P R I M E

PRompt Intervention
in
Mathematics Education

Executive Summary
of
Research and Programs

Editor

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Ohio Resource Center for Mathematics, Science, and Reading
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Contents

Prompt Intervention in Mathematics Education

An Overview

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The state of Ohio is taking seriously the idea that all students can learn mathematics. Deep and widespread commitment to this simple, yet largely unaccepted, idea will revolutionize mathematics instruction. The goal that all students will learn mathematics to high levels is diametrically opposed to the oft heard and deeply held belief that some people just cannot learn mathematics. This conference is designed to present a review of the research related to prompt intervention and to highlight a range of successful strategies for prompt intervention.

The literature analyzed as part of the PRIME project suggests two principles:

- All students can learn significant mathematics;
- Whether or not students learn depends on a variety of factors; the single most important factor is instruction.

Both of these principles are research-based understandings and not pie-in-the-sky hopes. Existence proofs for these principles are available—though frankly are not abundant in the United States or in Ohio. Student achievement is impacted by a variety of variables—some of which can be affected by schooling and some of which cannot.

If Ohio is to have a state educational system designed to assure a mathematically literate citizenry prepared to thrive in the technological 21st century, there simply must be fundamental changes in the way mathematics programs are structured. The remedial model of instruction permeates most approaches to teaching mathematics. The entire system "expects" student failure and is designed to address failure when it inevitably occurs, not prevent failure. *Prompt intervention* prevents failure by deepening students' understanding as they go along.

There are proactive steps that can be taken to facilitate prompt intervention. This conference will highlight programs and strategies that work:

- Restructuring the school day/week/year to maximize learning time;
- Providing instruction that:
  - Focuses on teaching students to think;
  - Takes learning difficulties into account when developing effective lessons;
  - Is culturally relevant;
  - Helps students learn how to be good learners;
- Support for teachers in the shift from a teaching system to a learning system;
- Effective use of technology;
- Alternative sequencing of topics;
- Diagnosis of student difficulty;
- Assessment that informs instruction;
- Roles for families.

Of the many important ideas that come from the literature, two are especially important. One is that prompt intervention can help make up for insufficient early learning experiences. The second is that, while there does not seem to be a point beyond which intervention in mathematics will not help, *prompt* is still an important word. The earlier a student can have experiences that support his or her understanding of number and space, the better.

This conference provides an opportunity to establish learning communities around the state who take seriously the notion that *all* students can learn mathematics and it is the responsibility of the educational system to design prompt intervention whenever and wherever appropriate.

Models of Intervention in Mathematics Education

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In this chapter, several models that schools can consider for early intervention in mathematics are described. Specifically, intervention can take the form of either professional development with teachers or direct instructional episodes with children. The models involving teachers include ongoing professional development workshops or programs, choosing appropriate curriculum, developing individual learning plans, and designing lesson plans using a constructivist philosophy. Intervention models involving students can take place within the classroom (using computer software, grouping students, providing peer tutoring, setting up learning centers, assigning alternative homework assignments, etc.), outside of the classroom but during the school day (pull-out programs, tutoring, study hall intervention, etc.), or outside of the school day (before or after school, on Saturday, in the summer, online, individual tutoring, etc.). Each of these models, their implications, and examples of schools implementing them are described in this chapter.

After discussion of the intervention models, several issues are addressed that educators must consider to ensure the success of these programs. Specifically, the five issues listed below are discussed in the chapter.

Communication

It is important that all professionals involved in the intervention programs (e.g., teachers, administrators, tutors, etc.) establish clear lines of communication. Also, caregivers of students must be kept up-to-date on goals and accomplishments of the programs.

Funding

Intervention in any form can be expensive, so school officials are encouraged to seek creative ways to implement these programs. Use of student or community volunteers, grant funding, and collaboration with other educational institutions are among the possible approaches to securing appropriate resources.

Duration and Content

Research has indicated that there is not a single program content or length that always achieves the best results. Instead, some programs are short term, while others are sustained over time. Some programs focus more on skill building, while others are designed to help children with thinking and problem-solving skills.

Coordinating Efforts With Classroom Teachers

Intervention experiences should be designed so that they support the efforts of the classroom teacher. When programs such as individual tutoring focus on isolated skills or "tricks" that the teacher did not explore in class, the intervention can actually undermine the teaching and learning process. Programs should be designed with direct input of classroom teachers.

School Day Schedules

Self-contained classrooms allow teachers of mathematics to shorten or lengthen a lesson, depending on the needs of the students on a particular day. However, middle and secondary school days are often designed in distinct 45-minute periods, so many schools have sought alternatives such as block scheduling to allow intervention to happen during the school day. However, research suggests that block schedules create their own set of problems, so caution is advised for schools considering these changes.

Intervention for *All* Students

Mathematics and Cultural Connections

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The best form of intervention for *all* students is "good teaching" through culturally relevant pedagogy, which links students' home and community experiences, their cultural knowledge, and their school experiences. Culturally relevant pedagogy is based on three criteria or propositions that students must: (1) experience academic success, (2) develop and/or maintain cultural competence, and (3) develop a critical consciousness through which they challenge the status quo of the current social order (Ladson-Billings, 1995a). Some theorists go a step farther and advocate for *praxis*, or informed action, which results from what students know and learn in schools. Once students develop critical consciousness, they use their knowledge to challenge the status quo through action, doing something within their community to address problems that exist. For example, Ohio students might study homelessness with a mathematical lens toward understanding data about the issue, finding ways to address the issue of homelessness, and helping people who are experiencing homelessness in their own communities.

Specific aspects of culturally relevant pedagogy, or "good teaching," are highlighted through research reports from authors such as: Ladson-Billings (1995a; 1995b; 1997); Gutstein, Lipman, Hernandez, and de los Reyes (1997); Jones (2004); and Malloy (2004). Ladson-Billings (1995a) studied the teaching practices of eight "exemplary" teachers who were identified by administrators based on their students' (a) low number of discipline referrals, (b) high rates of student attendance, and (3) high standardized test scores. Ladson-Billings found that these teachers consistently:

- Identified passionately and strongly with teaching as a profession;
- Had chosen to teach in a low-income African American school district;
- Saw themselves as part of the community in which they taught;
- Viewed teaching as a way to give back to the community;
- Attended community events and used community services;
- Felt that they were responsible for guaranteeing the success of their students;
- Believed that all students could and must succeed;
- Gave lots of individual attention and encouragement to students;
- Encouraged students to act as learners;
- Functioned as learners themselves;
- Developed a community of learners in their classrooms;
- Encouraged collaborative rather than competitive or individualistic achievement;
- Believed in the Freirean notion of "teaching as mining," as pulling out or unpacking knowledge, rather than teaching as depositing knowledge (Freire, 1974, p. 76);
- Believed that knowledge is not static but is "shared, recycled, constructed" (Ladson-Billings, 1995b);
- Felt knowledge must be viewed critically;
- Used scaffolding (connections) to facilitate learning;
- Believed assessment must be multi-faceted.

Following the section about culturally relevant pedagogy, the research findings and intervention programs described in this chapter are divided into categories that focus on different aspects of culture: Socioeconomic Status, Urban, Rural, Language (English as a Second Language), and Gender.

Family Roles in Effective Intervention

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This chapter examines various ways in which schools and families can work together to support the mathematical development and education of children. It considers roles parents can play in supporting their children, as well as ways in which schools can support parents in these efforts. A typical image of school-parental involvement is that of parents participating in school-based activities such as volunteering in school activities, serving on school committees, and attending school functions. Parental involvement can also involve motivating children, providing resources and study environments that support learning, monitoring their children's progress in school, helping them with schoolwork, and supporting their mathematical development.

Three education-based principles are used to guide and support this work:

1. Family intervention programs should provide parents with *social capital*, or the skills and information that enable them to assist and support their children in school-based activities.
2. The relationship between school and family should support the development of *social control.* This development is supported by regular communication between schools and families. When families and schools partner together, they have common expectations for students. In turn, both send consistent messages to students regarding goals and behavior.
3. Intervention, like education, should not be something schools do *to* families, but rather, *with* families.

In order to illustrate and expand upon the ways in which schools and parents can interact and support children's mathematical development, several programs and studies are reviewed that support an emphasis on intervention over remediation. Given that good teaching, in concert with good parenting, is a sound form of intervention, these programs and studies support the need to include and involve parents in the educational process.

Interventions That Support Future Mathematics Learning
Developing Self-Regulated Learners in K-12 Classrooms

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Attention to the development of self-regulated learning in K-12 settings is important due to changing perspectives on mathematics (NCTM, 2000) and mathematical competence (Kilpatrick et al., 2001). Conceptions of mathematics have changed from a body of facts to be memorized to "a way of thinking" that requires justification and reasoning. Therefore, mathematics educators are being challenged to think about classroom environments and instructional strategies that support the development of strategic learning behaviors, as well as learning mathematics content.

This chapter provides a different perspective on mathematics intervention by exploring "the importance and centrality of self-regulation in the context of the prevailing new conception of school mathematics" (De Corte et al., 2000, p. 721). Self-regulated learners are cognitively active in their own learning. They examine components of a task prior to beginning the task, decide on strategies to accomplish the task, and reflect on their progress to adjust their strategies when appropriate. School and district-level administrators are urged to support teachers' efforts to develop strategic learners by implementing systematic, building-level programs across grade levels to develop students' disposition toward learning as an effortful process that requires strategic behavior.

Some Lessons Learned From Research

- Students are self-regulated when they choose strategies to use, monitor their effectiveness, and make changes in their behaviors when they are not meeting goals;
- Self-regulation is developed in discourse-rich environments that make strategies explicit;
- Mathematics process standards—problem solving, reasoning and proof, communication, connections, representation (NCTM, 2000)—are both outcomes of mathematics instruction and vehicles for developing mathematical understanding and self-regulation;
- Components of classrooms that support development of self-regulation include (a) authentic contexts for learning that incorporate rich, complex tasks that invite varied strategies or multiple representations; (b) task choice and control of challenge; (c) opportunities for self- and peer evaluation; (d) teacher's sensitivity to varying needs of students; and (e) evaluation systems that emphasize feedback on the performance of skills rather than summative scores;
- Instructional practices should induce and support constructive, cumulative, and goal-oriented acquisition processes in students;
- Instructional practices should facilitate the acquisition of general learning strategies and problem-solving skills embedded within the mathematics curriculum;
- SRL intervention should draw on the rich mathematics education literature related to classroom discourse and the role of explanations and justifications;
- Strategy instruction includes several components: modeling strategies, guided practice, classroom discourse, self-verbalization, fading of support, and growing student autonomy;
- Students need (a) to see value in strategies by attributing success to strategy use and (b) ample practice applying strategies to real tasks in real contexts;
- Strategy instruction should begin with students' present strategies and expand these competencies gradually;
- Strategy instruction should include a Polya-like sequence for problem solution: understand the problem; devise a plan; carry out the plan; examine the answer to see if it makes sense.

Finally, the implementation of instructional practices aligned with the NCTM Standards requires a level of self-regulation. Conversely, instruction aligned with the self-regulation principles discussed here will encourage further movement toward the Standards ideal.

Instructional Strategies for Improving Student Achievement

Prevention and Intervention

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Professional development efforts in mathematics education, based primarily on the vision in *Principles and Standards for School Mathematics* (NCTM, 2000), are occurring throughout the country. This vision is predicated on students' learning mathematics with understanding. All students deserve the opportunity to become mathematically literate. Research supports such reform-based instruction as a promising way to improve student achievement in mathematics. The present chapter describes best practice instructional strategies that are research based:

- Use worthwhile mathematical tasks;
- Emphasize problem solving;
- Teach students to use self-regulation;
- Include appropriate manipulatives and other representations during instruction;
- Encourage discourse in whole-class instruction;
- Stress writing-to-learn mathematics strategies;
- Promote cooperative learning.

Researchers have found that by implementing greater academic challenge into the classroom, both high-achieving and low-achieving students show clear evidence of significantly increased problem-solving skills, as well as computational skills, over students taught with more conventional, skill-oriented approaches. Skill development does not need to precede problem solving but can be learned concurrently. Researchers encourage the use of challenging problem situations to introduce new concepts through conceptual learning instead of procedural learning.

Research suggests that instruction based on constructivist principles leads to better results than more direct conventional instruction. Problem solving plays an important part in a constructivist framework. Active learning through problem solving aids children in acquiring more useful and transferable mathematical knowledge. Students who develop conceptual understanding early perform best on procedural skills.

Intervention programs that include problem solving are most effective when self-regulating methods are explicitly taught. *Self-regulation* is defined as what students think and say to themselves both affectively and cognitively as they organize their thoughts while problem solving. Researchers found that self-instruction could be taught to children when teachers model steps in problem solving and strategies for self-instruction by "thinking out loud."

When considering the use of manipulatives, most researchers agree that *how* manipulatives are used is more important than *whether* they are used. Nevertheless, in a review of research on the use of concrete materials in mathematics instruction, Grouws and Cebulla (2000) conclude, "Long-term use of concrete materials is positively related to increases in students' mathematics achievement and improved attitudes towards mathematics" (p. 27).

Researchers suggest that whole-class discussion can be effective when the teacher encourages an openness to students' solution methods, including a need to share, explain, and debate their work with others in the classroom. Confusion and conflict often occur when students' thinking and reasoning are encouraged in class discussions. This cognitive conflict is of utmost importance in transforming thought. Whole-class discussion works best when student expectations about participation are clearly understood by the students. One major student expectation is to be a good listener who actively participates in the discussion and feels a sense of responsibility for other students' understanding. Students feel more comfortable discussing each other's methods and solutions when they come to understand that discussion is about contributing to the mathematical knowledge of the whole class without being critical of other sharers.

Writing in the mathematics classroom has been recommended as another way to enhance learning and increase conceptual understanding. Writing can be used to create thought or conceptual understanding and to promote the growth of reasoning, communication, and connections. Writing engages students in clarifying their thinking by reflecting on when and whether a strategy works in a particular situation. By having students write their own word problems in concert with cooperative learning, students can select personal experiences that make the problems more relevant.

Cooperative learning promotes several factors that are positively related to achievement. Students learn by explaining an idea, method, or solution to a team member. The group work is most effective when groups are taught how to give and receive help. More elaborate explanations, and not just answers, need to be encouraged during small-group work. However, low achievers tend to remain passive in small-group interactions and therefore need more time, more attention, and more scaffolding to develop their verbal skills. Cooperative learning combined with self-regulation strategies was found to be a very effective method for enhancing mathematical reasoning.

Topic Sequencing and Curricula

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Mathematics has long been considered a highly organized and sequential subject. Few would argue that a random ordering of topics in mathematics would lead to critical gaps in understanding, a high degree of disconnect between mathematical concepts, and a decrease in overall retention. Yet there is little consensus on the best ordering of topics throughout school mathematics, often leaving teachers to make curricular decisions based on tradition, the textbook, and anecdotal evidence. A careful consideration of the ordering of topics in a mathematics curriculum can, however, produce a better, more coherent curriculum that can increase intervention strategies and decrease remediation of mathematical topics.

Traditional U.S. Curricula and Pedagogy

- Reviewing previous material;
- Demonstrating how to solve problems for the day;
- Practicing the new material;
- Correcting seatwork and assigning homework, with time to begin homework in class.

(Stigler & Hiebert)

Non-Traditional Approaches

Whole Numbers

- Basic composition of number before computation (Children's Math Worlds Project);
- Multiple models for addition, subtraction, multiplication, and division;
- Introduction of integers at earlier grades—as a subset of rational numbers.

Rational Numbers

- Multiple models of rational numbers, with conceptual understanding first (Rational Number Project);
- Rational numbers as partitioning, equivalencing, measure, quotient, ratio, etc. (Kieren);
- Percents forming the foundation of rational numbers (Moss);
- Fractions held off until higher-level mathematics dictates their use (Groff).

Measurement

- Focus on conceptual development before procedural activities (McClain et al.);
- U.S. problems also rise from confusion over learning two systems of measurement and the debate over how much students should study conversions between systems.

Geometry

- Conceptual foundation being addressed in elementary and middle grades;
- Focus on relationship to children's everyday activities (Lehrer et al.);
- Building on the work of the Freudenthal Institute in the Netherlands with more activities around spatial reasoning, transforming, etc.

Algebra

- "Algebra for All" confronts the gate-keeping role that algebra traditionally plays;
- A factor in mathematical social justice (Robert Moses' Algebra Project);
- NCTM's current drive for "pushing algebra down" vs. research that questions teaching Algebra I in the eighth grade (Partenheimer and Miller).

Two curricula that embody much of the current research on how kids learn mathematics and give attention to the role of professional development in making the shift to new approaches:

- *Investigations in Number, Data, and Space* (K-5)
- *Connected Mathematics* (6-8)

Technology—Friend or Foe in Early Mathematical Intervention?

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Although we live in a world replete with examples of technological innovations, the mathematics classroom is often out of sync with everyday usage. However, much of the research on implementation of calculators, computers, and other technology in the mathematics classroom generally finds that the use of technology has beneficial academic and attitudinal results for students. As many technological tools as there are that are appropriate for the mathematics classroom, there are almost an equal number of issues and concerns regarding their use. Many of these concerns can be addressed by the efficient use of technology, which supports and enhances students' understanding of basic mathematical concepts and processes, rather than supplanting it.

This chapter briefly considers some of those concerns, but gives more emphasis to ways of approaching those concerns by recalling that any tool can be used either wisely or unwisely, and in ways that either debilitate or empower the users. Appropriate use of technology for early intervention in mathematics focuses on mathematical concepts, as well as the mathematical processes identified in *Principles and Standards for School Mathematics* (NCTM, 2000), namely, problem solving, reasoning and proof, communication, connections, and representation. With proper planning, timing, and implementation of the use of technology, students may reinforce concepts they are learning, learn new concepts by exploring patterns and generalizing about those patterns, and enhance their learning by recognizing multiple ways of finding answers and representing solutions to problems.

This chapter shares some information about specific uses of calculators, electronic spreadsheets, and geometric utilities. Although certain well-known programs are mentioned (such as *Geometer's Sketchpad, Logo, How the West Was One + Three x Four*), there are a variety of other software programs that facilitate learning, as well as provide an interesting context for exploration. There are also computerized learning management systems (such as *Destination Math* and *Accelerated Math*) that provide instructional assistance, monitor student progress, and give feedback regarding next steps. There are also other specific programs (such as Peer-Assisted Learning Strategies, Texas's *EdTech Pilots*, and Enhanced Anchored Instruction) for early intervention that use computerized systems for monitoring student progress, assisting with homework by providing various levels of tutoring, and accommodating special needs of learners. Each of the programs mentioned in this chapter is merely a sample of what is available from many sources. Programs should be selected based upon the degree to which they align with academic standards and other goals that will assist in efficient early intervention.

The question regarding the role of technology as friend or foe in early intervention of mathematics can best be answered by considering how efficiently technology is used to empower students to learn mathematics.

Using Assessment to Support Learning

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Teaching without assessing is like driving with your eyes closed. Knowing when to stop and when to proceed, noticing warning signs, and avoiding obstacles are all key components in successful teaching and safe driving. Everyone is aware of the importance of real-time feedback while driving, but not everyone understands the importance of real-time assessment in instruction. Results from research help everyone become aware of how real-time assessments can improve instruction and increase student achievement.

WHAT TYPE OF ASSESSMENT HAS THE GREATEST POSITIVE EFFECT ON STUDENT ACHIEVEMENT?

Research shows that the use of diagnostic and formative assessments—assessments occurring before and during instruction—has a positive effect on student achievement. This positive effect is documented by externally mandated assessments, as well as other measures of student achievement. Not only is achievement improved overall, but the difference in achievement between high and low achievers is narrowed because formative assessment helps low achievers even more than other students.

Studies show that children in classrooms where teachers use active teaching and assessment strategies to present ambitious curricula can do significantly better than generally expected. In fact, the level of achievement of children in poor inner-city schools can be improved to the point of narrowing or eliminating the gap in performance between them and East Asian children.

Summative assessments, occurring at the end of instruction, are less helpful. Although useful in providing information concerning students' mastery of content and the ultimate effectiveness of classroom instruction, summative assessments occur too late to assist teachers in making real-time adjustments to instruction or help students make adjustments in their learning strategies.

WHY ARE DIAGNOSTIC AND FORMATIVE ASSESSMENTS EFFECTIVE?

Diagnostic assessments, which occur before instruction, make teachers aware of their students' level of development. This information helps teachers create lessons and learning opportunities that build on their students' understandings and address individual students' needs. Real-time, formative assessments allow teachers to continually monitor their students' progress. They can discover any difficulties their students are facing, and they can decide what assistance to provide.

Students, too, benefit from receiving the feedback provided by formative assessments. They learn what works and what doesn't; they can pursue successful strategies while rejecting unsuccessful ones. Feedback in the form of comments (but not grades or scores) helps students focus on their own learning instead of focusing on acquiring gold stars or collecting grades.

Receiving assessment results throughout the entire learning process helps teachers, students, and parents obtain a truer picture of what each student is learning. It diminishes the chance that students will be *labeled* by their performance on one assignment or one test.

WHAT ARE THE CHALLENGES TO IMPLEMENTING A FORMATIVE ASSESSMENT SYSTEM?

Educators wishing to increase their use of formative assessment face a series of challenges: discarding long-held misconceptions, developing assessments linked to learners' individual needs and cultural backgrounds, documenting and using the variety of information obtained, sharing information with other educational stakeholders, and obtaining professional development that supports teachers in improving their practice.

Meeting and overcoming these challenges may seem daunting, but those who do will reap great rewards. Never again will they have to choose between good teaching and good results.

Teachers—The Key to Successful Mathematics Programs

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Teachers are the key to any successful program for improving students' mathematics achievement. Mathematical knowledge, beliefs, teaching methods, assessment practices, and knowledge of student learning must all be targets of professional development.

Effective Professional Development

Teachers must experience transformative professional development, in which their content knowledge, knowledge about students, and knowledge about how mathematics is learned are challenged and strengthened. Loucks-Horsley (1997) proffers a list of principles for creating an environment that will lead to successful experiences for teachers:

- Predictable stages of growth, including changes in beliefs;
- Uses methods of good teaching—teacher centered;
- Long-term change through active engagement;
- Attention to changing the system;
- Alternative venues for teacher learning.

Specific Actions for Effective Professional Development

The literature on effective professional development for mathematics teachers yields much information about explicit measures that have been used to follow the guiding principles.

Teacher Thinking

- Allow teachers time and opportunity to think—enough time for teachers to build rapport with others, try out ideas, and break down and rebuild practices;
- Many hours during the program should be devoted to authentic problem-solving situations;
- Teachers need an environment that encourages thinking.

Dissonance in Teachers' Beliefs

- Provide experiences that cause teachers to revise their assumptions about the nature of mathematics and the nature of student learning.

Teachers' Context

- Attention to teachers' work environments and how to navigate through expectations of various outside groups must be an integral piece of professional development;
- Embrace differences in teacher-created classroom contexts and help teachers capitalize on the individual strengths of their personally created learning environments.

New Skills

- Should address general and content-specific pedagogy;
- Must be seen as being connected to the students in the teacher's classroom;
- Require time for practicing in their own classrooms, a forum for discussing the intricacies of implementation, and access to support for trying and modifying these ideas.

Support

- Provides continuing help for teachers undergoing change;
- Must be available over a long period of time and at hours useful for the teachers.

Reflection

- Is a way to help teachers make sense of the disequilibrium they experience during the change;
- May take the form of monitoring students' reactions during the lesson or assessing the success of the lesson after completion.

PRIME Mathematics Intervention Programs

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The mathematics intervention programs listed here include programs that were presented at the PRIME conference April 21, 2005, or featured in the handout distributed at the conference. Though all programs ultimately involve students, teachers, and curriculum, the programs listed below have been arbitrarily grouped into programs that focus directly on students, programs that focus on professional development for teachers, and programs that are based largely on curricular materials.

PROGRAMS THAT FOCUS DIRECTLY ON STUDENTS

Programs in this category are listed roughly according to the ages of the students involved, beginning with preschool and ending with a college level program. Of course, many programs span several grade levels, and some are adaptable to levels not intentionally targeted.

Title: **Head Start**
Audience: 3- and 4-year-olds and their families
URL: http://www.ohsai.org/
Reference: Sophian, C. (2004). Mathematics for the future: Developing a Head Start curriculum to support mathematics learning. *Early Childhood Research Quarterly, 19*, 59-81.

Services include parental training in areas of child development, as well as specific strategies to support children in reading and mathematics. A pilot curriculum familiarizes children with alternative units for counting and the effects of variation in unit size on numerical outcomes. Results indicate significant positive effects on mathematics achievement in the intervention group.

Title: **Chicago Child-Parent Center Project**
Audience: Preschool–grade 3 students and families
URL: http://www.ecechicago.org/pages/home/programs/preschool/

Child-parent centers are located in or near low-income elementary schools and function under the leadership of the elementary school principal. The centers provide support during the transition from preschool to formal schooling. Training and resource materials focus on child development, literacy, and mathematics. Parents play numerous roles within the center in exchange for the support they receive.

Title: **Project Excel**
Audience: Bilingual K-3 classrooms
References: Flores, A. (1995). Bilingual lessons in early-grades geometry. *Teaching Children Mathematics, 1*(7), 420-424;
Percy, R. I. (1991). *Project Excel: Gifted potential*. San Diego, CA: San Diego City Schools.

The geometry activities in this project were used to identify gifted bilingual students. Early intervention programs are crucial to identify, attract, and retain students from underrepresented populations in programs for gifted students.

Title: **Saturday Program**
Audience: Students in grades K-5
URL: http://www.greatschools.net/modperl/browse_school/oh/519/

The Arlington Park Elementary School in Columbus, Ohio, has initiated a variety of strategies over the last several years to improve mathematics achievement, including an after-school program and a Saturday program focused on helping students do well on achievement and other tests.

Title: **PALS Math**
Audience: Students in grades K-6
URL: http://kc.vanderbilt.edu/kennedy/pals/index.html

Peer Assisted Learning Strategies Math (PALS Math) has been approved by the U.S. Department of Education's Program Effectiveness Panel as an effective educational practice. Repeated evaluations of PALS Math indicate that high-achieving, average-achieving, and low-achieving students, as well as students with learning disabilities, make greater progress in PALS classrooms than their counterparts in typically structured classrooms. This program trains peers to tutor each other in a guided manner to increase mathematical skills. Training packets are designed for computations and applications, including critical thinking skills.

Title: **Head Start Follow-on Intervention**
Audience: Children in grades 2 and 3
Reference: Reynolds, A. J. (1994). Effects of a preschool plus follow-on intervention for children at risk. *Developmental Psychology, 30*(6), 787-804.

The follow-on intervention was significantly positively correlated with school adjustment for economically disadvantaged children. The duration of the intervention might be just as important, or more important, to children's adjustment than the timing of the intervention. There must be equal concern for "upward" expansion of Head Start programs after students enter formal schooling.

Title: **Winburn Family Project**
Audience: Children in grades 2-6 and their parents
Reference: Strutchens, M., Thomas, D., & Perkins, F. D. (1997). Mathematically empowering urban African American students through family involvement: Equity in mathematics education is about access. In J. Trentacosta & M. J. Kenney (Eds.), *Multicultural and gender equity in the mathematics classroom* (pp. 230-235). Reston, VA: National Council of Teachers of Mathematics.

This 8-week project focused on developing students' and their parents' mathematics skills through the use of literature with cultural connections. At the end of the project, parents showed an increased ability to ask their children meaningful questions, and the parents expanded their use of physical models as a means to help both themselves and their children understand mathematical concepts.

Title: **Kids2Kids**
Audience: Students in grades 3-6
URL: http://www.orrville.k12.oh.us/district/initiatives/index.asp#maple

One of the goals of Maple Street School in Orrville is for all students to improve their mathematics skills. To accomplish this goal, many students have become members of the Principal's Math Club and have participated in the Kids2Kids tutoring program where older students tutor younger students.

Title: **Reciprocal Peer Tutoring**
Audience: 4th- and 5th-grade students and families
Reference: Fantuzzo, J. W., Davis, G. Y., & Ginsburg, M. D. (1995). Effects of parent involvement in isolation or in combination with peer tutoring on student self-concept and mathematics achievement. *Journal of Educational Psychology, 87*(2), 272-281.

This program used both parental involvement and reciprocal peer tutoring as an approach to improve students' mathematics achievement. The program provided parents with a variety of levels of engagement as it encouraged them to learn about and develop their roles in helping their children.

Title: **Title I Parent Programs**
Audience: Elementary and middle grades students and families
URL: http://www.nctic1p.org/
Reference: Shaver, A. V., & Walls, R. T. (1998). Effect of Title I parent involvement on students' reading and mathematics achievement. *Journal of Research and Development in Education, 31*(2), 90-97.

The National Coalition of Title I/Chapter I Parents (NCTIC1P) helps economically disadvantaged parents develop skills needed to make sound decisions regarding their children's education. One such program sponsored meetings to provide information, training, and discussion with teachers and other parents. Parents were provided with an update of their child's progress in reading and mathematics. Time was also provided for parents to work together with their children on specific skills presented at the meetings.

Title: **ERG**
Audience: Middle school girls
Reference: Koontz, T. (1997). Know thyself: The evolution of an intervention gender-equity program. In J. Trentacosta & M. J. Kenney (Eds.), *Multicultural and gender equity in the mathematics classroom: The gift of diversity* (1997 Yearbook, pp. 186-194). Reston, VA: National Council of Teachers of Mathematics.

ERG (Enrichment Readiness for Girls) was a middle school intervention program named after a unit of potential energy. This successful program was designed to encourage middle school girls to continue mathematics, science, and computer courses throughout high school. Among the goals of the program were to encourage group problem-solving projects and to increase career awareness in technical fields.

Title: **QUASAR**
Audience: Middle school students
Reference: Silver, E. A., & Stein, M. K. (1996). The QUASAR Project: The revolution of the possible in mathematics instructional reform in urban middle schools. *Urban Education, (30)*4, 476-521.

QUASAR (Quantitative Understanding: Amplifying Student Achievement and Reasoning) was funded by the Ford Foundation and located at the University of Pittsburgh's Learning Research and Development Center. The project aimed to raise low levels of student participation and performance in mathematics. QUASAR was an urban middle school demonstration project that fostered the development and implementation of improved mathematics instructional programs in economically disadvantaged communities. The program was developed around three key principles: (1) all students are able to learn a broad range of mathematical content; (2) all students can acquire a deeper and more meaningful understanding of mathematical ideas; and (3) all students can demonstrate proficiency in mathematical reasoning and complex problem solving.

Title: **The Algebra Project**
Audience: Middle school students, parents, and teachers
Reference: Moses, R. P., & Cobb, C. E. (2001). *Radical equations: Math literacy and civil rights*. Boston, MA: Beacon Press.

This project aims to provide access to algebra curriculum for all students. Instruction includes five crucial components (from concrete to abstract): (a) Physical Events, (b) Pictorial Representations/Modeling, (c) Intuitive Language/People Talk, (d) Structured Language/Feature Talk, and (e) Symbolic Representation. The Algebra Project also raises parents' awareness of the importance of algebra, and it teaches mathematical ideas to parents so they are able to help their children with homework.

Title: **Cognitive Tutor Algebra**
Audience: Algebra I students
URL: http://pact.cs.cmu.edu/

Cognitive Tutor Algebra is a full year Algebra I course developed collaboratively by Carnegie Mellon and an award-winning high school mathematics teacher. The program incorporates software that tracks individual students' learning, gives hints, and provides an interface that links text, graphs, equations, and tables. Typically students spend two days per week working in a computer lab environment and three days per week working on small-group activities in the classroom.

Title: **The Saturday Academy Program**
Audience: High ability minority students in grades 7-9 and their parents/guardians
Reference: Hayden, L. B., & Gray, M. W. (1990). A successful intervention program for high ability minority students. *School Science and Mathematics, 90*(4), 323-333.

Students who participated in this program were identified as academically talented, had at least a B average, and were recommended by a mathematics teacher, science teacher, or counselor at their schools. The program included summer enrichment and a parent/guardian component. The program had a significant effect on high school graduation, college enrollment, and selected major in college. The effect was more pronounced for males than females.

Title: **Science Bound Project**
Audience: Grades 8–12 students and families
URL: http://www.iprt.ameslab.gov/SB/.

The Science Bound program at Iowa State University is a partnership between a local school district and the university that aims to increase ethnic minority students' participation in science and technology. It includes a component that works with parents to promote the learning of mathematics and science. The family support component provides ways for families to encourage their children to pursue a mathematics- or science-related career.

Title: **Strategic Content Learning**
Audience: Secondary school level
Reference: Butler, D. L. (1998). A strategic content learning approach to promoting self-regulated learning by students with learning disabilities. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 160-183). New York: Guilford Press.

The Strategic Content Learning (SCL) instructional model is built on learning-disabled students' awareness of strategic behavior, ability beliefs, and self-regulation. First, students are asked to analyze an academic task they need to accomplish. Next, they discuss strategies they know to accomplish this task. They are then assisted in acting strategically and monitoring progress toward task completion. Results include improved performance on specific academic tasks; development of personalized and focused strategies, strategy transfer across contexts, and flexibly adapted strategic approaches across tasks.

Title: **Self-Regulation Empowerment Program**
Audience: Learning-disabled secondary school students
Reference: Cleary, T. J., & Zimmerman, B. J. (2004). Self-Regulation Empowerment Program: A school-based program to enhance self-regulated and self-motivated cycles of student learning. *Psychology in the Schools, 41*, 537-550.

This school-based intervention program incorporates a problem-solving model from school psychology. The first phase of the intervention empowers students to feel in control of their academic outcomes. A coach helps students connect the strategies they use with their outcomes. Second, the coach provides strategy instruction. Third, students engage in a cyclical feedback loop, in which they set goals, select strategies for accomplishing the goals, monitor their strategy use, and make adjustments when necessary. The intervention supports the development of self-regulated learning behaviors.

Title: **EMPT**
Audience: Students in grades 10-12
URL: http://www.empt.org/empt/

EMPT (Early Mathematics Placement Test) is a high school mathematics intervention program designed to help students, counselors, and parents make decisions on appropriate mathematics courses in grades 11 and 12, based on aspirations reported during the testing process. The Ohio EMPT Program placement tests are administered to high school sophomores, juniors, and seniors to give them an indication of where they stand in terms of mathematical understandings and readiness for college or the workplace. After receiving their individualized results, students must talk to a counselor and/or teacher for advice on what is the best mathematics class to schedule for the next term and/or school year. This process helps ensure that students are prepared for college level mathematics courses or are prepared for a skilled work experience. EMPT is intended to eliminate the need for remedial mathematics courses or basic mathematical on-the-job training. The test results are not placed in a student's college record and the tests are not a state or federal requirement. EMPT-type intervention has been recommended in the document *Ready or Not: Creating a High School Diploma That Counts*, a publication of the American Diploma Project. EMPT is funded by the Ohio Board of Regents and is based at The Ohio State University.

Title: **Strategies of School Success**
Audience: First- or second-year college students
URL: http://dennislearningcenter.osu.edu/index.asp

College learning centers frequently support students through strategy remediation efforts typically focused on general learning strategies. The learning strategies course at Ohio State University supports students' efforts in four areas: taking reasonable risk, taking responsibility for outcomes (e.g., avoid procrastination and believe in ability to succeed), searching the environment (e.g., actively listening or reading and preparing for exams), and using feedback. Higher grade point average and increased motivation for academic learning have been found for participating students as compared with students who do not take this course.

PROGRAMS THAT FOCUS ON PROFESSIONAL DEVELOPMENT FOR TEACHERS

The programs listed in this category help students by helping teachers recognize, diagnose, and prevent student difficulties. These programs provide teachers with techniques and perspectives to enhance the mathematics learning of all students, regardless of the particular curriculum materials being used. Some of these programs focus on a specified context, but all include methods that can enrich teaching and learning in any context.

Title: **Mathematics Recovery**
Audience: First-grade students
URL: http://www.mathrecovery.com/

Mathematics Recovery, developed in Australia, involves specialist teachers working to advance the mathematical knowledge of low-attaining first-grade students to a level where they can learn successfully in a regular class. This intervention is accomplished through a short-term teaching cycle utilizing intensive, individualized instruction. Mathematics Recovery is designed for implementation at a district or state level via a year-long professional development course for teachers.

Title: **CGI**
Audience: Teachers of grades K-3
URL: http://ccvi.wceruw.org/ccvi/CGISpider/newsletter/newsletter.asp

CGI (Cognitively Guided Instruction) is a problem-based approach to mathematics instruction for kindergarten through third grade. The strategies and principles encouraged through CGI professional development are not textbook or program specific and have been proven effective for students with diverse racial and ethnic backgrounds. Children's prior knowledge is central to instructional decision making in this teaching approach. CGI focuses on children's mathematical thinking and communication.

Title: **Project IMPACT**
Audience: Teachers of grades K-3
URL:

Project IMPACT (Improving Mathematics Practices and Classroom Teaching), funded by the Ohio Department of Education, is a professional development experience supporting school teams of K-3 teachers to increase their effectiveness in teaching mathematics. Participants engage in an in-depth study of K-3 content focusing on number sense and equality. The mathematical process standards are the platform for learning and teaching mathematics.

Title: **OMAP**
Audience: Teachers of grades 7-10
URL: http://www.ode.ohio.state.oh.us

OMAP (Ohio Mathematics Academy Program) summer professional development is offered for teachers to help them understand the concepts featured in the Ohio *Academic Content Standards* and to address the Standards in their own classrooms. Professional development modules in algebra, geometry, and data analysis and probability have been created and shared with teachers through this program.

Title: **ACCLAIM**
Audience: All students and teachers in rural settings
URL: http://acclaim-math.org/

ACCLAIM (Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics) aims to understand how the rural context pertains to learning and teaching mathematics and to articulate in scholarly works the "meaning and utility" of learning and teaching in rural contexts.

Title: **IMPACT**
Audience: Predominantly minority urban elementary students and their teachers
Reference: Campbell, P. F., & Rowan, T. E. (1997). Teacher questions + student language + diversity = mathematical power. In J. Trentacosta & M. J. Kenney (Eds.), *Multicultural and gender equity in the mathematics classroom* (1997 Yearbook, pp. 60-70). Reston, VA: National Council of Teachers of Mathematics.

IMPACT (Increasing the Mathematical Power of All Children and Teachers) helped teachers as they planned lessons that incorporated meaningful, real-world mathematics problems "aimed a little higher than usual for the students." Teachers reported that the expectations they held for their students increased and that their students had improved both their mathematics and language proficiency more than under other approaches.

Title: **Mathematics Case Methods Project**
Audience: Teachers
URL: http://www.weted.org/pub/docs/mem.htm
Reference: Barnett-Clark, C., & Ramirez, A. (2004). Language pitfalls and pathways to mathematics. In R. N. Rubenstein & G. W. Bright (Eds.), *Perspectives on the teaching of mathematics* (66th Yearbook, pp. 56-66). Reston, VA: National Council of Teachers of Mathematics.

This professional development program aimed to help teachers analyze the impact of language on their students' mathematical understanding. Specific language "pitfalls" and their implications are discussed.

Title: **Japanese Lesson Study**
Audience: Teachers at any level
URL: http://www.oai.org/smart/pdf/STv3i3.pdf

The SMART Consortium is providing leadership for a number of mathematics and science education projects in northeast Ohio. One such project is centered on the idea of lesson study. "Lesson study" is a process for improving student achievement in which teachers jointly plan, observe, analyze, and refine classroom lessons called "research lessons." Lesson study has its roots in Japanese education, but since 1999 has been implemented in sites across the United States.

PROGRAMS BASED LARGELY ON CURRICULUM MATERIALS

Instructional materials can be instrumental in effective intervention. Listed below is a small sample of the wide variety of curriculum and resource materials that teachers can use in assisting students. In addition, the first paper below suggests criteria for evaluating the appropriateness of a mathematics program.

Title: **Connected Equitable Mathematics Curriculum (CEMC)**
Audience: All students and teachers
Reference: Goodell, J. E., & Parker, L. H. (2001). Creating a connected, equitable mathematics classroom: Facilitating gender equity. In B. Atweh, H. Forgasz, & B. Nebres (Eds.), *Sociocultural research on mathematics education* (pp. 411-431). Mahwah, NJ: Lawrence Erlbaum.

CEMC researchers identify 12 characteristics of what they consider essential features of an ideal mathematics curriculum, and they provide a framework for discussions about and progress towards more gender-inclusive and equitable curriculum.

Title: ***Success for All/Math Wings***
Audience: Preschool and kindergarten students and families
URL: http://www.successforall.net/

Success for All/Math Wings is a developmentally appropriate reading and mathematics program for preschool and kindergarten students. The program places great emphasis on parental involvement and provides strategies for involving parents. Each school building has a family support team that provides programs and services for parents.

Title: ***Family Math***
Audience: Grades K-8 students and families
URL: http://www.lhs.berkeley.edu/equals/FMnetwork.htm

Family Math is based on the philosophy that (1) all children can learn and enjoy mathematics and (2) parents and other family members are their children's first and most influential teachers. *Family Math* topics relate to the school mathematics curriculum, including algebra, probability, statistics, estimation, logic, geometry, and measurement. *Family Math* is the doing of mathematics and uses inexpensive materials of all kinds—beans, blocks, bottle caps, toothpicks, coins—to help people figure out ways to solve problems.

Title: **Computer Software as Intervention**
Audience: Elementary school students and teachers
URL: http://perrynet.sparcc.org/genoa/pages/welcome.htm

Schools such as Genoa Elementary School in the Perry Local Schools in Massillon, Ohio employ computers to provide assistance to children in mathematics.

Title: **National Science Foundation Funded Mathematics Programs**
Audience: Elementary, middle grades, and high school students and teachers
URLs: Elementary: http://www.comap.com/elementary/projects/arc
Middle grades: http://www.showmecenter.missouri.edu
High school: http://www.ithaca.edu/compass

Over the past decade or so, an interesting variety of innovative curriculum materials have been developed with NSF funding to reflect the spirit and intent of national Standards in mathematics. The websites listed above provide an introduction to these materials at the indicated levels.