the new perspective, teachers lead classroom activities that are activity-oriented and applicable in real world settings. Changes in pedagogy are necessary before American students can achieve international levels. The focus of these changes should be directed toward teachers becoming facilitators of learning rather than dispensers of knowledge.

The difficulty with the actuation of this radical change in both content and methods of teaching, however, is that mathematics professionals tend to be experts in either mathematics or mathematics education. Efforts are clearly needed to develop a joint strategy that will connect these two areas of expertise. Only then can widespread improvement occur to the benefit of mathematics students. The situation is exasperated by a lack of appropriate course materials and suitable graduate programs for secondary mathematics teachers.

Gaps in the knowledge base of prospective and practicing teachers make the problem even more complex [3]. The recent research of Liping Ma [4] concludes that teachers who do not have a deep understanding of mathematics will emphasize procedures rather than concepts. Teachers must possess a deep understanding of secondary mathematics before they can successfully reform their teaching practices. Presently, undergraduate mathematics majors take numerous required courses that do not emphasize the same mathematical content that secondary teachers traditionally teach, and these prospective teachers are not instructed using models that would best present challenging mathematics to middle and high school students. Newly designed graduate courses are needed to assist teachers in a deep understanding of the high school content and in learning the methodologies required to engage their students in higher-level mathematical understanding.

There are few commercial materials available that examine the content of secondary mathematics from both a reform and an advanced understanding perspective. Those few materials, which do exist, are mainly related to the undergraduate curriculum.

The innovative graduate program at Clarion University funded through a grant from the United States Department of Education, Fund for the Improvement of PostSecondary Education (FIPSE) and Clarion University entitled *A Partnership in Preparing Master Mathematics Teachers* offers a solution to the problems presented. Thirteen new courses are being written for a new program that will address these concerns.

The teams writing each of the courses consist of partnerships of a mathematician, a mathematics educator, and a practicing secondary mathematics teacher. By creating a blend of three areas of expertise, each of the courses will include rich mathematical tasks, a focus on best teaching practices, and the practical knowledge gained from actually teaching in today's secondary mathematics classroom. Past

efforts to improve the quality of mathematics teaching did not include such a combination of content knowledge, pedagogical knowledge, and experience.

After the courses are written and prior to being taught, a national evaluation team comprised of a mathematician, a mathematics educator, and a practicing experienced secondary high school teacher, review the syllabus and materials and make recommendations for changes.

The program includes: five content knowledge courses that revisit the high school mathematics curriculum from an advanced perspective, five thematic courses, and a four core courses. In the content courses teachers learn how high school mathematics can be extended to higher-level mathematics. They learn “what comes next” for their students and become prepared to artfully explain why their students need to learn the high school mathematical concepts. The five content courses that revisit the entire secondary mathematics curriculum in the new graduate curriculum are: Pre-algebra, Algebra and Number Theory, Geometry and Trigonometry, Discrete Mathematics, and Analysis. Algebra and Number Theory is a required course. Students may select two of the other content courses for the proposed program.

The curriculum design of this graduate program is quite unique, because it weaves mathematical content knowledge from the high school curriculum with thematic courses that address reform methods of pedagogy. The thematic/pedagogy courses are: Quantitative Reasoning, Problem Solving, Modeling and Applications, Technology, and the Historical Development of Mathematics. Each of these courses addresses the content of the entire high school curriculum while the content courses weave through each of the five thematic courses. Problem Solving is a required course, and students may choose two other courses in these areas.

In addition to the innovative blend of the content and pedagogy courses, four core courses create the foundation for the program. They are: Introduction to Research, Teaching Secondary Mathematics, Curriculum and Evaluation, and the Research of Mathematics Teaching and Learning. Students learn the basis for mathematics research and acquire the statistical knowledge to design an action research project for their classrooms. The Introduction to Research course is a core course for several Master’s programs at Clarion University.

The methodology by which mathematics is taught is very important and is addressed in the program as well as being modeled by the graduate faculty. By gaining an understanding of the research in mathematics teaching and learning, and by observing the faculty actively modeling different instructional strategies in the Teaching of Secondary Mathematics course, teachers develop the ability to implement reform methods of instruction in their own classrooms. Curriculum and evaluation issues are also addressed as core competencies of the program.

The Teaching of Secondary Mathematics and the Algebra and Number Theory courses were the first two graduate courses to be designed and were taught during the summer of 2001. In the first course, students are required to implement what they learn in their own high school mathematics classes during the fall. The design of this particular graduate course entails two follow-up sessions in which teachers report on their new practices and provide evidence of changes in their instructional strategies. As the teachers shared the new ideas that they implemented in their classrooms, the partnership between the teachers and their university instructor became stronger. Through using different instructional strategies learned in the course, the teachers witnessed both improved student attitudes and performance. Partnerships also formed among the teachers in the class. They shared copies of their new lessons, supported each other’s ideas, and discussed various ways to make further improvements in their teaching. They look forward to taking another class together. One teacher commented in an interview after the course.

The best thing was collaborating with everybody else...getting ideas from the other teachers.  
Getting their ideas and knowing that everyone has the same frustrations.

Another example of the partnerships, which developed among the teachers, was during the Algebra and Number Theory class. Teachers worked together to develop projects that were applicable and appropriate in their classrooms. This graduate course did not required follow-up sessions, but the professor created a CD that each student received which provided the students with copies of each other’s projects.

These two courses were first taught as experimental courses and then were refined by the writing teams after the completion of the class. All new courses will follow the same revision process. Partnerships are presently being sought with other institutions of higher education to employ the new courses at the graduate level. The partners will then provide further feedback and suggestions on changing the courses. Clarion University is one of 14 universities in the Pennsylvania State System of Higher Education (SSHE). Conversations are being conducted with sister institutions that are interested in using some of the new course materials. In recent conversations with Indiana University of Pennsylvania (IUP), some of the members of their mathematics faculty have agreed to partner with Clarion University faculty to write three of the courses. The collaboration of a mathematics educator from one university with a mathematician from another university demonstrates how the unique graduate program might be disseminated.

The Project Directors have also shared the project materials and activities through presentations at the Joint Mathematics Meetings, the Association of Mathematics Teachers of Northwestern Pennsylvania, the Thirteenth International Conference on Teaching and Learning, the Pennsylvania Academy of Scholars in Teaching, and the Scuola Superiore G. Reiss Romoli International Conference (in L'Aquila, Italy) in search of partners during the past year. Because of these presentations, other United States universities in Texas, Arkansas, Louisiana, and New Hampshire, besides the home state of Pennsylvania, have expressed interest in the program. During the process of developing partnerships to share the new courses, further examination of the materials and course syllabii will certainly occur.

Beginning with the partnerships of the mathematicians, mathematics educators and high school teachers working to design the courses, continuing to the formation of partnerships with the teachers in the local school districts who enroll in the courses, and going on to the partnerships that these secondary mathematics teachers form with each other, the final goal of improving the teaching of mathematics is taking place. The partnerships that develop with other institutions of higher education will result in further dissemination of the program. All of the different types of partnerships that are being formed will cause an improvement in the instruction of secondary mathematics, and ultimately enhance student learning. The partnership between Clarion University and the United States Department of Education (FIPSE) is a program that could be replicated in other disciplines besides mathematics such as Science, English, and Social Studies.

Presenting the program at an international conference is a wonderful opportunity to develop international partners. We can also learn from each other by sharing our ideas to improve mathematics education.

### **References**

- [1] Conference Board of the Mathematical Sciences (2001). *The Mathematical Education of Teachers Part I*, p. 9, Mathematical Association of American/American Mathematical Society.
- [2] United States Department of Education (1998) *Improving mathematics in middle school: Lessons from TIMSS and related research* (Contract No. 4331HA710013). Washington, DC: US Department Education.
- [3] Deborah Ball, (1990). *The Understandings that Prospective Teachers Bring to Teacher Education*. *The Elementary School Journal*, 90, (4), 449-465.
- [4] Liping Ma (1999). *Knowing and Teaching Elementary Mathematics*. Lawrence Erlbaum, Associates.