Mentoring Mathematical Minds

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Abstract

Project M^3: Mentoring Mathematical Minds is a five-year 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 ten schools of varying socioeconomic levels in Connecticut and Kentucky. Project M^3 is directed by Dr. M. Katherine Gavin of the University of Connecticut and co-directed by Dr. Linda Jensen Sheffield of Northern Kentucky. 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, Project M^3 is creating 12 curriculum units of advanced mathematics for talented elementary students and these units are being field tested in the participating schools accompanied by professional development including training institutes and technical assistance. Research questions focus on three items: measuring the changes in mathematics achievement and attitudes for talent pool 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. To date, students have made highly significant gains from pre to post testing on unit tests and standardized tests and have significantly outperformed a comparison group of similar ability from the same schools.

Program Overview

In 1980, the National Council of Teachers of Mathematics (NCTM) made a bold statement, "The student most neglected in terms of realizing full potential, is the gifted student of mathematics." (NCTM, 1980, p. 18) Richard Riley, the U. S. Secretary of Education, in the introduction to *National Excellence: A Case for Developing America's Talent*, stated, "All of our students, including the most able, can learn more than we now expect. But it will take a major national commitment for this to occur." (Ross, 1993, p. iii) The report goes on to point to a "quiet crisis in educating talented students" saying, "The United States is squandering one of its most precious resources – the gifts, talents,

and high interests of many of its students." (Ross, 1993, p.1) As national and international test scores indicate, progress since that time in challenging high-level students in the United States has been slow or nonexistent in this area. This is especially true for underrepresented students from economically disadvantaged backgrounds. Project M^3: Mentoring Mathematical Minds was designed to address this issue, developing a program designed to challenge students to "think like mathematicians". Funding for the project comes from the United States Department of Education Javits Gifted and Talented Students Education Act.

As part of Project M^3, a team of specialists in the fields of mathematics, mathematics education, and gifted education are creating 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 has been identified in each of the ten schools (total N = 800) and the units are being implemented in a variety of settings. Some of these units are also being modified to use with all students across ability levels and backgrounds in differentiated classroom settings. Pre and post achievement and attitude data are being gathered using standardized and criterion referenced tests. To enhance the effectiveness of these units, extensive professional development is offered for a total of 40 teachers, including yearly summer institutes, school year in-service, and an Internet portal (http://www.projectm3.org/) for continuous communication and dissemination of resources.

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, 1995). Measures to identify students for Project M^3 include 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 M^3: Mentoring Mathematical Minds are third graders who began the program in Fall 2003. These students are currently in fifth grade. The second cohort of students began as third graders in Fall 2004 and are currently in fourth grade.

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.

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.

Results

Project M^3 is currently in the third year of implementation. At this point, the four third grade mathematics units have been implemented for two years in at ten elementary schools in Connecticut and Kentucky, revised based on student and teacher feedback, and are currently available commercially through Kendall/Hunt Publishing Company. The four fourth grade units are in the second year of implementation and revision, and the four fifth grade units are being implemented for the first time in these ten schools. All units will be available commercially following two years of research and revision.

Preliminary 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 enhancing 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)

As the program continues into the fourth year, additional results will be forthcoming.

Conclusion

Preliminary reports from teachers, students, administrators, principals, and the outside evaluator all indicate that "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)

School districts around the country are becoming interested in the curriculum, seeking training, and starting to use the curriculum with their mathematically talented students. We look forward to positively challenging additional students and teachers in the coming years. Additional information on Project M3 can be found on our website at http://www.projectm3.org.

References

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