The Curriculum is More than Textbooks and Technology: Project M³: Mentoring Mathematical Minds

Linda Jensen Sheffield

Northern Kentucky University, Highland Heights, USA

Project M³: Mentoring Mathematical Minds is a United States Department of Education Javits research grant project designed to provide challenging, motivational curriculum units for students with mathematical promise in grades two through six. In addition to the print materials for students and teachers, the project is designed to develop problem solving heuristics and strategies through the use of rich learning tasks, questioning strategies, hints for students having difficulties, "Think Beyond" questions to assist with the differentiation of the tasks, and verbal and written discourse.

Program Overview

In 1990, Cornbleth stated, "The curriculum is not a tangible product but the actual, day-to-day interactions of students, teachers, knowledge and milieu." Following this concept of curriculum, Project M³: Mentoring Mathematical Minds was designed to address the need for a curriculum to nurture students' mathematical promise by developing a program to challenge students to "think like mathematicians". Professional development to support teachers' content knowledge and pedagogical content knowledge was a critical aspect of the program.

Project M³: Mentoring Mathematical Minds (www.projectm3.org) is a collaborative research effort of faculty at the University of Connecticut, Northern Kentucky University, and Boston University and teachers, administrators, and third through fifth grade students in eleven schools of varying socioeconomic levels in Connecticut and Kentucky. Project M³ is directed by Dr. M. Katherine Gavin of the University of Connecticut and co-directed by Dr. Linda Jensen Sheffield of Northern Kentucky University. Funding for the project came from the United States Department of Education Javits Gifted and Talented Students Education Act. The goals of the project include:

- Creating challenging and motivational curriculum units for students
- Providing ongoing professional development for teachers
- Increasing math achievement and attitudes toward math in talented and diverse students and
- Narrowing the gap in math achievement for students with talent potential from economically disadvantaged backgrounds, those with limited English proficiency, and minorities.

To achieve these goals, 12 curriculum units of advanced mathematics for talented elementary students have been developed and field-tested in the participating schools accompanied by professional development including training institutes, embedded weekly professional support in the classroom and technical assistance.

As part of Project M³, a team of specialists in the fields of mathematics, mathematics education, and gifted education have created a total of 12 curriculum units of advanced mathematics (four units per grade level) accompanied by professional development modules. A mathematics talent pool of students was identified in each of the eleven schools (total N = 800) and the units were implemented in a variety of settings. Some of these units were also modified to use with all students across ability levels and backgrounds in differentiated classroom settings. Pre and post achievement

and attitude data were gathered using standardized and criterion referenced tests. To enhance the effectiveness of these units, extensive professional development was offered for a total of 40 teachers, including two-week summer institutes, school year professional development preceding the teaching of each unit, weekly support in the classroom, and an Internet portal (http://www.projectm3.org/) for continuous communication and dissemination of resources.

Research Questions

Research questions focused on three items: measuring the changes in mathematics achievement and attitudes for talented mathematics students after exposure to the intervention model; measuring the difference in mathematics achievement and attitudes between the experimental and comparison groups; and measuring the changes in mathematics achievement and attitudes of students exposed to modified units in differentiated classroom settings.

Identification of Gifted Students and Assessment of Potential

In order to identify, create and serve students with mathematical promise, especially those in economically disadvantaged areas, a variety of measures were used. This was in line with the Report from the National Council of Teachers of Mathematics Task Force on Mathematically Promising Students that called for a multi-pronged strategy that seeks to increase the numbers and levels of mathematically promising students by maximizing their ability, motivation, beliefs, and experiences and opportunities (Sheffield et al., 1995). Measures to identify students for Project M³ included traditional measures such as achievement tests and teacher recommendations as well as other instruments such as a nonverbal ability test and measures of creativity. Students in the program have widely divergent scores on a variety of measures. Data indicate that no single measure or combination of measures is sufficient to identify the majority of students from diverse backgrounds with mathematical promise.

Curriculum and Learning Environments

The initial group of students selected for Project M³: Mentoring Mathematical Minds were third graders who began the program in Fall 2003 and completed the program in Spring 2006 as fifth graders. The second cohort of students began as third graders in Fall 2004 and completed the program in spring 2007.

One of the most critical aspects of the program is the use of a student-centered inquiry approach that encourages students to think like mathematicians, asking questions that enable them to make sense of mathematics. Students study four units per year that were developed to add depth and complexity to the typical elementary mathematics curriculum following recommendations from the National Council of Teachers of Mathematics *Principles and Standards for School Mathematics* and based on best practices in gifted education. In each set of four units, there is one unit centered on Number, one unit on Geometry and Measurement, one unit on Algebraic Thinking, and one unit on Data Analysis and Probability. Each lesson has "Think Deeply" questions and a Mathematician's Journal that students use to develop and organize their mathematical reasoning. These questions generally follow an investigation where students are asked to delve deeply into a "big idea" in mathematics and are designed to assist students in organizing their thinking and making sense of the concept. For example, in a unit on the study of geometric shapes, a "Think Deeply" question posed to the students reads, "Miranda has made a discovery. She claims that all squares are rectangles! Do you agree or disagree? Explain your answer." This high-level question encourages students to reflect on the properties of these two shapes. They must compare and contrast their properties and in doing so organize their thinking to form classifications of two-dimensional shapes. A sample

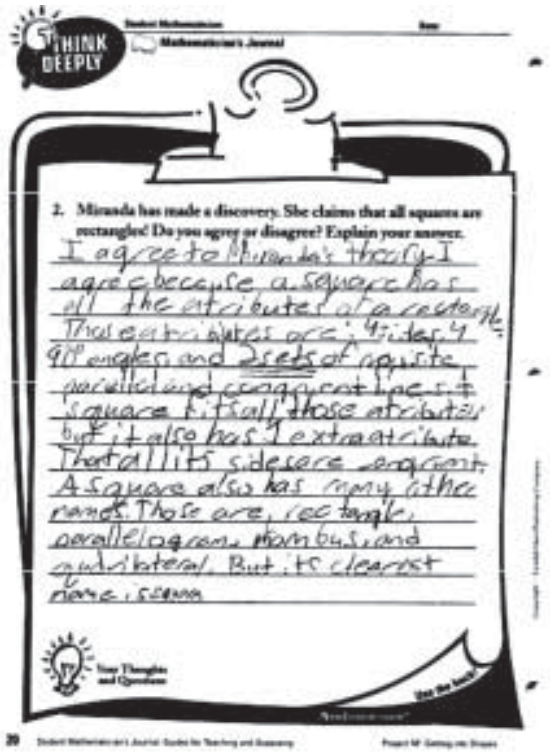

Fig. 1. A sample student response to a "Think Deeply" question.

student response is shown in Figure 1.

Students who are ready for more challenge are presented with "Think Beyond" questions that encourage them to delve more deeply into the mathematics. For example, in the lesson on shapes, students are asked to "Think Beyond" by representing the relationships among all quadrilaterals with a Venn diagram. "Hint Cards" are available for students who need more information to get started on an investigation. For example, a "Hint Card" for the shape lesson suggests that students write down all the properties of rectangles and all the properties of squares and compare them in order to get started on the "Think Deeply" question posed above.

Students frequently work with a partner and in small groups that provide stimulating and necessary dialogue to foster conceptual understanding. This is often followed by whole class discourse giving students an opportunity to further develop and consolidate their own mathematical reasoning and questioning skills as they work with classmates to develop and analyze complex skills and concepts.

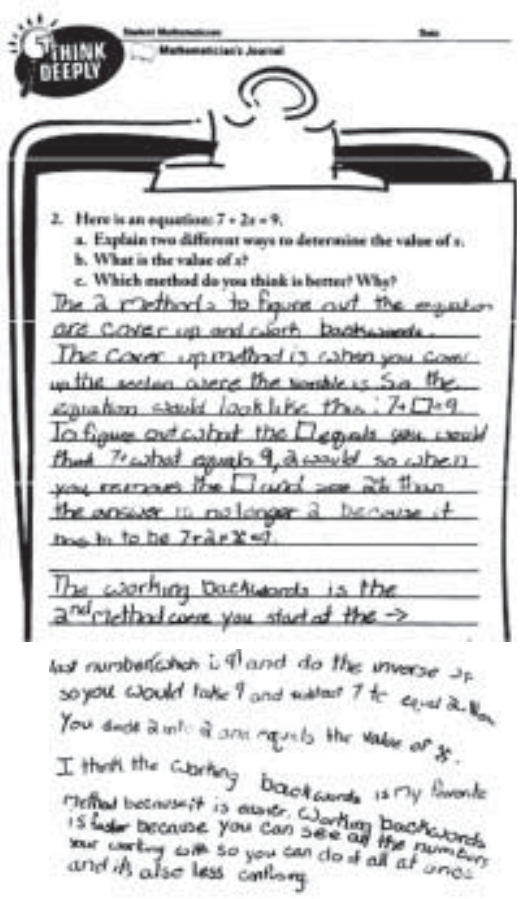

Fig. 2. A sample student response to a "Think Deeply" question.

For example, following partner work and a whole-class discussion in a lesson in an algebra unit on solving simple linear equations, students were asked to write in their journals to explain two methods for solving these equations. "Hint Cards" asked students to think about questions that helped them make sense of the number covered up when solving an equation and "Think Beyond" questions asked students to extend their equation-solving methods to equations involving rational expressions and to teach the methods to another class of students. A sample response to a Think Deeply question is shown in Figure 2.

Results

Following the research design, data has been collected on over 800 students who participated in the Project M^3 program for three years. The four units at each level were implemented for two years in eleven elementary or middle schools in Connecticut and Kentucky, revised based on student and teacher feedback, and are currently available commercially through Kendall/Hunt Publishing Company.

Findings that address the research questions indicate a "positive difference in mathematics achievement on the targeted skill areas, as well as the total score" on a standardized test of mathematics achievement and problem solving (Carroll, 2004, p. 6). In particular, there have been highly significant gains from pre to post testing on the three mathematics subsections of the Iowa Tests of Basic Skills (concepts and estimations, problem solving and data interpretation, and computation) across cohorts and years of implementation. The intervention cohorts have also had significant gains over a comparison group of like ability on these standardized tests. Similar results were found on all items from the Open Response Assessment that contained released items from the National Assessment of Educational Progress (NAEP) and the Trends in International Mathematics and Science Study (TIMSS). (Carroll, 2004) The formative evaluation includes an annual assessment of the delivery of training using classroom observations, teacher interviews and surveys, and student focus groups. Results from this evaluation included the following.

- The selection process was perceived as working effectively to identify participants for the project.
- Teachers reported using best practices in education to teach the Units and said that those were introduced during the summer training sessions.
- Professional development was described as highly beneficial.
- The participation in the project was perceived as enhanc-

ing student development. Teachers reported more positive behaviors in the classroom… There was a strong sense of self-efficacy and empowerment among students, according to teachers.

- Principals were very impressed with the student gains in pre to post testing. There was a confidence that the program would positively impact standardized test scores in both Connecticut and Kentucky.
- The Student Journals were reported to greatly enhance the metacognitive skills of the students (Carroll, 2004, pp. 37-38).

Conclusion

Reports from teachers, students, administrators, principals, and the outside evaluator all indicate "program implementation, teacher development and training, and most importantly student achievement with respect to mathematics and positive attitudes have been exceptional accomplishments" (Carroll, 2004, p. 42). For each of the last four years, a unit from Project M³ has won an award from the curriculum studies division of the National Association for Gifted Children (NAGC) and has been judged to be an exemplary model of curriculum for high-ability learners. Project M³ provides the first set of research-based mathematics units in the United States designed for talented elementary students and with advanced mathematics content to promote challenge and enjoyment. For more information see http://www.projectm3.org/.

References

Carroll, S., & Carroll, D. (2004). *Mentoring Mathematical Minds Project: Program Year Two Evaluation Report*. Unpublished report. Torrington, CT.

Cornbleth, C. (1990). *Curriculum in Context*, Basingstoke: Falmer Press.

National Council of Teachers of Mathematics (NCTM). (1980). *An Agenda for Action: Recommendations for School Mathematics of the 1980s*, Reston, VA: NCTM.

Ross, P. (1993). *National Excellence: A Case for Developing America's Talent.* Washington, DC: U.S. Department of Education, Office of Educational Research and Development.

Sheffield, L., Bennett, J., Berriozábal, M., DeArmond, M., and Wertheimer, R. (1995) "Report of the Task Force on the Mathematically Promising", 32. Reston, VA: *NCTM News Bulletin*.