AFTERSCHOOL MATHEMATICS PRACTICES

A Review of Supporting Literature

Developed by the

McREL

MID-CONTINENT RESEARCH FOR EDUCATION AND LEARNING

For the

NATIONAL PARTNERSHIP FOR QUALITY AFTERSCHOOL LEARNING

Advancing Research, Improving Education

SEDL

Afterschool Mathematics Practices

A Review of Supporting Literature

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Introduction

In recent years, there have been an increasing number of afterschool programs funded by both private and public sources. Many of these programs were originally designed to meet non-academic needs of students. However, given the current emphasis on providing evidence of increased student achievement, many afterschool programs are expanding their focus to include support for students' academic growth. Recognizing the needs in the field resulting from this shift, the U.S. Department of Education funded the National Partnership for Quality Afterschool Learning (National Partnership) in September 2003 to assist 21st Century Community Learning Center (CCLC) grantees in building local capacity to provide high-quality, academic enrichment opportunities. Specifically, the National Partnership has been asked to provide models, tools, and assistance to help grantees design, implement, and sustain effective academically-oriented programs.

One of the tools the National Partnership has been charged by the Department of Education with developing is an online *Afterschool Training Toolkit* (http://www.sedl.org/afterschool/toolkits/). The Toolkit is designed to provide afterschool program directors and instructors the resources they need to design fun, innovative, and academically enriching activities that not only engage students, but extend their knowledge and increase academic achievement. The Toolkit provides afterschool practitioners with a wealth of guidance for integrating literacy, mathematics, science, the arts, homework help, and technology into their programs. Each section of the Toolkit is organized around a set of content-area practices, or effective approaches to teaching and learning in the afterschool environment. The intended audience of the toolkit includes afterschool project directors and site coordinators. However, afterschool instructors and other staff will also find the information contained within these materials to be useful.

This review of supporting literature pertains specifically to the mathematics portion of the Toolkit. Seven afterschool mathematics practices have been identified to date:

1. Finding Math
2. Math Centers
3. Math Games
4. Math Tools
5. Math Tutoring
6. Family Connections
7. Math Projects

In the mathematics portion of the Toolkit you will find a brief description of each practice, a summary of the literature that supports it, and examples of the practice in action (i.e., sample lessons, video clips).You will also find implementation considerations and related resources to support each practice. This review of supporting literature is provided as an additional resource to provide a more in-depth review of the literature used to support the mathematics practices and guidance provided in the Toolkit.

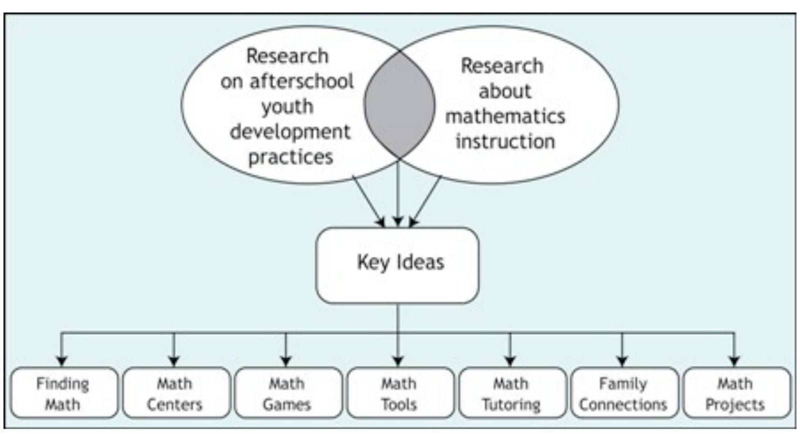
Methodology

In 2003, McREL conducted a research synthesis of available rigorous research from 1984 onward that considered whether out-of-school time (OST) strategies improved the mathematics and reading achievement of low-achieving and at-risk students. These studies specifically examined the effectiveness of a program, practice, or strategy delivered outside of the regular school day. The results of this study were published as *The Effectiveness of Out-of-School-Time Strategies in Assisting Low-Achieving Students in Reading and Mathematics: A Research Synthesis* (Lauer, Akiba, Wilkerson, Apthorp, Snow, & Martin-Glenn, 2004, available: http://www.mcrel.org/topics/productDetail.asp?topicsID=9&productID=151) and served as the foundation for the development of the mathematics practices. Development was also informed by additional research related to mathematics instruction and afterschool programming, multiple site visit observations (at sites with multiple years of evaluation data validating overall increased math achievement), and the professional knowledge and expertise of the developers.

This document, which is a supplement to the 2003 OST synthesis mentioned above, summarizes additional literature to support each of the mathematics practices drawn from:

- Research and literature excluded from the 2004 Research Synthesis due to study constraints (e.g., studies involving K-12 populations who are not specifically low-achieving or at-risk)
- Research and literature published after 2003 (when the 2004 Research Synthesis was completed) related to effective mathematics practices in afterschool; and
- Research on effective mathematics instruction for the day program.

In its review of the available research, McREL found limited research specifically addressing mathematics practices in afterschool. In order to define practices based on the best available research, McREL built a “logic train” of support for each of the practices that draws from what we know from both the in-school and out-of-school fields of research.



In 2006, a combined team of researchers and content experts engaged in a review process to provide users of the National Partnership for Quality Afterschool Learning’s Online Training Toolkit with a summary of research and literature to support the math practices. Examination team members included McREL math content experts (Chris Briggs-Hale, Heather Martindill, April Judd) and research experts (LeAnn Gamache, Mya Martin-Glenn).

The team examined a total of 85 documents, all of which were obtained and printed in full text. Of these, 57 documents that relate to mathematics and afterschool were included in this review of supporting literature. The search for documents was conducted using the Academic Search Premier and ERIC[1] databases and reference chasing. In addition, content experts recommended publications and web sites where additional research could be found. The team used search terms of “afterschool” and practice titles (e.g., “math games,” “family connections”), along with their associated synonyms (e.g., “family night”). Although the current project is focused on academic enrichment in mathematics, studies that analyzed tutoring and homework help were also included, because this is an area of focus for the National Partnership. Due to the limited research available on mathematics practices in afterschool, studies were not rejected on the basis of research design. Given the limited number of studies, literature which represents the opinions of experts in the afterschool field was also considered and included.

The examination team read each article that was ordered and received by July 20, 2006. Articles/papers/books were chosen for review based on relevance to the current project. Each team member used a common review protocol, which tracked information such as citation, research design, key findings, and alignment to practices. Documents were then sorted according to their alignment with practices, and key findings were used to write the practice summaries. To ensure coherence and continuity, one examination team member, April Judd, took the primary lead in synthesizing the findings and writing the abstracts included in this review of supporting literature.

McREL realizes that there are limitations to this review. The primary limitation is the scope of literature that exists related to the topic. Many of the articles/books/papers that were reviewed were not research-oriented; rather they were programmatic and practitioner based. The majority of studies included in this review were synthesis of research and quasi-experimental research.

To complete this review, McREL first reviewed what research says about best practices in afterschool and what research says about best practices in mathematics instruction. Pulling from these two areas and relying heavily on the limited research that exists where these two circles overlap, McREL discovered three prominent, or key, ideas that add rigor to the intentional integration of mathematics learning and youth development (e.g., social, emotional, physical). These key ideas include:

- encouraging problem solving,
- developing and supporting math talk, and
- emphasizing working together.

The following section outlines the research supporting each of the key ideas cross-cutting the mathematics practices in the Toolkit. Following the discussion of key ideas, readers will find a short overview and annotated bibliography of the research and literature supporting each of the mathematics practices.

[1] Note: The ERIC Clearinghouse was closed at the end of 2003. When the Clearinghouse re-opened in June of 2005, they began refurbishing the database; however, this process was incomplete at the time of this review. The examination team acknowledges that there may be resources available for the time period from 2003-2005 that were not accessible at the time of the search cut-off for this review.

Relevant Literature and Research on Key Ideas Cross-Cutting Mathematics Practices

Practices that support young people's social, emotional, and physical development provide the relevant link between successful afterschool programming and effective instruction in mathematics. Specifically, programming that supports the development of collaboration, discussion, and teamwork has logical links to instruction that leads to greater levels of understanding in mathematics. As McREL's research synthesis of out-of-school time learning indicates, "Programs that add social enrichment to an academic focus can have positive effects on mathematics achievement" (Lauer et al., 2004, pp 71–72). The three key ideas described below serve as a central link between the research on the effectiveness of youth development in out-of-school-time and those instructional strategies described in mathematics instruction literature that are made more effective through social interaction.

Key Idea #1: Encourage Problem Solving

Problem solving involves helping students pursue solutions to intriguing problems using what they know about mathematics facts, skills, and strategies. Researchers in the field of mathematics instruction have argued that while problem solving is not the only way to learn mathematics, it is a critical component (Van De Wall, 1994; NCTM, 2000). In *Adding It Up: Helping Children Learn Mathematics*, the official report from the National Research Council Mathematics Learning Study Committee of the National Research Council, specific instructional recommendations are made based on a synthesis of research on elementary and middle school student learning in mathematics (National Research Council, 2001). Of particular interest to the authors of the mathematics section of the Toolkit were the recommendations that add value to the instructional context as it typically exists in afterschool. For example, the recommendation that problem solving become the "context" for learning mathematics (National Research Council, 2001, p. 420) offers support for afterschool instructors who wish to embed mathematics into their programming.

Additional research from the National Research Council, the National Council of Teachers of Mathematics (NCTM), and others supports the centrality of problem solving in instructional programming as well. When students have opportunities to explore their preconceptions and engage their own problem solving strategies, they are able to build new knowledge (National Research Council of the National Academies, 2005). Additionally, it is within the problem-solving context that students are offered the most rigorous opportunities to develop the skills to communicate reasoning and strategies (NCTM, 2000; National Research Council of the National Academies, 2005; Van De Walle, 1994). This literature suggests that the intentional integration of problem solving in afterschool activities supports conceptual knowledge in mathematics by encouraging discussion, interaction, and collaboration.

Research indicates that good problem solving is fostered by problems that are interesting to students, and that encourage students to ask questions and use their thinking skills. Problem solving is enhanced when students discuss a problem together and when instructors use guiding questions that encourage students to discover a strategy or solution on their own. Afterschool activities lend themselves to problem solving because practitioners can incorporate math learning in fun, hands-on activities that students already enjoy, and ultimately increase students' enthusiasm for learning math.

Key Idea #2: Develop and Support Math Talk

Developing and supporting math talk refers to the students' use of language to express their ideas to each other, build on ideas together, and share strategies and solutions, as well as the instructor's support for this type of communication.

When students communicate mathematically, they are actively engaged in the learning process. Communicating about mathematics helps them clarify their thinking, construct their own meaning, analyze and interpret mathematical ideas, develop reasoning and metacognitive skills, make connections to what they already know, become aware of areas in which they need further clarification or explanation, and stimulate interest and curiosity (Countryman, 1992; Sutton & Krueger, 2002; NCTM, 2000; Pugalee, 2001). A student engaged in mathematical communication might put ideas into his/her own words, have conversations about math with others, explain his/her reasoning, present methods for obtaining and justifing solutions, act out concepts, use objects or drawings to represent problems, or ask questions about new or puzzling ideas (Hiebert et al., 1997; Sutton & Krueger, 2002; NCTM, 2000).

Many afterschool programs have positively affected mathematics achievement by combining social and academic enrichment (Lauer et al., 2004). Since communication by nature requires interaction with others, afterschool programs offer an ideal environment for capitalizing on the positive effects of integrating social and academic development. By communicating mathematically with others, students learn how to pose questions and develop respect for different ideas and ways of thinking (Hiebert et al., 1997; Sutton & Krueger, 2002; NCTM, 2000). In addition to direct benefits for students, encouraging and supporting mathematical communication helps afterschool instructors monitor student learning, identify misconceptions, and provide students with immediate feedback (NCTM, 2000; Pugalee, 2001).

Key Idea #3: Emphasize Working Together
Afterschool programs offer abundant opportunities for children to work together to solve problems because the nature of afterschool lends itself to social interaction and activity. Working together will support a high level of quality student interaction and mathematics learning (National Research Council, 2001; Policy Studies Associates, 1995). When children work together to discuss concepts, compare ideas, justify methods, and articulate thinking, they become motivated to learn mathematics. The children also gain awareness, respect, and admiration for the different problem-solving strengths their peers bring to the tasks. Children working together to solve problems are given the freedom to draw upon each other's knowledge and to connect different mathematical skills. This type of activity allows them to observe, compare, contrast, and evaluate unique strategies individuals apply to problem solving (National Research Council, 2001). The collective awareness that is developed when working with others to solve problems often supports higher levels of performance than if the child was working independently. This type of learning encourages the development of mathematical content, problem solving, communication skills, and supports the development of social skills (NCTM, 2000; Van de Walle, 1998; National Research Council, 2001).

Mathematics Toolkit Practice #1: Finding Math

Finding Math is the practice of using culturally relevant, real-world activities that children already appreciate and enjoy to create teachable moments that help students make connections to mathematics content and skills. For example, an afterschool cooking club could be used to provide students meaningful, relevant connections to mathematics by measuring ingredients, comparing measurements of liquids and solids, converting between standard and metric systems, and reducing or enlarging recipes. Literature from best practices in general education, effectiveness of out-of-school time strategies, and the teaching and learning of mathematics supports the importance of Finding Math.

In particular, literature on student motivation for learning suggests three motivating characteristics for afterschool activities. First, activities that incorporate academic content into popular activities based on students' interests, needs, culture, and prior knowledge help form connections between academic content and real-life situations (Brewster & Fager, 2000; Brophy, 1987; ERS, 1998; Hootstein, 1994). Second, activities that entail social interaction provide students with opportunities to form strong and satisfying relationships with adults and peers, give students immediate feedback, and allow students to respond actively to feedback (Brophy, 1987; ERS, 1998). Third, physical activities such as games, sports, and hands-on learning engage students by allowing them to be physically active (ERS, 1998). Literature from math education also supports this idea of physical activity. Griffiths & Clyne (1994) state that physical movement adds a kinesthetic aspect to learning.

Literature from OST best practices and evaluations focuses on integrating academic content into popular activities students already enjoy, such as a cooking class, sports, or art (EDCI, 2006; US DOE, 1998; Miller & Snow, 2004). Afterschool programs can uniquely provide a fun and flexible environment for students to explore skills and ideas with few boundaries and time constraints. In fact, most activities in an afterschool program contain some kind of academic content (EDCI, 2006). Becoming intentional about finding connections to the academic content and helping students see these connections provides meaningful learning contexts for *all* students. In particular, Miller & Snow (2004) report that OST programs that combine mathematics instruction and social activities such as cooking and gardening resulted in the largest gains in academic performance among at-risk students.

Finally, work from mathematics teaching and learning, both in afterschool programs and the day school program, indicates that using culturally relevant, real-world activities build on students' understanding while increasing their desire to learn mathematics and provides more meaningful learning opportunities for students struggling with math (Lauer et al., 2004; Bonotto & Basso, 2001; Kleiman, 1991). In an evaluation of afterschool programs for 3rd and 6th grade students in Austin, Texas (as reported in Lauer et al., 2004), Baker & Witt (1996) found programs that used activities such as science field trips, gardening, sports, and cultural activities in addition to academic classes had positive effects (d = .31) on student academic performance. In a synthesis of best practices in mathematics education, Bonotto & Basso (2001) state that exposure to real-world situations in school mathematics is necessary to develop a positive attitude towards mathematics in students. Bonotto & Basso also suggest using cultural artifacts to present mathematics as a tool for understanding reality and to break students' perception of mathematics as a static, remote body of knowledge. Kleiman (1991) also argues for using activities that present mathematics as a living body of knowledge intricately connected to real-world activities.

> *When mathematics is connected to the human experience, the same type of classroom culture advocated in the writing process – one that supports collaborative work, discussion and sharing of ideas, mutual respect for each learner's approach, and students sense of ownership of their work – becomes essential for mathematics learning ... Mathematics provides a language for quantifying, measuring, comparing, identifying patterns, reasoning, and communicating precisely. This language, like English or any other natural language, can provide a means for understanding, analyzing, and communicating across the curriculum and thought students' lives. It's a language children can bring into the worlds they create. (Kleiman, 1991, p 51)*

Supporting Literature and Research:

Bonotto, C. & Basso, M. (2001). Is it possible to change the classroom activities in which we delegate the process of connecting mathematics with reality? *International Journal of Mathematical Education in Science and Technology*, *32*(3), 385–399.

Bonotto & Basso draw on their experience in teaching and research in mathematics education to discuss the relationship between mathematics instruction and "the real world." After a brief introduction to explain current trends in using real-world knowledge in mathematics and the authors' perspective on mathematics activities and reality, Bonotto & Basso describe why the use of cultural artifacts enriches students' experience of mathematics. In fact, Bonnoto & Basso believe that the real-world context is the essential knowledge, whereas mathematics serves as a means of decoding this knowledge. The authors also discuss establishing behavioral norms in the mathematics classroom that encourage student experimentation and give examples of mathematics activities they believe will help students make the connection between mathematics content and their real-world context.

Brewster, C. & Fager, J. (2000). *Increasing student engagement and motivation: From time-on-task to homework.* Retrieved March 3, 2003, from http://www.nwrel.org/request/oct00/textonly.html.

This paper is 14th in a series of reports from the Northwest Regional Education Laboratory (NWREL) on current educational concerns and issues. Brewster and Fager discuss research and literature on motivating students to learn and give suggestions for adapting these ideas to encourage student engagement in classroom activities. The report includes an introduction to research on motivation covering topics such as putting learning in context and "what the research says." In particular, Brewster and Fager discuss how concepts underlying the Finding Math practice can increase student motivation.

Education Development Center, Inc. (2006). Afterschool time: Choices, challenges, and new directions. *MOSAIC 8*(1).

This issue of *MOSAIC* highlights a roundtable discussion on the afterschool movement and details the challenges facing the field. Participants in the discussion include industry leaders Bernie Zubrowski, Tony Streit, Laura Jeffers, and Ellen Gannett, co-director of the National Institute on Out-of-School Time. The panel discussed afterschool science and engineering; integrating technology, media, and project-based learning; and afterschool research, training, and policy. EDCI believes that afterschool programs can provide a fun, flexible environment for students to "discover connections between traditional academic subjects and popular culture, art, media and technology, careers and their own communities" (p. 2). *Mosaic* is a journal produced and published by Education Development Center, Inc. that examines key education and public health topics.

Educational Research Services (ERS). (1998). Enhancing student engagement in learning. *The Informed Educator Series.* Arlington, VA: Author.

This report provides an objective, comprehensive summary of research and opinion on factors that increase students' engagement in learning. The report discusses current thinking on factors that affect student engagement, offers suggestions for schoolwide practices that create a culture of high student engagement, and gives examples of instructional methods designed to engage students in learning. In particular, ERS lists several factors that affect student engagement related to Finding Math. For example, ERS states that work must be authentic (i.e., tasks that are meaningful, meet students' interests, and are connected to the real world), stimulate students' curiosity (i.e., awakens students' desire to understand phenomena around them), and give students opportunities to create strong, satisfying relationships with people they care about (e.g., peers, parents, and their community). ERS also discuss experience-based learning (activities that immerse students in experiences that model real life professions) as an instructional method that increases student achievement.

Lauer, P.A., Akiba, M., Wilkerson, S.B., Apthorp, H.S., Snow, D., & Martin-Glenn, M. (2004). *The effectiveness of out-of-school-time strategies in assisting low-achieving students in reading and mathematics: A research synthesis.* Aurora, CO: Mid Continent Research for Education and Learning.

Lauer et al. conducted a meta-analysis of 53 studies related to mathematics and reading in OST programs to examine the relationship among outcomes, methodological rigor, and content area. The authors conducted an exhaustive search of published and unpublished research and evaluation studies dated after 1984. One thousand, eight hundred and eight citations were found. Of these, 371 were reports and 53 met the inclusion criteria. Studies included in the meta-analysis met criteria on characteristics of the OST strategies used, type of students addressed, research design, methodology, data analyses and research quality. The authors focused their efforts on the impact of OST programs for at-risk students, considering moderating factors such as program characteristics (e.g., grade level, timeframe, focus, and duration), study quality, publication type, and achievement score type.

The review of research found positive effects for afterschool programs in Texas which combined recreation and academics. The review also found that "programs that add social enrichment to an academic focus...have positive effects on mathematics achievement" (pp. 71–72). For example, in a study of five urban Boys and Girls Clubs of America afterschool programs involving 283 fifth through eighth grade participants (all residents of public housing), positive effects were reported in mathematics achievement for students participating in specific mathematics- and literacy-related activities. These activities included discussion groups that provided opportunities to talk about math, creative writing sessions, homework help, peer tutoring, and recreational activities such as gardening, sports, and cultural events. Overall, Lauer et al. found the following results: OST strategies can have positive effects on the achievement of low-performing or at-risk students in reading and mathematics; activities do not need to focus on academic content to have positive effects on achievement; and programs that provide one-to-one tutoring have strong positive effects on student achievement.

U.S. Department of Education (June 1998). *Safe and smart: Making afterschool hours work for kids.* Retrieved 5/3/06 from www.ed.gov/pubs/SafeandSmart/title.html.

This report presents research and examples of quality afterschool activities that keep children safe and learning. It presents empirical and anecdotal evidence of success in afterschool activities and identifies key components of high-quality programs and effective practices such as effective partnerships with community-based organizations and steps to building an afterschool partnership (e.g., using community resources effectively and involving families and youth in program planning). The report also describes exemplary afterschool and extended learning models with proven results. For example, the report lists connecting the afterschool curriculum to classroom content through real-life activities such as tap dance and drawing cloud formations in an art project as an important characteristic of effective programs. The U.S. Department of Education also states that successful programs use activities that are fun, culturally relevant, and meet students' interests.

Mathematics Toolkit Practice #2: Math Centers

We define "math centers" as small-group stations where students work together on activities such as puzzles, problems using manipulatives, and brainteasers. The goal of these centers is to give students opportunities to practice mathematics problem solving through a variety of activities, at their own pace, with a choice of working independently or with their peers. A majority of the support for math centers comes from literature in afterschool programs (Stephens & Jairrels, 2003; Welsh et al., 2002) and general education (American Council on Immersion Education, 2004; Bottini & Grossman, 2005). However, some support for such learning centers can also be found in textbooks such as *Elementary and Middle School Mathematics: Teaching Developmentally* (Van de Walle, 2004). In this text, Van De Walle supports the use of learning centers as an opportunity to allow students to work independently and make choices on their own.

Stephens & Jairrels (2003) see learning centers as educational environments that allow students to deepen their content understanding in reading, mathematics, science, and social studies through self-directed learning. Students are able to choose which centers to work on and how to approach a problem solving situation based on their strengths, ability, and interests. Learning centers also enhance socialization skills as students work together. Welsh et al. (2002) emphasize the social aspect of learning centers. They describe learning, or work, centers as authentic opportunities and time for students to work together on a problem, talking about and explaining the mathematics they are using and learning. However, Welsh et al. (2002) also believe learning centers "provide meaningful independent practice." Thus, learning centers offer students opportunities to develop independence, practice making their own choices in a safe environment, explore different approaches to problem solving, build their communication skills in mathematics, and learn how to work together.

From the literature in general education, the American Council on Immersion Education (ACIE) (2002) focuses on encouraging math talk, explanations, and student choice through the use of learning centers while Bottini & Grossman focus on student ability to make choices and work together. In addition, ACIE describes learning centers as a space where students can learn without constant supervision from the teacher. That is, learning centers encourage student independence. According to ACIE, centers can be designed to support the development of mathematical concepts and students' interests, among other things. They can also give students the opportunity to work together to discover and create solution strategies at their own pace. Bottini & Grossman believe centers allow children to make choices, socialize, and work cooperatively, helping one another with explanations of the mathematics involved.

Supporting Literature and Research:

American Council on Immersion Education (2004). Learning centers: Meaningful contexts for language use in the primary immersion. *The Bridge: From Research To Practice.* Minneapolis, MN: Author.

The American Council on Immersion Education (ACIE) is a network of individuals interested in language immersion education (teaching children primarily in a second language with support in their first language). Members include teachers, administrators, teacher educators, researchers, and parents. The goal of ACIE is to facilitate communication among educators and others interested in immersion education. The ACIE newsletter, *The Bridge: From Research to Practice,* provides articles focused on research-based ideas and best practices and research reports in immersion education. This issue is dedicated to defining the use of learning centers. ACIE explains how the use of learning centers contributes to student achievement, gives instructional strategies specific to learning centers, and provides several examples and explanations for integrating learning centers in the classroom.

Frederick County Public Schools (2003). *Literacy and numeracy work centers.* Retrieved July 21, 2006 from http://fcps.org/boez.htm#board.

This is an early childhood instructional resource published for Frederick County Public Schools' teachers and administrators focusing on the use and management of learning centers in reading and/or mathematics (the publication may be downloaded by the general public). The introduction defines effective characteristics of learning centers and discusses effective implementation. The document also provides examples of work centers with suggested materials and tasks, a glossary of terms, and an annotated bibliography.

Lauer, P.A., Akiba, M., Wilkerson, S.B., Apthorp, H.S., Snow, D., & Martin-Glenn, M. (2004). *The effectiveness of out-of-school-time strategies in assisting low-achieving students in reading and mathematics: A research synthesis.* Aurora, CO: McREL.

Lauer et al. conducted a meta-analysis of 53 studies related to mathematics and reading in OST programs to examine the relationship among outcomes, methodological rigor, and content area. The authors conducted an exhaustive search of published and unpublished research and evaluation studies dated after 1984. One thousand, eight hundred and eight citations were found. Of these, 371 were reports and 53 met the inclusion criteria. Studies included in the meta-analysis met criteria on characteristics of the OST strategies used, type of students addressed, research design, methodology, data analyses and research quality. The authors focused their efforts on the impact of OST programs for at-risk students, considering moderating factors such as program characteristics (e.g., grade level, timeframe, focus, and duration), study quality, publication type, and achievement score type.

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Stephens, H. & Jairrels, V. (2003). Weekend study buddies: Using portable learning centers. *TEACHING Exceptional Children, 35*(3) pp. 36–39.

Stephens and Jairrels explain how to use a weekend study buddy as a portable learning center for students (ages 5–9) with mild disabilities. A study buddy is a portable learning center in the form of a colorful paper or cloth bag that students take home afterschool. The authors define learning centers and "study buddies." They also describe designing a study buddy and how to encourage parent involvement.

Welsh, M.E., Russell, C.A., Williams, I., Reisner, E.R., & White, R.N. (2002, October). *Promoting learning and school attendance through afterschool programs: Student-level changes in educational performance across TASC's first three years*. Washington, DC: Policy Studies Associates, Inc.

Created in 1998, The Afterschool Corporation (TASC) supports more than 130 community-based afterschool programs in the New York City area. In 2002, TASC sponsored a comprehensive evaluation of 96 TASC afterschool projects to assess implementation and effectiveness of the programs. The purpose of this evaluation is to report on the education-related characteristics and changes affecting K–8 participants during the first three years of TASC support (1998–1999, 1999–2000, and 2000–2001).

TASC projects included in this evaluation served the most disadvantaged children in the New York school systems. Both participants and non-participants were children at-risk of academic failure. Outcome measures were collected and analyzed around afterschool attendance, academic achievement, and school attendance. Results indicated positive effects on student growth, especially for students who participated frequently and regularly over two years or more. Attendance in the afterschool programs rose steadily over the first three years. In turn, the TASC projects were consistently associated with improvement in school attendance. Improved achievement in mathematics was also reported across all grade levels and subgroups of students. In particular, Welsh et al. report that opportunities to engage in math games and tutoring gave students the practice, application, and special help they needed to achieve higher levels of performance.

Mathematics Toolkit Practice #3: Math Games

Math Games are fun activities that develop targeted math strategies and skills by leveraging students' natural inclination to play. The best games are those that encourage involvement, call for both skill and chance, require students to think deeply, and allow for students to use multiple strategies of problem solving (Hildebrandt, 1998). Games can be competitive, cooperative, or used in large groups, small groups, or individually.

Mathematical games have repeatedly been proven to increase student understanding and achievement in mathematics (Holton et al., 2001; Kamii & DeVries, 1980; Ortiz, 2003; Peters, 1998). In an evaluation of the The Afterschool Corporation (TASC) in New York City, Welsh et al. (2002) report that opportunities to engage in math games and tutoring gave students the practice, application, and special help they needed to achieve higher levels of performance. In the afterschool environment, games provide a rich context for social and mathematical development (Hildebrandt, 1998). Students are able to explore new strategies for problem solving and mathematical calculations and discuss these strategies with their peers (Hildebrandt, 1998). Another benefit of mathematical play is that students can take part at their own level and build on their own knowledge and understanding (Holton et al., 2001). Mathematical games also provide a safe environment for students to make errors (Holton et al, 2001).

Although most of our support for mathematical games comes from the literature in mathematics education, there are several resources in general education (e.g., Kamii & Devries, 1980) that discuss the effective use of game playing to enhance student learning.

Supporting Literature and Research:

Hildebrandt, C. (1998). Developing mathematical understanding through invented games. *Teaching Children Mathematics. 5*(3) pp. 191–195.

Hildebrandt reports on action research she conducted beginning in the fall of 1995 on using invented games to promote mathematical reasoning among primary school children. The author describes the "money game" she used in her methodology and how her research evolved during implementation. To play the money game, you need a pair of dice and a few dollars in coins (i.e., pennies, nickels, dimes, and quarters). Students should be in small groups or teams. Teams roll the dice in turns. The amount shown on the dice is the number of cents the team gets from the bank. The first team to reach a total of one dollar wins.

Hildebrandt also discusses principles she learned for playing invented games with students. For example, Hildebrandt observed that "group games can provide a rich context for social and mathematical development," that repeated play gives children opportunities to develop new strategies for performing mathematical computations, and that the best games are those that "allow multiple strategies for problem solving, competition, and collaboration."

Holton, D., Ahmed, A., Williams, H., & Hill, C. (2001). On the importance of mathematical play. *International Journal of Mathematical Education in Science and Technology, Volume 32, 3*(1), 401–415.

Holton et al. explore the importance of play in learning mathematics. The paper is divided into seven sections. The first section introduces the concept of play and outlines the structure of the paper. The second section reviews several perspectives on play, in general, as presented in the literature, and the authors define what they mean by mathematical play in the third section. Mathematical play is problem solving through experimentation and creativity to generate and follow ideas. The learner is able to explore the limits of the problem situation and follow their thoughts wherever they may lead. Mathematical play is a learner-centered activity in which the student is given autonomy.

The fourth and fifth sections link the idea of play to research. The fourth section provides a review of studies exploring the relationship between play and cognition in general learning, and the fifth section links play to mathematical research. The authors then give examples of play at work in several problems that they used with students. Finally, the authors connect the information presented in each section to draw conclusions about the use of play for mathematical learning.

Ortiz, E. (2003). *Research Findings from Games Involving Basic Fact Operations and Algebraic Thinking at a PDS.* The ERIC Clearinghouse on Teaching and Teacher Education. Washington, D.C. (Non-refereed.)

Ortiz conducted research in the spring of 2002 to measure the effectiveness of instructional games in helping students master basic arithmetic operations. Participants of the study were students in kindergarten through fifth grade in an urban Florida public school within a predominantly lower–middle class neighborhood. There were six groups of students from each grade, for a total of 145 participating students. Sixteen students were in kindergarten, 24 in first grade, 19 in second grade, 24 in third grade, 21 in fourth grade, and 23 in fifth grade. Pre- and post-tests were administered to each student. Pre-tests were administered the week before treatment implementation. Then participants engaged in different levels of games (selected by the classroom teacher) for five days over the next one- to two-week period. After implementation of game play for two weeks, students took a post-test. The data from the pre- and post-tests were analyzed for significant differences by grade level. In addition, observations and annotations of student work were collected from Ortiz's field notebook. These were analyzed for possible patterns. Results of the analyses suggest that game playing had a positive effect on students' mathematical performance at the kindergarten through second grade levels. Results for third through fifth grade were inconclusive due to complications over the use of variables. In other words, the activities for kindergarten through second grade students involved straight arithmetic operations (e.g., 3+2=★, ★=___) while the activities for third through fifth grade students had the added component of variables (e.g., X•X=Z, X=___, Z=___). Thus, it is difficult to determine whether the use of variables in the activities or the activities themselves had an effect on student performance.

Peters, S. (1998). Playing games and learning mathematics: The results of two intervention studies. *International Journal of Early Years Education, 6*(1), 49–58.

Peters reports the findings of two studies, which were part of the Early Mathematics Improvement Project (EMI-5s). EMI-5s was designed to investigate the ways to improve the understanding of number among five-year-olds. The two studies described by Peters are follow-up interventions designed to explore how the ideas from EMI-5s can be implemented on a wider scale. The first study measured the impact of parents playing games with small groups of children in the classroom. The progress of eighteen, five-year-old children was measured over their first eight months of school. Data were collected through private task-based interviews as the start of school, two months into the school year, and at the end of eight months of school. The data collected for 14 of these children was compared to a control group of 37 children starting school at the same time.

The second study measured the same impact among seven-year-old-children. There were 128 participating students. Thirty-nine students received a similar treatment to the first study for six months. Parents were invited into the classroom to play games with small groups of students once a week. Fifty-eight children played identical games in small group without parent involvement, and 31 students only received the normal mathematical instruction, without games. Private task-based interviews were conducted before and after the interventions were implemented. Both studies also used observations and interviews to capture the experiences of participants as they played the mathematical games and during their normal instruction.

Both studies provided evidence that playing mathematical games with children has positive effects on students' mathematical development. In the first study, there were large and persistent gains among five-year-olds who received the intervention throughout the eight month implementation. In addition, these results were consistent with results from the EMI-5s studies. The second study, however, had mixed results. Because of lack of control over the school environment, the control group had much more adult contact and support than was intended. Along with this, the first intervention group did not have enough parent support and participation. Thus, the control group had much more adult participation than the intervention group, which was contrary to the study design. In spite of this complication, students who received the two types of interventions (game play with adults and game play without adults) made similar progress to the control group who only received their normal mathematics instruction (without game play). The fact that the students in the intervention groups (with low levels of adult support) made similar progress to the children in the control group who received high levels of adult support indicates that the interventions did provide some benefits. However, it is difficult to say how much impact the interventions had on student development without further investigation. Overall, the results of these studies indicate that mathematical games appear to be most effective in enhancing students' development when a caring adult is present to support and extend student learning.

Mathematics Toolkit Practice #4: Math Tools

Mathematical tools can be broadly defined as any concrete material used to measure, count, sort, or evaluate a mathematical problem. Such materials may include manipulatives such as beans, counters, blocks, measuring devices (e.g., rulers), pictures, symbols, and technology (Van de Walle, 1998; Hiebert et. al, 1997; National Research Council, 2001). Research in mathematics education has shown that the use of manipulatives has a positive impact on student achievement and improves student attitude toward learning. For example, in his analysis of 60 studies, Sowell (1989) found that mathematics achievement was increased through the long-term use of concrete instructional materials and that students' attitudes toward mathematics were improved when instruction with concrete materials was provided by teachers knowledgeable about their use.

Using tools to make sense of mathematics is a powerful learning experience. They help students think flexibly about mathematics, allow for more creative approaches to new mathematics problems (Hiebert et al, 1997), and explore mathematics with less anxiety (English & Halford, 1995; Hiebert et al., 1997)). In his chapter on developing mathematical understanding, Van de Walle (2004) points out that models of mathematical situations help students explore, reflect on, and make sense of new ideas, and many models can be explored using physical materials. Likewise, Hiebert et al. (1997) state that using tools enables students to develop deeper meaning of the mathematics that the tools are being used to examine. This is especially true as students start to use tools in a variety of situations or use several different tools for the same situation. Using tools in a variety of situations helps students create deeper meaning for the tools themselves. Using a variety of tools for *one* situation helps student make connections between different representations (Griffiths & Clyne, 1994).

However, it is important to remember that mathematical ideas are not automatically seen through the use of a tool (Ball, 1992). That is, mathematical meaning does not necessarily reside in a tool. It is constructed by students as they interact with tools (Hiebert et al., 1997). "Models help children think and reflect on new ideas" (Van de Walle, 2004, p. 30). When tools are used wisely, students learn to be mathematicians rather than merely learning about mathematics

(Clements & McMillen, 1996). That is, students learn to see connections among objects, symbols, language, and ideas (National Research Council, 2001). This requires more than watching a demonstration by a day-program teacher or afterschool staff. Students need to work with tools over extended periods of time, try them out, and observe what happens (Hiebert et al., 1997). Thus, physical and computer manipulatives should be chosen carefully to illustrate meaningful representation, and instruction should guide students in making connections between the mathematical tools they are using and their representation of important mathematical concepts (Clements & McMillen, 1996).

Afterschool programs offer unique opportunities to provide the extended practice with various mathematical tools that students need. For example, in their summary of best practices from 14 successful afterschool programs, Policy Studies Associates, Inc. (1995) report that research shows the use of mathematical tools has a positive impact on students achievement and suggest that afterschool programs use tools to improve student development. Many activities that are a regular part of afterschool programs can form a basis for exploring mathematics (EDCI, 2006; Mokros, Kliman, & Freeman, 2005). Recall from the "Finding Math" section of this report that Miller & Snow (2004) found that OST programs that combine mathematics instruction and social activities such as cooking and gardening resulted in the largest gains in academic performance among at-risk students. Activities like cooking, gardening, and painting support using math tools such as measuring cups/spoons, rulers, geometric diagrams, and art tools for drawing pictures in perspective.

Supporting Literature and Research:

Ball, D. (1992). Magical hopes: Manipulatives and the reform of math education. *American Educator, 16*(1), 14–18, 46–47.

This article discusses the appropriate use of manipulatives to help students think flexibly about mathematics. Ball uses a story of a student exploring the concept of even and odd numbers to illustrate that mathematical truths are not necessarily automatically "seen" through the use of concrete objects. Ball points out that as mathematicians, teachers can see the mathematics represented in concrete materials *because* we already have the very mathematical understandings we are looking for. Thus, it is important to consider the context in which students will use a particular math tool. How are students working with the tool? Why are they using this tool, and how does it connect to the mathematics they are expected to learn? What kinds of talk or interaction will the students engage in while using the math tool? Questions such as these help guide instruction that is enriched by the "wise use" of mathematical tools.

Clements, D. H. & McMillen, S. (1996). Rethinking "concrete" manipulatives. *Teaching Children Mathematics*, *2*(5), 270-279.

Clements and McMillen discuss the effective use of manipulatives. The authors review research findings that suggest that computer manipulatives have an important place in learning but do not carry the meaning of the mathematical idea. The article gives suggestions for choosing computer tools that use meaningful representations of mathematical ideas. The authors also emphasize the importance of instruction that guides students in making connections between these representations.

Education Development Center, Inc. (2006). Afterschool time: Choices, challenges, and new directions. *MOSAIC 8*(1).

This issue of *MOSAIC* highlights a roundtable discussion on the afterschool movement and the challenges facing the field. Participants in the discussion include industry leaders Bernie Zubrowski, Tony Streit, Laura Jeffers, and Ellen Gannett, co-director of the National Institute on Out-of-School Time. The panel discussed afterschool science and engineering; integrating technology, media, and project-based learning; and afterschool research, training, and policy. EDCI believes that afterschool programs can provide a fun, flexible environment for students to discover connections between traditional academic subjects and popular culture, art, media through experiential learning. In particular, the afterschool environment provides an opportunity to work with concrete materials (e.g., math tools) and understand how they work. *Mosaic* is a journal produced and published by Education Development Center, Inc. that examines key education and public health topics.

Fuson, K.C. (1992). Research on whole number addition and subtraction. In D.A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 243-275). Old Tappan, NJ: Macmillan.

Fuson begins his chapter by outlining the types of whole number addition and subtraction situations that exist in “the real world” (e.g., compare, combine, change add to, and change take from). The purpose of this discussion is to describe the different problem types children might encounter and the effect they have on children’s solution strategies. The second and third parts of the chapter describe how children between the ages of eight and 12 develop conceptual structures for unitary and multiunit addition and subtraction to interpret and solve the types of situations describe in the first part of the chapter. Each discussion (unitary and multi-unit) includes support of mathematical tools for exploring concepts, building mathematical knowledge, seeing connections among objects, symbols, language, and ideas, and helping students think flexibly about mathematics. For example, Fuson states that working with concrete, milti-unit objects (e.g., unifix cubes®) helps facilitate students’ understanding of addition and subtraction problems involving multi-digit whole numbers. The chapter ends with suggestions for applications in the classroom.

Mokros, J., Kliman, M., Freeman, H. (2005). *Time to enhance math in after-school*. Cambridge, MA: TERC. Retrieved August 16, 2006 from http://www2.terc.edu/UPLOADED/DOCUMENTS/TimeEnhanceMath.pdf.

Mokros, Kliman & Freeman conducted an evaluation of afterschool programs in the Boston area to examine ways in which mathematics was incorporated into the program (e.g., tutoring, mentoring, math games, real-world activities, etc.) and to identify the potential of these programs to support mathematical learning at the elementary and middle school levels. The authors used several sources of data. They reviewed the current mathematics curricula used in Boston area schools, examined recent Massachusetts Comprehensive Assessment System scores, examined math-related programs and materials in the afterschool settings, and reviewed research studies on the effectiveness of academic support in afterschool programs. Mokros et al. also interviewed key mathematics staff in the Boston Public School System, afterschool leaders, and curriculum developers.

Sowell, E. (1989). Effects of manipulative materials in mathematics instruction. *Journal for Research in Mathematics Education, 20*, 498–505.

Sowell conducted a meta-analysis of results from 60 studies on the effectiveness of using manipulative materials in mathematics instruction. Studies included in the analysis compared equivalent treatment groups using concrete materials with groups using an abstract approach. Seventeen studies were conducted at the K–2 grade levels; 17 in grades 3–9; nine in grades five and six; 11 in grades 7–9; and six at the college level. The duration of treatment varied among the studies, and, thus, it can be assumed that the mathematics content varied during the administration of any particular treatment. The collected data was analyzed for effect size among achievement level and student attitude. Treatments lasting a year or more showed a moderate to large positive effect size at the elementary level. Sowell also found that instruction using concrete materials that was provided by teachers who are knowledgeable about the effective use of math tools can improve student attitude towards mathematics.

Mathematics Toolkit Practice #5: Math Tutoring

Math tutoring can be defined as helping and supporting the mathematical learning of students in an interactive, purposeful, and systematic way (Topping, 2000). Tutoring can take place in small groups or in one-on-one sessions. Anyone can be a tutor. Tutors can be parents or other adult caregivers, siblings, other members of the family, peers, and various kinds of volunteers such as college students and retired members of the community. Most important, tutoring needs to be targeted to a student’s individual strengths and needs through the cooperation of the tutor, student and teacher(s).

The literature in afterschool programming indicates that high-quality, frequent, and consistent one-to-one tutoring has positive effects on student achievement. Cosden (2001) described afterschool programs as a “safety net” for disadvantaged children, and Miller (2003) and Welsh et al. (2002) found that tutoring programs provide the individualized help students need to achieve academically. In a literature review of academic tutoring and mentoring, Powell (1997) stated the tutoring is especially beneficial among disadvantaged students, “with learners showing greater than average gains in reading and mathematics and less absenteeism.”

Research also show that afterschool tutoring helps students achieve improved academic performance in a number of ways. Students experience greater confidence levels (Cosden, 2001), increased grades in school and higher completion rates in homework assignments (Brown et al., 2003), and perform higher on standardized exams (Elbaum et al., 2000; Powell, 1997; Welsh et al., 2002). To encourage these positive impacts on student achievements, programs must have several key characteristics. In a study of several afterschool programs, Policy Studies Associates for the U.S. Department of Education (1995) identified a few of the characteristics critical to successful afterschool tutoring. First and foremost, non-certified staff need high quality training (also supported by Miller (2003)). In addition, programs should connect with the regular school day curriculum and experiences so that students extend their learning throughout the day. Further, the Office of the Under Secretary, Planning and Evaluation Services for the U.S. Department of Education (1997) identified six factors that generate the most consistent positive effects on student achievement. These are: (1) close coordination with the day school teacher; (2) intensive and ongoing training for tutors; (3) well-structured content and carefully scripted delivery of instruction; (4) careful monitoring and reinforcement of progress; (5) frequent and regular sessions between 10 and 60 minutes long; and (6) specially designed interventions for children with learning disabilities.

Supporting Literature and Research:

Brown, E.G., McComb, E.M., & Scott-Little, C. (2003). *Afterschool programs: Evaluations and outcomes*. Greensboro, NC: SERVE.

This meta-analysis documents the impact of afterschool programs on student achievement. Several studies have shown that afterschool programs have a positive impact of student outcomes. However, these results come from a wide range of studies that do not always rely on best research practices and many conclusions come from recommendations from experts, anecdotal evidence, and process evaluations that did not take student outcomes into consideration. The purpose of this meta-analysis was to develop a profile of effective best practices in afterschool programs that are based on outcome data available through current, well-designed research.

Results from 27 studies of afterschool programs were analyzed and organized into academic outcomes, school attendance, psychological/youth development outcomes, and satisfaction with the program. A detailed description of their selection methodology and descriptions of each program are included in the report. Results from experimental and quasi-experimental research indicated higher achievement scores in reading and math and higher attendance rates for afterschool programs in general. Results from non-experimental research indicated higher scores on standardized math tests and higher homework completion rates for students who participated in programs that included tutoring and mentoring services.

Cosden, M., Morrison, G., Albanese, A. L., & Macias, S. (2001). *Evaluation of the Gevirtz Homework Project: Final report*. Santa Barbara, CA: Gevirtz Research Center.

The Gevirtz Homework Project (GHP) was a three-year afterschool program implemented in three public elementary schools in the Santa Barbara, California area. The goal of GHP was to increase student achievement through assistance with homework and study skills. Students entered the program in the fourth grade and were expected to continue participation through their sixth grade year. Students received individualized tutoring 45 minutes a day, three to four times a week from a credentialed K–6 teacher. The evaluation of this study was designed to investigate the impact of afterschool homework assistance on elementary school children with a broad range of abilities.

Cosden et al. used an experimental design using stratified random assignment of participants. Participants were grouped according to gender, level of academic performance, and English proficiency. Academic performance and language fluency were rated by each student's teacher. Seventy-two students were assigned to the control group and seventy-four were assigned to the homework participation group. Data on attendance, academic performance, student perceptions, social skills and support, and parental involvement was collected at the beginning and end of each academic year.

Analysis of the data indicated that children who received homework assistance reported more confidence in their academic performance, and teachers seemed to like that the students completed their homework and turned it in each day. In addition, participants with limited

English proficiency were rated higher than both their counterparts in the control group and participants with functional English proficiency on academic effort and study skills. Overall, results showed that afterschool homework programs provide a "safety net" for children who may not have available academic support.

Miller, B. M. (2003). *Critical hours: Afterschool programs and educational success*. Brookline, MA: Miller Midzik Research Associates for the Nellie Mae Education Foundation. Retrieved June 15, 2003, from http://www.nmefdn.org/CriticalHours.htm

This report synthesizes information from studies of afterschool programs, offers conclusions about the role of OST programs in promoting student success, and presents effective components of OST programs for fulfilling this role. Miller explores the links between out-of-school time and academic success by combining theory in education, psychology, child development, and recreation. The report begins with a brief overview of early adolescent development in educational, economic and social contexts, followed by a review of major attitudes and behaviors associated with academic achievement. After setting this stage for school learning, the report goes on to examine current afterschool programs, discussing the role of OST programs in promoting student success and creating a link between participation in OST programs and school learning.

Finally, the report identifies components of effective afterschool programs that promote student success. In particular, Miller discusses the effect of emotional engagement with caring adults and positive peer influences through mentoring and peer tutoring.

Office of the Under Secretary, Planning and Evaluation Service, U.S. Department of Education (1997). *Evidence that tutoring works*. Retrieved from http://www.ed.gov/inits/americareads/resourcekit/miscdocs/tutwork.html.

This resource summarizes research and critical thinking on the effect of tutoring on academic achievement. Citing research studies, this report details the six components of effective tutoring: (1) tutoring programs that incorporate research-based elements; (2) intensive and ongoing training for tutors; (3) well-structured tutoring sessions in which the content and delivery of instruction is carefully scripted; (4) careful monitoring and reinforcement of progress; (5) frequent and regular tutoring sessions, with each session between 10 and 60 minutes daily; and (6) specially designed interventions for children with severe reading difficulties.

Powell, M.A. (1997). *Academic tutoring and mentoring: A literature review*. Sacramento, CA: California Research Bureau, California State Library. Retrieved from http://www.library.ca.gov/CRB.97.11/97011.pdf.

Sponsored by the California Research Bureau, this report discusses theories underlying the use of tutoring and mentoring and cites research supporting the effectiveness of both. The document is divided into four sections: (1) an introduction to developmental, learning, and social intervention theories; (2) descriptions of several tutoring program models; (3) a discussion of findings from an evaluation of *Peer Tutoring and Mentoring Services for Disadvantaged Secondary School Students*; and (4) a summary of three key reports on mentoring programs. The purpose of the first section is to illustrate the relevance of social intervention theory to academic achievement and connect academic tutoring and mentoring programs to social intervention.

The report suggests that tutoring is especially effective for disadvantaged children. The report also emphasizes the importance of training, collaboration with local colleges, one-on-one tutor and tutee relationships, the use of incentives for supporting tutors, and recruiting at-risk tutors. The report details different tutoring structures and programs and discusses policy implications. The report discusses the use of mentoring as a strategy for supporting student development.

Welsh, M.E., Russell, C.A., Williams, I., Reisner, E.R., & White, R.N. (2002). *Promoting learning and school attendance through after-school programs*. (October 2002). Washington, DC: Policy Studies Associates, Inc.

Created in 1998, The Afterschool Corporation (TASC) supports more than 130 community-based afterschool programs in the New York City area. In 2002, TASC sponsored a comprehensive evaluation of 96 TASC afterschool projects to assess implementation and effectiveness of the programs. The purpose of this evaluation is to report on the education-related characteristics and changes affecting K–8 participants during the first three years of TASC support (1998–1999, 1999–2000, and 2000–2001).

TASC projects included in this evaluation served the most disadvantaged children in the New York school systems. Both participants and non-participants were children at risk of academic failure. Outcome measures were collected and analyzed around afterschool attendance, academic achievement, and school attendance. Results indicated positive effects on student growth, especially for students who participated frequently and regularly over two years or more. Attendance in the afterschool programs rose steadily over the first three years, and the TASC projects were consistently associated with improvement in school attendance. Improved achievement in mathematics was also reported across all grade levels and subgroups of students. In particular, Welsh et al. report that opportunities to engage in math games and tutoring gave students the practice, application, and special help they needed to achieve higher levels of performance.

Mathematics Toolkit Practice #6: Family Connections

This practice refers to capitalizing on family and community resources and/or partnerships to support academic learning. The goal of this practice is to engage parents, caretakers, and students in meaningful learning experiences that help support students' mathematical learning both in and afterschool. Research on OST programs and general education strongly supports the importance of family connections to student learning.

In their evaluation of a pilot afterschool program targeting "at-risk" students in Palm Beach County, Florida, Lacy & LeBlanc (2001) found that a critical attribute of a high-quality afterschool program was the effective use of community resources (e.g., developing partnerships with local business and law enforcement). Similarly, in a research synthesis of 51 studies on the impact of school, family, and community connections on student achievement, Henderson & Mapp (2002) found a positive and convincing relationship between family involvement and benefits to students in the form of higher GPAs, higher scores on standardized tests, increased enrollment in academically challenging programs, better attendance, and an increase the number of classes passed and earned credits. Henderson & Mapp also concluded that family involvement that is specifically linked to student learning (e.g., math nights) and/or programs that engage families in supporting student learning *at home* have a larger effect on student achievement than other forms of involvement.

Literature on best practices in OST programs explains why family connections are so important to student achievement. "[C]ollaboration between schools, parents, and communities widens the pool of resources, expertise, and activities available to any program, giving disadvantaged students more options" (Policy Studies Associates, Inc., 1995) and address specific parent and community needs (Henderson & Mapp, 2002). In a report on positive research and examples of OST programs that illustrate the potential of quality afterschool activities to keep children safe and learning, the U.S. Department of Education (1998) states that incorporating the ideas of parents and children in planning for OST programs draws greater support from the community in general because activities are more culturally relevant and fun for students.

More specifically, literature from OST and math education shows that family connections build an environment where parents feel knowledgeable and comfortable to help their children succeed in mathematics. Policy Studies Associates, Inc. (1995) report that parent involvement has been an integral part of the Title 1 program, and recent research on youth development provides evidence that families need help in supporting children's education. From the math education perspective, Griffith & Clyne (1994) argue that family support can be as simple as reading a book and talking about the mathematics it contains or playing games that explore or use mathematical skills and concepts. Another popular choice of OST programs is family math nights, which give parents and students a chance to enjoy mathematics together, foster positive attitudes towards mathematics in both parents and children, and encourage the development of positive relationships between school and families.

Supporting Literature and Research:

Harris, E. & Wimer, C. (2004). *Engaging with families in out-of-school time learning.* Cambridge, MA: Harvard Family Research Project. Retrieved from http://www.gse.harvard.edu/hfrp/content/projects/afterschool/resources/snapshot4.pdf.

The Harvard Family Research project has published several research briefs on highlighting research and policy around afterschool and family connections to learning. This report provides an overview of how researchers are evaluating the way OST programs engage with families. Strategies for engaging with families are discussed in terms of program goals, specific activities programs used to reach out to families, and frequency of these activities.

Henderson, A.T. & Mapp, K.L. (2002). *A new wave of evidence: The impact of school, family, and community connections on student achievement* (2nd Ed.). Austin, TX: National Center for Family and Community Connections with Schools, Southwest Educational Development Laboratory.

This report is second in a series examining key issues in the field of family connections in student learning. Henderson and Mapp present the results of a research synthesis of 51 studies measuring the impact of family and community connections with schools on student achievement. The authors conducted a literature search of studies and evaluations conducted during the years 1993–2002 on the impact of parent and community involvement on student achievement; effective strategies to connect schools, families, and community; and parent and community organizing efforts to improve schools. Two hundred research studies and literature articles were identified. Of these 200, 51 were chosen for inclusion in the synthesis. These studies use pre-experimental, quasi-experimental, ex post-facto and correlational, and experimental research methodologies. Data were collected on community as well as parent and family demographics using different sources of data (e.g., survey research, evaluations, case studies, experimental and quasi-experimental studies). Students in the studies range from early childhood to high school, span all regions, and come from various income and racial/ethnicity backgrounds.

Henderson & Mapp discuss their findings on how studies defined family involvement and student achievement and what these studies found in terms of the impact of parent and community involvement. They also discuss study findings on effective strategies to connect schools, families, and the community, as well as parents and community organizing to improve schooling. Overall, Henderson and Mapp found small to moderate, *significant* effect sizes. That is, the authors found that studies showed a small to moderate positive effect of parental and community involvement on student achievement. Henderson & Mapp conclude their report by giving recommendations for putting their findings into action.

Lacy, C. H. & LeBlanc, P. R. (2001). *Advocacy for all: A 21st century community learning center for at-risk students*. Paper presented at the Annual Meeting of the Association for Teacher Educators (February 2001).

This paper reports on the evaluation results of a pilot afterschool program, targeting at-risk students, that was implemented in Palm Beach County, Florida in 1999. The program was designed to improve the behavior, school attendance, and academic performance of 63 at-risk students identified as having behavioral and/or academic problems in a high-needs elementary school. Students completed a 27-day program with activities designed to provide social skills, share recreational activities, and share art and cultural experiences. Participating teachers monitored attendance and provided instruction. Data on student demographics academic achievement, attendance, and behavior was analyzed to determine the impact of the program on student achievement. Results of the analysis indicated that social skills, grades, standardized test scores, and attendance were positively impacted by attendance in program. In particular, Lacy &

LeBlanc found that a critical attribute of a high-quality afterschool program was the effective use of community resources.

Policy Studies Associates for the U.S. Department of Education. (1995). *Extending the learning time for disadvantaged students: An idea book*. Volume 1, Summary of Promising Practices. Washington, DC.

Intended as a resource for policymakers, this book is a summary of best practices from 14 programs in out-of-school time for disadvantaged students in diverse areas. Promising practices were selected from 14 programs in private and public schools. These programs included elementary and secondary students of diverse racial and ethnic backgrounds in urban, rural, and suburban areas. The handbook has three chapters: (1) rationale for OST programs, the purpose of the book, and selection criteria for the example programs; (2) examples of best practices; and (3) conclusions about the relationship between OST programs and achievement of disadvantaged students. Volume I summarizes best practices from these programs. Key features include careful planning and design (e.g., clearly established needs and goals, deciding when to offer the program, deciding how much time to add, and consideration of program costs), cooperation between the extended time program and the regular academic program, a clear focus on using extended time effectively, a well-defined organization and management structure, parent and community involvement, a strong professional community, continuous search for creative funding, a willingness to resolve or work around obstacles, and thoughtful evaluation of program success.

U.S. Department of Education (1998). *Safe and smart: Making afterschool hours work for kids*. Retrieved from http://www.ed.gov/pubs/SafeandSmart/title.html.

This report presents research and examples of quality afterschool activities that keep children safe and learning. It presents empirical and anecdotal evidence of success in afterschool activities and identifies key components of high-quality programs and effective practices such as effective partnerships with community-based organizations and steps to building an afterschool partnership (e.g., using community resources effectively and involving families and youth in program planning). The report also describes exemplary afterschool and extended learning models with proven results.

Mathematics Toolkit Practice #7: Math Projects

The Buck Institute for Education defines project-based learning as a "systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks" (Markham & Larmer, 2003, p 4). Math projects use students' natural curiosity about a situation to investigate the central concepts and principles of mathematical content. Math projects are distinguished from math centers by their complexity, open-ended nature (EDCI, 2006) and modeling of real life professional experiences (ERS, 1998).

Afterschool programs are especially conducive to project-based learning because they provide a fun and flexible environment for students to explore ideas with few boundaries and time constraints (EDCI, 2006). In fact, through their evaluation of successful afterschool program implementation, Resiner et al. (2002) found three instructional strategies that produced intellectually engaging, enjoyable activities that stimulated student cognition and social development: culminating performances, culminating written products, and *group* projects. EDCI found that using projects in the afterschool programs also allows students to make connections between academic content and various cultures, art, technology, careers, and their own communities. In addition, students can integrate art, music, sports, or other creative endeavors into their solution strategies.

Although a majority of the support for math projects comes from the literature on afterschool programming, support can also be found in literature from general and mathematics education. The ERS (1998) states that project-based learning promotes critical thinking, in-depth learning, and develops students' collaboration skills. Meyers, Turner, & Spencer (1997) list project-based learning as a way to deepen students' understanding of mathematics and encourage deeper thinking skills. They also point out that the complexity of math projects requires student build on their current understandings and make connections between various representations of their knowledge. Kostecky & Roe (1996) see math projects as a way allow for student choice and independence. They also believe math projects develop students' skills in problem solving and talking about math.

There are also several helpful resources that discuss implementing project-based learning such as *Generating excitement with math projects* by Kostecky & Roe (1996) and the *Project-based learning handbook: A guide to standards-focused project based learning for middle and high school* teachers (Markham & Larmer, 2003).

Supporting Literature and Research:

Education Development Center, Inc. (2006). Afterschool time: Choices, challenges, and new directions. *MOSAIC 8*(1).

This issue of *MOSAIC* highlights a roundtable discussion on the afterschool movement and challenges facing the field. Participants in the discussion include industry leaders Bernie Zubrowski, Tony Streit, Laura Jeffers, and Ellen Gannett, co-director of the National Institute on Out-of-School Time. The panel discussed afterschool science and engineering; integrating technology, media, and project-based learning; and afterschool research, training, and policy. EDCI believes that afterschool programs can provide a fun, flexible environment for students to discover connections between traditional academic subjects and popular culture through the use of project-based learning. *Mosaic* is a journal produced and published by Education Development Center, Inc. that examines key education and public health topics.

Educational Research Services (1998). Enhancing student engagement in learning. *The Informed Educator Series.* Arlington, VA: Author.

Educational Research Services provide an objective, comprehensive summary of research and opinion on factors that increase students' engagement in the learning. This report discusses current thinking on factors that affect student engagement, offers suggestions for schoolwide practices that create a culture of high student engagement, and gives examples of instructional methods designed to engage students in learning. ERS explores several instructional methods designed to increase student achievement. Among these are project-based learning, experience-based learning, and cooperative learning. ERS describes project-based learning as an approach that promotes critical thinking, in-depth learning, and a sense of belonging to a community.

Meyer, D.K., Turner, J.C. & Spencer, C.A. (1997). Challenge in mathematics classroom: Students' motivation and strategies in project-based learning. *The Elementary School Journal* 97(5), 501–521.

Meyer, Turner, & Spencer analyzed the mathematics problem-solving efforts of 14 fifth- and sixth-grade students during one class period. During observations, students worked on a project-based unit in geometry. Students were expected to study and apply principles of geometry and aerodynamics by building, testing, and evaluating the properties of various flying objects. The guiding question was "What makes a kite aerodynamic?" Students were assessed through individual interviews with the teacher in which they were asked to explain the rationale for their kite design and their interpretation of the success of its flight based on geometric properties. Students also completed two surveys measuring failure tolerance and patterns of adaptive learning 6 weeks before participation in the kite unit. Meyer et al. also observed daily instruction and interviewed the students before, during, and after the kite building unit.

Results of the study showed the students who were the highest challenge seekers formed many positive associations with math and the project, were able to monitor and evaluate self-explanations and persist through mistakes. Implications for instructional practice include creating learning environments that emphasize a constructive view of error; project-based math goals of justification, thoughtfulness, and revision; and collaboration. In addition, educators should (1) provide time for discussion of problem solving strategies, (2) provide opportunities for students to describe what they learned through their successes and errors, and (3) foster an improvement – based approach to learning.

Reisner, E.R., Russell, C.A., Welsh, M.E., Birmingham, J., & White, R.N. (March 29, 2002). *Supporting quality and scale in afterschool services to urban youth: Evaluation of program implementation and student engagement in the TASC afterschool program's third year.* Washington, D.C.: Policy Studies Associates, Inc.

Created in 1998, The Afterschool Corporation (TASC) supports more than 130 community-based afterschool programs in the New York City area. In 2002, TASC sponsored a comprehensive evaluation of 96 TASC afterschool projects to assess implementation and effectiveness of the programs. The purpose of this evaluation is to describe implementation practices that supported positive developmental experiences and strong community relationships.

TASC projects included in this evaluation served the most disadvantaged children in the New York school systems. Both participants and non-participants were children at-risk of academic failure. Data was collected and analyzed around student characteristics, recruitment, enrollment, and retention; hiring, deploying , supervising, and retaining qualified project staff; building relationships with the school and community; using resources to improve project operations and quality; selecting and using appropriate curricula, activities, and services; reactions and changes in the schools hosting TASC projects; and change in certain student competencies and reactions. Results related to project-based learning showed that successful TASC programs frequently used extended projects and group efforts. These types of activities promoted active learning and positive interactions. In particular, the evaluation indicated that culminating performances, culminating written products, and group projects produced intellectually engaging, enjoyable activities that stimulated cognitive and social development.

References

American Council on Immersion Education (2004). Learning centers: Meaningful contexts for language use in the primary immersion. *The Bridge: From Research To Practice.* Minneapolis, MN: Author.

Ball, D. (1992). Magical hopes: Manipulatives and the reform of math education. *American Educator, 16*(1), 14–18, 46–47.

Bonotto, C. & Basso, M. (2001). Is it possible to change the classroom activities in which we delegate the process of connecting mathematics with reality? *International Journal of Mathematical Education in Science and Technology*, *32*(3), 385–399.

Baker, D., & Witt, P. A. (1996). Evaluation of the impact of two after school programs. *Journal of Park and Recreation Administration, 14*(3),

Brewster, C. & Fager, J. (2000). *Increasing student engagement and motivation: From time-on-task to homework.* Retrieved March 3, 2003, from http://www.nwrel.org/request/oct00/textonly.html.

Brophy, J. (1987). Synthesis of research on strategies for motivating students to learn. *Educational Leadership*. October pp 40-48.

Brown, E.G., McComb, E.M., & Scott-Little, C. (2003). *After-school programs: Evaluations and outcomes*. Greensboro, NC: SERVE.

Clements, D. H. & McMillen, S. (1996). Rethinking "concrete" manipulatives. *Teaching Children Mathematics*, *2*(5), 270-279.

Countryman, J. (1992). *Writing to learn mathematics: Strategies that work.* Portsmouth, NH: Heinemann

Cosden, M., Morrison, G., Albanese, A. L., & Macias, S. (2001). *Evaluation of the Gevirtz Homework Project: Final report*. Santa Barbara, CA: Gevirtz Research Center.

Education Development Center, Inc. (2006). Afterschool time: Choices, challenges, and new directions. *MOSAIC 8*(1).

Educational Research Services (ERS). (1998). Enhancing student engagement in learning. *The Informed Educator Series.* Arlington, VA: Author.

Elbaum, B., Vaughn, S. Hughes, M.T. & Moody, S.M. (2002). How effective are one-to-one tutoring programs in reading for elementary students at risk for reading failure? A meta-analysis of the intervention research. *Journal of Educational Psychology,* 92(4), 605-619.

English, L.D. & Halford, G.S. (1995). *Mathematics Education: Models and Processes.* Mahwah, NJ: Lawrence Erlbaum Associates.

Fashola, O.S. (1998). *Review of extended-day and after-school programs and their effectiveness* (Report No. 24). Baltimore, MD: Center for Research on the Education of Students Placed at Risk, Johns Hopkins University.

Frederick County Public Schools (2003). *Literacy and numeracy work centers.* Retrieved July 21, 2006 from http://fcps.org/boez.htm#board.

Fuson, K.C. (1992). Research on whole number addition and subtraction. In D.A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 243-275). Old Tappan, NJ: Macmillan.

Griffiths, R. & Clyne, M. (1994). *Language in the mathematics classroom: Talking, representing, recording.* Portsmouth, NH: Heinemann

Grossman, J.B., Price, M.L., Fellerath, V., Jucovy, L.Z., Kotloff, L.J., & Raley, R., et al. (2002, June). *Multiple choices after school: Findings from the extended-service schools initiative.* Philadelphia, PA: Public/Private Ventures.

Harris, E. & Wimer, C. (2004). *Engaging with families in out-of-school time learning.* Cambridge, MA: Harvard Family Research Project. Retrieved from http://www.gse.harvard.edu/hfrp/content/projects/afterschool/resources/snapshot4.pdf.

Henderson, A.T. & Mapp, K.L. (2002). *A new wave of evidence: The impact of school, family, and community connections on student achievement* (2nd Ed.). Austin, TX: National Center for Family and Community Connections with Schools, Southwest Educational Development Laboratory.

Hiebert, J., Carpenter, T.P., Fennema, E., Fuson, K., Wearne, D., Murray, H., Olivier, A., & Human, P. (1997). *Making sense: Teaching and learning mathematics with understanding*. Portsmouth, NH. Heinemann.

Hildebrandt, C. (1998). Developing mathematical understanding through invented games. *Teaching Children Mathematics. 5*(3) pp. 191–195.

Holton, D., Ahmed, A., Williams, H., & Hill, C. (2001). On the importance of mathematical play. *International Journal of Mathematical Education in Science and Technology*, *Volume 32, 3*(1), 401–415.

Hootstein, E.W. (1994). Enhancing student motivation: make learning interesting and relevant. *Education* 114(3), 475.

Kamii, C. & DeVries, R. (1980). Group Games in Early Education: Implications of Piaget's Theory. Washington, DC: National Association for the Education of Young Children.

Kleiman, G. M. (1991). Mathematics across the curriculum. *Educational Leadership.* 49(2) pp 48-51.

Koralek D., Collins R., (1997). America Reads Challenge On the Road to Reading: A guide for Community Partners. Vienna, VA : The Early Childhood Technical Assistance Center.

Kostecky, J. & Roe, L. (1996). Generating excitement with math projects. *Teaching Pre K – 8.* retrieved July 24, 2006 from http://www.findarticles.com/p/articles/mi_qa3666/is_199601/ai_n8755969/print.

Lacy, C. H. & LeBlanc, P. R. (2001). *Advocacy for all: A 21st century community learning center for at-risk students*. Paper presented at the Annual Meeting of the Association for Teacher Educators (February 2001).

Lauer, P. A., Akiba, M., Wilkerson, S. B., Apthorp, H. S., Snow, D., & Martin-Glenn, M. (2004). *The effectiveness of out-of-school-time strategies in assisting low-achieving students in reading and mathematics: A research synthesis* (Updated ed.). Aurora, CO: Mid-continent Research for Education and Learning.

Meyer, D.K., Turner, J.C. & Spencer, C.A. (1997). Challenge in mathematics classroom: Students' motivation and strategies in project-based learning. *The Elementary School Journal* 97(5), 501–521.

Miller, B. M. (2003). *Critical hours: Afterschool programs and educational success*. Brookline, MA: Miller Midzik Research Associates for the Nellie Mae Education Foundation. Retrieved June 15, 2003, from http://www.nmefdn.org/CriticalHours.htm

Miller, K. & Snow, D. (2004). *Noteworthy perspectives: Out-of-school time programs for at-risk students.* Aurora, CO: Mid-continent Research for Education and Learning.

Mokros, J., Kliman, M., Freeman, H. (2005). *Time to enhance math in after-school*. Cambridge, MA: TERC. Retrieved August 16, 2006 from http://www2.terc.edu/UPLOADED/DOCUMENTS/TimeEnhanceMath.pdf.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Research Council. (2001). *Adding it up: Helping children learn mathematics*. J. Kilpatrick, J. Swafford, and B. Findell (Eds.). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

National Research Council of the National Academies. (2005). *How students learn: History, mathematics and science in the classroom.* Washington, D.C.: The National Academies Press.

Office of the Under Secretary, Planning and Evaluation Service, U.S. Department of Education (1997). *Evidence that tutoring works*. Retrieved from http://www.ed.gov/inits/americareads/resourcekit/miscdocs/tutwork.html.

Ortiz, E. (2003). Research Findings from Games Involving Basic Fact Operations and Algebraic Thinking at a PDS. The ERIC Clearinghouse on Teaching and Teacher Education. Washington, D.C. (Non-refereed.)

Peters, S. (1998). Playing games and learning mathematics: The results of two intervention studies. *International Journal of Early Years Education, 6*(1), 49–58.

Policy Studies Associates for the U.S. Department of Education. (1995). *Extending the learning time for disadvantaged students: An idea book*. Volume 1, Summary of Promising Practices. Washington, DC.

Potter, J., Blankenship, J., & Carlsmith, L. (1999). So that every child can read: A review of effective and promising practices in volunteer reading tutoring programs. Portland, OR: Northwest Regional Educational Laboratory.

Powell, M.A. (1997). *Academic tutoring and mentoring: A literature review*. Sacramento, CA: California Research Bureau, California State Library. Retrieved from http://www.library.ca.gov/CRB.97.11/97011.pdf.

Pugalee, D.K. (2001). Writing, mathematics, and metacognition: Looking for connections through students' work in mathematical problem solving. *School Science and Mathematics*. vol 101.

Reisner, E.R., Russell, C.A., Welsh, M.E., Birmingham, J., & White, R.N. (March 29, 2002). *Supporting quality and scale in after-school services to urban youth: Evaluation of program implementation and student engagement in the TASC after-school program's third year.* Washington, D.C.: Policy Studies Associates, Inc.

Shaffer, D. W. (2006). Epistemic frames for epistemic games. *Computers & Education*, 46, 223—234.

Sowell, E. (1989). Effects of manipulative materials in mathematics instruction. *Journal for Research in Mathematics Education, 20*, 498–505.

Stephens, H. & Jairrels, V. (2003). Weekend study buddies: Using portable learning centers. *TEACHING Exceptional Children, 35*(3) pp. 36–39.

Sutton, J., & Krueger, A. (Eds.). (2002). *EDThoughts: What we know about mathematics teaching and learning*. Aurora, CO: Mid-continent Research for Education and Learning.

Topping, K. (2000). *Tutoring*. Educational Practices Series. (ERIC Document Reproduction Service No. ED 447 111)

U.S. Department of Education (June 1998). *Safe and smart: Making after-school hours work for kids.* Retrieved 5/3/06 from www.ed.gov/pubs/SafeandSmart/title.html.

Van de Walle, J.A. (1994). *Elementary school mathematics : Teaching developmentally* (2nd ed.). NY : Longman.

Van de Walle, J.A. (2004). *Elementary and middle school mathematics: teaching developmentally* (5th ed.). Boston, MA: Pearson Education, Inc.

Vega-Rivera, C. & Legowski, M. (2004). *Making tutoring palatable to students.* East Harlem Tutorial Program: New York, NY. Presentation at 2004 21st Century Community Learning Centers Summer Institute, Los Angeles, CA.

Welsh, M.E., Russell, C.A., Williams, I., Reisner, E.R., & White, R.N. (2002, October). *Promoting learning and school attendance through after-school programs: Student-level changes in educational performance across TASC's first three years*. Washington, DC: Policy Studies Associates, Inc.

Wynn L. (2004). Expanding Student Learning Opportunities Through Tutoring Programs., *The Vision,* Volume 3, Number 1, 26-29. Serve