PROJECT MATRIX: IDENTIFYING THE MATHEMATICALLY TALENTED AND MEETING THE MATHEMATICAL NEEDS OF ALL

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Project Overview

In January 1999, Charlottesville City Schools began a three-year project, Mathematics and Talent Recognition: Instruction for Excellence (Project MATRIX), designed to identify young children with strong mathematics potential among populations typically underserved by gifted programs.

Along with developing techniques for talent recognition, Project MATRIX leaders have created a differentiated mathematics curriculum with the goals of meeting the needs of these gifted learners, as well as of challenging all learners at an appropriate level. Training in mathematics pedagogy and content is provided for participating teachers to ensure successful implementation of the Project MATRIX identification strategies and the accompanying curriculum.

Setting and Audience

The Charlottesville City School system serves 4,000 students and is made up of six elementary schools (grades K-4), one upper-elementary school (grades 5-6), one middle school (grades 7-8), and one high school (grades 9-12). The student population is comprised of approximately 50% African-American students, 47% Caucasian students, and 3% Asian or Hispanic students. Of the six elementary schools, five have at least 50% of their students qualifying for free or reduced-price lunch; this statistic serves as an indicator of the low socio-economic status of many of the families served by the school system. Project MATRIX is being implemented in three of these elementary schools, with the remaining three schools serving as controls.

Project MATRIX was developed to address several concerns of teachers and administrators within the Charlottesville school system. First, the fact that few African-American *children, as well* as students from economically disadvantaged backgrounds, enrolled in upper-level mathematics classes by seventh and eighth grade was an indicator that these students were not identified as talented in mathematics early on in their educational careers. Charlottesville City Schools felt a strong need to ensure that children from all sectors of the school population who are talented in mathematics were identified as such, and that they received instruction at a suitably challenging level.

A second issue, generated from the first concern, was to provide challenging, meaningful mathematics instruction for students of all levels. In order to do this, a well-articulated, differentiated mathematics curriculum for all grade levels would have to be developed. This

The Journal of Mathematics and Science: Collaborative Explorations Volume 4 No 2 (2001) 143 - 152

curriculum would need to meet the requirements of the 1995 Standards of Learning for Virginia Public Schools (SOL), as well as align with the national standards as outlined by the National Council of Teachers of Mathematics [1,2].

Along with the aforementioned issues, school administrators and teachers had been concerned for several years about the low pass rates of Charlottesville City School students on the SOL end-of-year mathematics exams, especially at the elementary and middle school levels. Reasons for low achievement are unclear, but possible solutions include a more cohesive curriculum, consistently implemented from school to school, along with increased opportunities for staff development for mathematics teachers. As stated above, Project MATRIX is addressing the issue of improving the curriculum. In addition, to help ensure successful implementation of this enhanced curriculum, Project MATRIX has provided extensive staff development for project participants, including intensive workshops in mathematics instruction, mathematical content knowledge, and issues surrounding gifted children and their academic, social, and emotional needs.

Cognitively Guided Instruction

By far the largest component of Project MATRIX has been staff development in Cognitively Guided Instruction (CGI), a research-based instructional method developed at the University of Wisconsin-Madison [3-6]. CGI is based on the belief that young children enter school with a great deal of mathematical knowledge, and are capable of solving problems requiring addition, subtraction, multiplication, and division without direct instruction from their teachers. By posing different types of problems, and then observing how the child solves those problems, a teacher may assess a child's mathematical achievement level and then plan appropriate instruction. One aspect of the research describes different types of problems, and discusses why some problem types are easier, or more difficult, to solve. Another facet of the research discusses strategies children use to solve problems, from a relatively unsophisticated counting strategy to the fluent use and application of number facts.

For instance, certain types of problems imply some type of action taking place: either joining or separating. Examples of joining problems include:

> Bob had 5 candies. His sister gave him 3 more. Now how many candies does Bob have? (This is a Join, Result Unknown problem. Here, we know the amount Bob starts with, and we know the amount by which the original set will change. We do not know the final result—how many candies Bob has now.)
>
> Bob had 5 candies. His sister gave him some more. Now Bob has 8 candies. How many candies did Bob's sister give him? (This is a Join, Change Unknown problem. In this problem, we know the amount Bob starts with, and we know the result when the amount changes. We do not know the amount by which the original set changes.)

Bob had some candies. His sister gave him 3 more. Now Bob has 8 candies. How many candies did Bob have at first? (This is a Join, Start Unknown problem. We know how much the original set changes, and we know the result—how many candies Bob has in the end. We do not know the amount Bob had at the start.)

The first of these problems is relatively simple for a child to solve if they can count to eight. In fact, a child may act out the solution to such a problem: the child will put out five candies, put out three more candies, and then push the groups together. To find a solution, the child will count the total number of candies.

The next two problems are not as clearly demonstrated, and prove to be more difficult for children when first encountered. For the second problem, a child may put out five candies, and then put out eight candies. If the implied action of the problem is not clear, the child may add the two groups and come up with an incorrect answer of eight. Or a child may attempt to add candies to the original pile of five, but fail to keep track of the number of candies added to the pile. With experience, however, the student will learn to reason out these problems and solve them correctly in ways that are meaningful to him.

As children become mathematically sophisticated through repeated and varied experiences, they not only solve more difficult problems, but they do so using complex strategies. Initially, a child may use a strategy that involves counting each object in the story. With experience, a child will learn to count-on, as in "I have 5, 6, 7, 8. There are 8 candies." When appropriate, children will also begin to use easily learned facts to solve problems. For instance, to solve the problem, "Bob had 3 candies. His sister gave him 3 more. Now how many candies does Bob have?" a child might count-on, but will often say, "I know 3 and 3 is 6. Bob has 6 candies."

Eventually, a child will be able to use knowledge of some basic facts to derive other facts. For instance, to compute the sum of six and seven, a child may say, "I know double-6 is 12, and since 7 is one more than 6, 6 plus seven is one more than 12. The answer is 13." Finally, a child will use their developed ability to recall all facts in solving simple problems, and will be able to extrapolate this knowledge to solve problems involving multi-digit numbers.

Perhaps the most important aspect of CGI is implementation in the classroom. The technique is similar whether used with a small group, with an individual, or as a whole-class activity. The teacher poses a problem for the child, or children, to solve. The child chooses tools he will use to solve the problem—manipulatives, hundreds boards, or pencil and paper—and then attempts to solve the problem. If the child cannot solve the problem, the teacher may provide another problem, either by choosing an easier type of question, adjusting the size of the numbers, or by making another decision based on her knowledge of the student. If the children solve the problem, or think they have solved the problem, solution strategies are shared. The goal is not simply to highlight the correct answer, but to have children model different successful strategies. In doing so, other students gain insights into the particular problem. In addition, the children are learning to support their thinking and to provide mathematical proof.

Some Initial Results

Perhaps the most enduring result of Project MATRIX is the changes teachers have made in mathematics instruction as a result of participating in the project. During the first year of implementation, kindergarten teachers at the participating three schools, as well as their instructional assistants, received training in CGI. In addition, three Project MATRIX staff members were available in each teacher's classroom at least once a week, to either model a lesson, instruct a small group, or to observe and provide feedback on the lesson the teacher delivered. All staff members were certified teachers who had chosen to work part-time for the year, and received initial CGI training with project teachers.

At first, the kindergarten teachers were skeptical about their students being able to solve the problems posed. However, after watching children of all abilities develop problem-solving skills, as well as facility, with numbers far beyond those required by the Virginia Standards of Learning by the end of the school year, many teachers had altered views of what children could accomplish. The result is that teachers are asking more of their students, both in terms of the content presented to children, as well as the complexity with which children are expected to handle that content.

During the second year, kindergarten teachers continued training and implementing CGI, while first-grade teachers were brought on board and began CGI training. First-grade teachers noted the same skepticism felt by the kindergarten teachers the previous year. But, just as before, these teachers soon began reporting that their students were better problem-solvers, especially in their willingness to persevere to find a solution. In addition, first-grade teachers reported that children had a better grasp of doubles facts (2 plus 2, 5 plus 5, et cetera) and seemed to be learning other facts more quickly than students in previous years. At one school where second-grade teachers were trained during the second year (all kindergarten and first-grade students and teachers were involved in the project during its first year), comments were similar to those of first-grade teachers at other schools at the beginning of the year. However, by the middle of the year, these second-grade teachers were reporting that their students were indeed further advanced than students from previous years. In fact, a second-grade teacher who taught third grade the previous year stated that her second-grade students were further along than her third graders were the year before.

At the end of the second year of the project, a series of interviews were completed with a random sample of students in kindergarten and first grade from each of the participating schools, as well as from two of the elementary schools not in the project. In addition, all students in the division were administered a system-wide, end-of-year test, created by a committee of teachers with representatives from each elementary school. This assessment is based on expectations set forth by the Virginia Standards of Learning. Initial analysis of these assessments indicate that Project MATRIX students are at least as successful on the division-wide, end-of-year test; at the same time, they are demonstrating stronger problem-solving skills, including the ability to solve more complex problems with more sophisticated strategies. This indicates that our focus on problem solving is not detrimental to the development of basic skills; furthermore, children in Project MATRIX schools appear to have developed higher-level skills for problem solving. A complete analysis of this data will be available in the next few months.

Yet another indicator of success comes from reports of the school-based, gifted education specialists. Each spring, these teachers are involved in the system-wide identification of gifted students. Several standardized ability tests are given to children, including the Wechsler Intelligence Scale for Children-R (WISC-R). According to the gifted education specialists at Project MATRIX schools, the mathematics portion of the WISC-R took far longer to administer this year, in comparison to prior years: confident, practiced students persevered in solving problems when they may not have tried as hard in the past. Because of their persistence, children were able to advance further in the test than in previous years. Again, initial comparisons of student scores on the WISC-R seem to indicate that students at Project MATRIX schools have stronger problem-solving abilities. Also, Project Matrix schools appear to have more students from underserved populations either working above their grade level in mathematics, or being recommended for gifted services.

Areas for Further Action

Project MATRIX has been very consistent in providing teachers with opportunities to learn and to use mathematical instructional methods. In applying these methods, teachers are developing new ways to identify students with mathematical talents through classroom activities. At this juncture, we must begin to turn our focus to curriculum development and implementation. While teachers are gaining experience applying the concepts of CGI to number sense and operations, there is still a lot of progress to be made in applying CGI to other mathematics curriculum areas, such as geometry, probability, and statistics. Some progress has been made toward creating a "scope and sequence" for grades K-2 that reflects the higher levels of achievement teachers are beginning to expect of their students. Now, teachers need to try to follow this "scope and sequence," as well as recommend revisions and additions.

Teachers in the project commented that while they are now better equipped to provide differentiated mathematics instruction, especially for advanced students, they are still unsure of how to help the struggling learner. There are programs available that are closely related to CGI that focus on early mathematics remediation. This is a topic on which future staff development needs to focus.

Finally, one of the reasons that Project MATRIX has been supported so well by teachers and has shown such positive results is that throughout the project, there have been half-time project assistants working daily with teachers in the classroom. These assistants are all qualified teachers: they have served as tutors, observers, sounding boards, problem writers, videographers, and curriculum developers. Their effectiveness has resulted in plans for mathematics resource teachers in each school.

Budget and Funding

Project MATRIX is funded by the United States Department of Education as part of the Jacob K. Javits Gifted and Talented Students Education Program. The grant totals $516,739. Funding began in January 1999, and ends in January 2002, with the possibility of a no-cost extension for any remaining funds. The grant has paid for the following components of the program: project personnel (one grant coordinator, and several part-time assistants each year); stipends for teachers participating in training throughout the project; contracted services, including CGI trainers and evaluators; materials for classroom teachers, both print and manipulatives; travel and conference reimbursement; computers and video equipment; and, supplies. The school division has contributed secretarial time, office equipment and costs, and additional money for supplies.

Javits grants run in two-year cycles and are due in the beginning of May of that year. Assuming Congress approves the funds, the next grant application will be due in spring of 2002; grant applications may be obtained by contacting the United States Department of Education. The grant should be written in narrative form, and should include background information addressing the need for the grant, a description of the project design, a description of personnel and their responsibilities, a budget, and an evaluation plan.

Alternative Settings

Any school district concerned with providing differentiated mathematics instruction should explore the possibilities that may emerge with Cognitively Guided Instruction. CGI is an invaluable tool for helping teachers assess a child's level of mathematics achievement, as well as for aiding in planning instruction appropriate for each child in the class. Research on CGI has shown that it can be an effective method of mathematics instruction in all types of settings, from middle- and upper-class suburban schools to poorer inner-city schools [3-6]. Children taught in CGI classrooms are generally stronger mathematical problem-solvers than peers in non-CGI classes; at the same time, CGI children develop skills that are the focus of traditional mathematics instruction at the same, or greater, level than peers in non-CGI classes. ■

Acknowledgements

Project MATRIX is funded through the Office of Educational Research and Improvement (OERI) which administers the Jacob K. Javits Gifted and Talented Students Act of 1994, authorized under Part B of Title X of the Elementary and Secondary Education Act (Award # R206A990004).

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INTERVIEW WITH MEGAN K. MURRAY

Q: What career path did you follow to reach your present position? Is this what you originally aimed for, or were there a few twists and turns that brought you here?

A: I actually started off as an engineering school student, which lasted all of one year. At that point, I took a year off from school (at my father's request), worked as a nanny for a year, returned to school, and graduated from University of Virginia (UVa) with a degree in Latin American Studies. I did nothing with that degree, but after a year or two bartending in Washington, I decided to actually do what I had really always wanted to do—teach, so I got a job as a teacher in a preschool. After working at that job for two years, I returned to UVa to get my teaching certificate, as well as a Master of Teaching Degree in Elementary Education (K-8). I had always wanted to teach middle school math (honestly! and it is still my favorite age to teach!) and taught seventh and eighth grade math, algebra, and geometry in Charlottesville for seven years. During the past three years in Charlottesville, I have also served as half-time mathematics curriculum coordinator.

Q: Have you been involved in similar programs before? Was there a particular moment, or stimulus, that caused you to begin this project?

A: Several things occurred as I worked as a curriculum coordinator. First, I realized that I did not know enough about mathematics, or about curriculum, to be as comfortable with the job as I would have liked. Second, I had opportunities to see lots of math at lots of levels, and began to think that to really change mathematics instruction, we need to start a program in kindergarten and follow it through middle school; this idea was to emerge as an impetus for Project MATRIX. Third, I took a course on *Curriculum for Gifted Children* and decided I had to go back to school full-time to learn math, to learn about curriculum, and to get a Ph.D. I would never have guessed that one of those graduate courses, *Underserved Gifted* with Professor Carolyn Callahan, would open the door for my creation of Project MATRIX.

Q: Have there been any unique, or unexpected consequences for you resulting from your project?

A: I have learned a great deal about kindergarten, first, and second grades, especially about math education in those grades, through Project MATRIX. I have also been able to spend time looking at the specifics of how what is taught in primary mathematics develops for children as they move through elementary school and middle school. I am now very familiar with the curriculum at these levels, what we can expect of children at various ages, and have developed very firm beliefs about the elements of quality instruction. More importantly, I have grown to appreciate the many faces of good instruction since I have watched many teachers, with very different styles, deliver instruction that is engaging, meaningful, and challenging to children. I don't want to sound too sweet (I don't consider myself a sweet person!), but I have been overwhelmed by the amount of trust teachers have had in me—allowing me to observe them teach a subject they do not consider their strength, as they implement teaching methods that I am convinced will work, but of which they are sometimes skeptical. I am able to share, on a regular basis, great triumphs with the teachers in the school system as we see a child show deep understanding for the first time, or as we watch a child develop a new strategy of which no one else had thought.

Q: Are you able to identify the greatest lesson you have learned and the rewards you have gained through working on Project MATRIX? What is the greatest benefit you see coming to students, and to teachers, through their engagement with this project?

A: The greatest benefit coming to students and teachers through their engagement with Project MATRIX has been the change in attitude toward mathematics and math instruction. I think children involved with Project MATRIX really like mathematics: they enjoy solving problems, and demonstrate a determination to learn when faced with a situation that is new to them. Likewise, teachers appear to be attending more closely to the meaning behind their mathematics instruction. Teachers are watching carefully as children solve problems, and are engaging children in deep discussions of solutions. Teachers are becoming more adept at creating mathematical tasks that challenge children at all ability levels. And I have seen teachers rework activities they have done in the past so that the activities develop mathematical thinking in children, rather than focus on less demanding skills, such as learning by rote.