

Best Teaching Practices and Strategies for Students with Mathematics

Learning Disabilities: A Literature Review

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By

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Abstract

In this literature review teaching strategies that are successful in developing students with mathematics learning disabilities (MLD) conceptual learning are explored. The strategies discussed are Concrete-Representational-Abstract (CRA), Schema-based Instruction (SBI), mnemonics, and self-regulation. The environments, inclusion and resource room, were also discussed. As stated by different components in The Individuals with Disabilities Education Act (IDEA), No Child Left Behind (NCLB), and National Council Teachers of Mathematics (NCTM) students with mathematics learning disabilities (MLD) must be educated in the least restrictive environment and have exposure to meaningful mathematics.

To teachers who educate students with mathematics learning disabilities

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Chapter 1

Introduction

Purpose

The purpose of this literature review is to explore best teaching practices and pedagogical styles of educating students with math learning disabilities (MLD). The debate about where a student with MLD is best served is one of the most volatile issues in special education. The controversy is whether full inclusion or a continuum of alternative placements is the most beneficial approach (Ackerman, Jaeger, & Smith, 2012). Originally, PL 94-142, also known as Education of All Handicapped Children Act, stated that individuals with disabilities ages 3-21 with disabilities must be educated in the least restrictive environment. Since 1975, the No Child Left Behind (NCLB) Act of 2001, and the reauthorization of Individuals with Disabilities Education Act IDEA (2004), more students with MLD are being educated in the general mathematics classroom than previously. This shift happened when inclusion supporters insisted that students with disabilities have the legal right to be educated with typical peers (Walther-Thomas, Korinek, McLaughlin, & Williams, 1999). This literature review would not be complete without investigating which teaching practice(s), approaches, and style(s) of educating students with mathematics learning disabilities are most effective.

Research Questions

The intent of this extensive literature review is to answer the following research questions:

1. What are the best practices, most effective tools and strategies for teaching mathematics to students with MLDs?
2. What does the research tell us about the differences in inclusion and resource instruction?

Each component of NCLB, IDEA, and National Council of Teachers of Mathematics (NCTM) guides the implementation of meaningful mathematics when educating students with mathematics learning disabilities MLD. New programs and strategies have been implemented to provide students opportunities to develop an improved sense of conceptual understanding.

The quantitative research for students with MLD far outweighs the qualitative research. However, throughout the literature review both qualitative and quantitative research paradigms will be utilized to explore and explicate themes.

Background

There are several types of disabilities. Some of the most common in schools are other health impaired, brain injuries, learning, medical, physical, psychiatric, and speech and language disabilities. Learning disabilities are by far the most common disability among school-age children. More than half of students with disabilities are learning disabled (Jarrett, 1995). School districts in the United States use two methods for diagnosing students with a disability. These methods may include intelligence testing, achievement testing, classroom observations, and possibly doctor's diagnosis. The most common process is for a district psychologist, the district's expert on learning disabilities, to administer and interpret diagnostic assessments on individual

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students. The most commonly used tools for intelligence and achievement testing are the Wechsler Intelligence Scale for Children and the Stanford Binet and the Woodcock Johnson Test of Student Achievement, the Peabody Individual Achievement Test, and Wechsler Individual Achievement Test for achievement (Ysseldyke, Algozzine, Richey, & Graden, 1982; Sattler, 2001). An intelligence test measures the student's intelligence quotient (IQ), and an achievement test measures academic subjects such as reading, writing, math, science, and social studies. The district psychologist interprets the scores using psychometric and statistical methods. Then, the psychologist determines if there is a severe discrepancy between the intelligence and achievement test. If the psychologist determines that the student has a disability, school staff, including: teachers, a case manager, principal, and possibly the school counselor and nurse are consulted. Subsequently, a meeting is held and the data are discussed along with a determination of which disability exists. If data suggests a disability, the team delineates the disability as a mathematics, reading, or writing disability, or sometimes multiple disabilities. Once the type of learning disability has been ascertained, the development of an Individualized Educational Plan (IEP) becomes a team approach consisting of parents, teachers, support staff, principal, psychologist, case manager, and others as appropriate (Ellingstad, et al., 2000) During the meeting, a plan is developed, types of services are designated. The team then makes the determination of the least restrictive environment. Choices usually include settings such as a resource room program or participation within the general education classroom.

As this literature review is focused on specifically on mathematics, a specific learning disability in this area is called a Mathematics Learning Disability also abbreviated as a MLD (Berch & Mazzocco, 2007; Montague & Jitendra, 2006).

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According to Huang (2006), MLDs range from mild to severe and manifest themselves in multiple ways. Some of the most common difficulties are basic arithmetic and written computation (Huang). In addition, some students with MLDs are unable to build their conceptual understanding without meaningful arithmetic skills and written computation skills (Huang).

Mathematics and special education teachers should build on students' conceptual understanding, not focusing only on remediating students' weakness, but building on their prior understanding. Student advancement of the National Council of Teachers of Mathematics (NCTM) process standards are critical components of development in mathematics education. The NCTM mathematics content standards, Number and Operations, Algebra, Geometry, and Data Analysis & Probability, are required areas of mathematics for all students. The NCTM benchmarks are useful in setting up tools for teachers and district staff developers to progress and observe the quality of the mathematics programs being used in the district. They can also be used by individual mathematics teachers to enhance their own teaching/learning practices, as a guide for curriculum framework, to design assignments, as a guide for state and local districts to develop guiding principles, and to deepen conversations about the best way to help students gain a deeper understanding of mathematics.

Limitations

The process used to obtain the information on best teaching practices and strategies to use with students with disabilities in middle-level regular education mathematics classroom began with referencing resources provided through the University of Wyoming Middle Level Mathematics Master's program and locating studies and articles. The terms inclusion, educational studies, middle level mathematics, special education, NCTM, educational studies in

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mathematics, mathematics strategies in special education, evidence based practices for students with disabilities, and MLD were used to refine the search. Professional journals, such as *Mathematics Teacher*, *School Science and Mathematics*, *The Journal of Special Education*, *Exceptional Children*, *Learning Disabilities Research and Practice*, Dissertation Abstracts International, PSYCINFO, ERIC Document Reproduction Service, Academic Search Premier, and Teacher Reference Center were some of the databases used to locate research articles. The information from the above mentioned sources was read and pertinent themes relating to middle level math teaching practices and strategies were identified. With the breadth of research in the area of best practices and strategies for students with MLD, there are areas that fall outside of the scope of this review and therefore will not be addressed at this time.

Definition of Key Terms

- Mathematics learning disabilities (MLD): A neurological disorder that makes it difficult for students to acquire certain academic skills. Students with dyscalculia may have difficulty understanding math concepts and solving even simple math problems (<http://www.nclb.org/ld-basics/ld-aamp-language/ld-aamp-math/counting-on-research-math-learning-disabilities>).
- “§ 300.320 Definition of individualized education program. (a) *General*. As used in this part, the term individualized education program or IEP means a written statement for each child with a disability that is developed, reviewed, and revised in a meeting in accordance with §§ 300.320 through 300.324...”
- No Child Left Behind (NCLB): Legislation (2001) developed to ensure accountability and flexibility and increased federal support for education. (United States Department of Education) (http://www2.ed.gov/nclb/overview/intro/guide/guide_pg12.html).

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- IDEA (2004): Legislation, formally known as Education of All Handicapped Children Act (Public Law 94-142). The Individuals with Disabilities Education Act (IDEA) ensures services to children with disabilities and governs how states and public agencies provide early intervention, special education and related services to more than 6.5 million eligible infants, toddlers, children and youth (U.S. Department of Education, Office of Special Education Programs 10.4.06).

Chapter 2

Literature Review

Introduction

A significant amount of research, literature, discussion, and instructional information was developed in the area of math learning disabilities (MLD) between 1998 and 2010. However, the debate continues regarding whether pull-out or integrated programs are the best environment for educating these students. Likely, the efficacy of each approach is contingent upon student characteristics and educational objectives. More students with learning disabilities are being educated in the regular mathematics classroom as compared to ten years ago (Walther-Thomas, Korinek, McLaughlin, & Williams, 1999). The shift from resource room to inclusion happened when supporters of inclusion noted that students with disabilities have the legal right to be educated with peers without disabilities (Walther-Thomas et al., 1999). Gersten, et al. (2007) reinforces this, stating that the fields of “developmental psychology, cognitive science, mathematics education, special education and even law have given rise to the multidisciplinary field of MLD research and practice that exists today” (p. 7).

More than half of the students identified with a disability are considered “learning disabled”. This disability is defined as the discrepancy between achievement and ability. Students are identified through methods including intelligence and achievement testing, classroom observations, and sometimes a doctor’s diagnosis. MLD is a subset of learning disabilities. This identification arises due to the fact that the discrepancy is expressed in mathematics. Students with MLD have abilities that range from mild to severe and manifest themselves in multiple ways (Huang, 2010).

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Mathematics and Special Education teachers should simultaneously focus on remediating weakness as well as building students' conceptual understanding. The National Council on Teachers of Mathematics (NCTM, 2000) states all students have access to rigorous, high-quality mathematics instruction. The process standards are critical components of development in mathematics education and the content standards cover the required areas of mathematics instruction for all students. In addition, IDEA states that, students must have access to the general curriculum to the maximum extent possible (Individuals with Disabilities Education Improvement Act of 2004, Pub. L. No. 108-446, 118 Stat. 2647 (2004) (amending 20 U.S.C. §§ 1400 *et seq.*). Further, NCLB states that students must have access to and success in mathematics within the general education curriculum (No Child Left Behind Act of 2010, p. 6).

NCTM's *Principles and Standards for School Mathematics* (2000) are described as a linked frame of mathematical understandings and proficiencies making them a comprehensive foundation for all students, rather than a menu from which to make curricular choices. The ten standards include five content standards: Number and Operations, Algebra, Geometry, Measurement, Data Analysis and Probability; and five process standards: Problem solving, Reasoning and Proof, Communication, Connections and Representation.

Best Practices

In 2000, the understanding of best practices for students with MLD is addressed within *The Principles and Standards for School Mathematics* (2000) published by NCTM. According to Lemke, et al. (2004), this publication spurred standards-based reform in mathematics education and teacher preparation programs to better prepare America's children for the mathematical challenges of the 21st century. This document is used as a resource for interested stakeholders making decisions that influence mathematics education for students from pre-kindergarten

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through grade 12. The six principles provide a framework for high-quality mathematics education, and include; Equity, Curriculum, Teaching, Learning, Assessment, and Technology (NCTM, 2000). According to NCTM, (2000), the Principles are an outline of the characteristics that should be included in a “high quality mathematics education.” This next section will review and elaborate on each of these principles.

Equity principle. The Equity Principle is built on the expectation that all students, regardless of their individual characteristics, experiences, physical, or mental challenges, must have opportunities to study and be provide necessary support to learn mathematics. Equity does not mean all students will receive identical instruction, rather reasonable and appropriate accommodations will be provided as needed to promote accomplishment. According to NCTM (2000), all students should have access to an excellent and equitable mathematics program that provides solid support for their learning and is responsive to their prior knowledge, intellectual strengths, and personal interests. For example, this may mean increased time for some students to complete assignments or understand concepts, the provision of oral rather than written assessments, use of additional resources such as peer-tutors, or access to supplemental after-school programs. The Equity Principle provides resources and support for teachers and students. To achieve equity in the classroom, curriculum, tools, materials, supplemental programs and community resources play a vital role. The Equity Principle also acknowledges the need for appropriate professional development and teacher preparation. NCTM (2000) recognizes how important it is for teachers to know and understand strengths and weakness of individual students including advanced students.

Curriculum principle. The Curriculum Principle states that a coherent curriculum is critical for a high-quality mathematics program because the curriculum is a strong determinant of

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what and how students will learn. A coherent curriculum provides the necessary lessons that link to and build on one another, connected to the “big ideas” of mathematics (Bryant, Kim, Harman, & Bryant, 2006). For example if this principle is applied to students with MLD, classroom teachers would be helping student activate their prior knowledge about the topic being studied.

A well-articulated curriculum is considered a road map to guide students to increasingly higher-level knowledge. It provides a guide for students’ conceptual understanding such that new learning builds on previous skills. For example, in grades K-2 students typically explore similarities and difference among two-dimensional shapes. If this skill-set is acquired, in grades 3-5 they can be taught to identify characteristics of various quadrilaterals. Later, in grades 6-8 they may be able to be to examine characteristics of various quadrilaterals (NCTM, 2000) thus promoting conceptual understanding and progression through van Hiele levels of geometric understanding (Burger, & Shaughnessy, 1986).

Teaching principle. For this principle, the focus is on recognizing what students’ know and need to learn, while challenging and supporting them to learn it well (NCTM, 2000). All students learn differently, therefore teachers must possess an understanding of various pedagogical strategies to provide meaningful experiences. To deliver meaningful experiences teachers determine how to deliver instruction while supporting student learning. Students with MLDs may need explicit instruction beyond what may be expected for non-MLD students for them to grasp new skills. Some students may need modeling, additional examples, and extra practice to understand new concepts. Other students may need manipulatives or representations to foster understandings of such concepts as fractions. Students that continue struggle with basic facts could be provided with tools such as a multiplication chart or a calculator. Sometimes the instruction itself needs to be changed. One strategy used includes breaking down the instruction

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into small steps and presenting it in smaller bits. This can help students to not feel so overwhelmed. As teachers determine the individual needs of each student, using a variety of techniques in response to their disability, students can benefit from instruction.

Learning principle. This principle views conceptual understanding as the learning of mathematics through experiences and prior knowledge. Students need to understand mathematics, not just learn mathematical algorithms and computational strategies, to be successful in the 21st century. When students learn with conceptual understanding they become more successful, the learning is easier, and they are able to make more sense of mathematics. In most cases, students with MLDs can benefit from standards-based instruction with the use of adaptations. For example, a concrete-representational-abstract (CRA) method is a good strategy to use to promote understanding. Students can use geoboards (concrete) to create two-dimensional shapes. Next, the student can transfer this concept into a drawing (which is the representational shape), and finally they may use both of these skills to be able to solve the algorithm (the abstract shape). CRA is one method that can be used to promote active engagement for student with MLDs and will be discussed in more detail later on in this literature review.

Assessment principle. The Assessment Principle supports the learning of mathematics by providing necessary feedback to teachers about how and what their students are learning. Assessing students should not be a one time thing, rather is should be an ongoing process. Formative assessing embedded within instruction informs teachers of inconsistencies in learning and problems on regular basis. Teachers' consistent feedback from students can alter the instructional decisions, and catch problems before students repeatedly make the same mistakes.

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Therefore, teachers can intervene and make necessary adaptations to help students become successful learners.

Technology principle. The Technology Principle allows students to focus on “decision making, reflection, reasoning, and problem solving” (NCTM, 2000). Bryant et al. (2006) recognizes technology can be used as an adaptation for students with disabilities who may require support with basic procedures (e.g., arithmetic combinations, whole-number computation). Students with MLD use technology and assistive technology to express their conceptual knowledge, when paper pencil is difficult. It is important to note that teachers have an onus of recognizing when technology can create a more robust learning environment and use it appropriately.

Standards

The Standards are descriptors of the understanding, knowledge, and skills students should acquire from prekindergarten through 12th grade (Bryant, 2006). According to NCTM, 2000 the ten Standards, five content and five process, do not neatly separate the school mathematics curriculum into non intersecting subsets. Because mathematics as a discipline is highly interconnected, the areas described by the Standards overlap and are integrated (NCTM, 2000).

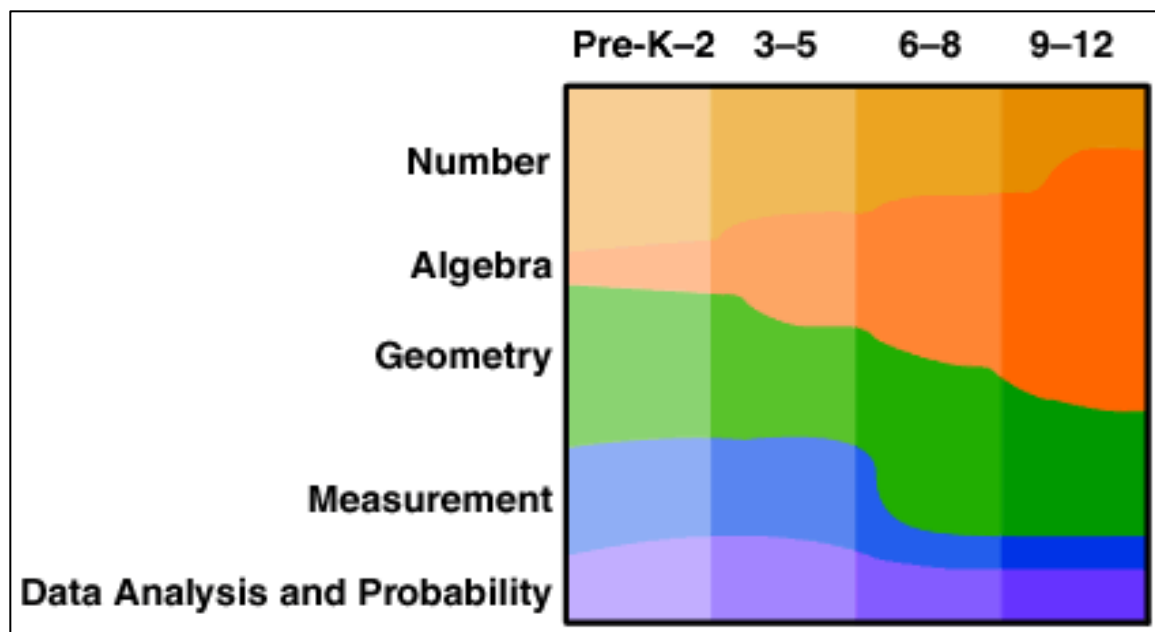


Figure 1. An illustration of how the NCTM Content Standards are emphasized as they are taught throughout the grades. (NCTM, 2000).

NCTM Principles and Standards

Understanding the Principles and Standards is imperative, but it is also important to keep mathematical content relevant to the learner and presented in real world context (Maccini, Gagnon, 2000; Witzel, Smith, & Brownell, 2001). Gathering knowledge, students are likely to be more engaged when working in cooperative groups solving worldly situations, rather than applying rote memorized algorithms. According to Maccini and Gagnon (2000), students in the United States spend 96% of instructional time completing routine algorithms without conceptual understanding. NCTM standards call for students to be engaged in learning complex problem solving through conceptual understanding and not merely rote memorization of skills and tasks. The NCTM standards represent the philosophy for teaching and learning in which students are able to solve real-life problems; write, discuss, clarify math ideas; include coherent reasoning; and use conceptual understanding. Students with a MLD require more than a basal textbook and

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a teacher that teaches only by the book. Along with best practices, this population needs other strategies to help them be successful in mathematics.

Educators need strategies to help students be successful in meeting the rigor of the Standards and Processes set forth by the NCTM. Within the mathematics classroom, educators should present concepts multiple ways to for students to attach meaningfulness and generalization of the concepts (Cathcart, Pothier, Vance, & Bezuk, 2000; NCTM, 2000; Tucker, Singleton, & Weaver, 2002). The strategies presented next have been successful when used with students with MLDs. The four strategies described will include Concrete-Representational-Abstract (CRA), Schema-Based instruction (SBI), Mnemonics, and self-regulation.

Instructional Strategies

Problem solving is a fundamental theme in the *Principles and Standards for School Mathematics*. There are many strategies to help students be successful with this fundamental theme. Some of these strategies are CRA, Schema-Based instruction, Mnemonics, and Self-regulation. Each of the strategies provide ways for students to develop the understanding of mathematics needed to be successful in learning, comprehending, and applying concepts in the 21st century.

Concrete-Representational-Abstract. Allsopp et al. (2007) states that “Piaget, Bruner, Montessori, and others helped educators understand that learning is a developmental process, one that moves fluidly from lesser to greater levels of understanding and complexity” (p. 72). The CRA structure of teaching builds on this developmental process and should be used when instructing students with a MLD (Allsopp, et al., 2007). The plethora of research on CRA supports its effectiveness for students with MLDs (Harris, Miller & Mercer, 1995; Mercer, Jordan, & Miller, 1996; Mercer & Mercer, 1993; Mercer & Mercer, 1998; Peterson, Mercer, &

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O'Shea, 1988) as well as for students without learning disabilities (Baroody, 1987; Kennedy & Tipps; 1998; VanDeWalle, 1994).

The CRA strategy is based on three levels of learning. Each level has a distinct purpose and builds upon one another. These levels are concrete, representational, and abstract. Using the CRA method students are introduced to the concrete level first. The use of manipulatives during this level provides students' an opportunity to develop and demonstrate their level of understanding of the concept being taught. When students are proficient with the concrete level the next level, representational, is introduced. Allowing students to first develop and master the concrete understanding of the mathematics concept/skill, they are more likely to perform that mathematics skill and develop the conceptual understanding of the mathematics at the abstract level. Research-based studies confirm that students who use concrete manipulatives, under the right conditions, develop more accurate and more inclusive mental representations, often show more enthusiasm and on-task behavior, comprehend mathematical ideas, and better apply these ideas to life situations (Harrison & Harrison, 1986; Suydam & Higgins, 1977). Developing a strong foundation is the key to the development of concepts in learning fractions, decimals, percentage, number relationships, place value, computation, measurement, probability, algebra, statistics, geometry, money, number bases, and problem solving (Bruni & Silverman, 1986). Manipulatives may be used to facilitate conceptual understanding in the concrete level. Manipulatives allow students to explore and build their understanding and make connections to the problem and the question being asked. Once a student demonstrates proficiency within the concrete level, teaching tactics should align with the next, i.e. representational, level. During the representational level pictures may be drawn allowing students to make necessary connections to their conceptual learning. Finally, symbols replace the pictures to facilitate understanding in the

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abstract level. At the abstract level students demonstrate high levels of conceptual understanding linking previous knowledge to abstract symbolism of mathematical concepts. Throughout all levels, teacher modeling, multiple opportunities for practice and demonstration are essential for student success.

The following description of CRA includes examples and guidelines. Huntington (1994) noted that students with MLDs who used manipulatives under the right conditions in algebra not only met proficiencies, but generalized the information to other situations. These students had memorized algebra vocabulary, but did not understand their meanings. Only after using concrete representations did the students truly understand the meaning of the concepts: difference, twice, and consecutive.

Witzel (2003) found after working with more than 350 sixth and seventh grade students and 10 mathematics teachers in inclusive settings, students using the concrete and representational level achieved significantly higher posttest scores than the students who used only abstract representations. In this study, students were divided into treatment and comparison groups and provided with 19 fifty-minute lessons on algebraic concepts. The treatment group used the concrete representation level and the comparison group used the abstract level. In a follow-up study, Witzel (2005) looked at pre- and post-test scores of students enrolled in an inclusive middle school Algebra I class and found that students using CRA outperformed the comparison group using symbolic and abstract reasoning on posttests.

Butler et al. (2003) they found that students who had difficulties in mathematics learned better with the CRA instructional sequence than teaching directly from the text using algorithms only. Butler et al. (2003) compared the effects of teaching equivalent fraction concepts and procedures by using the CRA with three steps. Throughout the lesson sequence, the students used

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concrete manipulatives consisting of plastic circles and beans. In the representational stage, students were taught to shade portions of fractions to make equivalent fractions. This involved learning to shade a picture of items into fractional portions to visually illustrate their equivalency. In the abstract stage, students were introduced to the abstract algorithm for calculating equivalent fractions. Through these steps, students are developing a deeper understanding of their mathematics.

In another study, Morin and Miller (1998) taught mathematics to three seventh graders with mental disabilities, a disability characterized by significant limitation in intellectual functioning and in adaptive behavior, using the CRA instructional strategy. During the lessons teachers used explicit instructional strategies, including introduction, demonstration, guided practice, independent practice, prompting, and immediate feedback. Students used paper plates and blocks to represent groups and objects in the concrete level. When students demonstrated proficiency, the next level was introduced. In representational-level instruction, students were taught to solve multiplication tasks by using pictures of objects (boxes containing dots, circles containing dots, and horizontal lines containing tallies). Once again, when this level was mastered, the students were moved to the abstract level of instruction. Harris, Miller, and Mercer (1995) taught students to memorize multiplication facts and use the DRAW and/or FASTDRAW methods (**D**iscover the sign, **R**ead the problem, **A**nswer or draw and check, and **W**rite the answer) to solve problems. DRAW and/or FASTDRAW provide a script for students to follow when problem solving. The DRAW and FAST DRAW strategies (see Figure 2) have been used by Harris, Miller, & Mercer (1995) to teach students with MLD to solve multiplication facts.

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<p>The DRAW strategy is used for problem solving.</p> <p>Discover</p> <ul style="list-style-type: none">• Discover the Sign• The student looks at the sign to figure out what operation to perform <p>Read</p> <ul style="list-style-type: none">• Read the problem• The student says the problem aloud or to himself or herself <p>Answer</p> <ul style="list-style-type: none">• Answer, or draw, and check• The student thinks of the answer or draws lines to figure out the answer• The student checks his or her drawing and counting <p>Write</p> <ul style="list-style-type: none">• Write the answer• The student writes the answer in the answer space
<p>The FASTDRAW strategy is used as a transition from pictures to abstract numbers.</p> <p>Find</p> <ul style="list-style-type: none">• Find what you are solving for• Students look for the question in the problem <p>Ask</p> <ul style="list-style-type: none">• Ask yourself, “What are the parts of the problem?”• Students identify the number of groups and the number of objects in each group <p>Set</p> <ul style="list-style-type: none">• Set up the numbers• Students write the two numbers in the problem in a vertical format <p>Tie</p> <ul style="list-style-type: none">• Tie down the sign• Students add the multiplication sign to the problem <p>Discover</p> <ul style="list-style-type: none">• Discover the Sign• The student looks at the sign to figure out what operation to perform <p>Read</p> <ul style="list-style-type: none">• Read the problem• The student says the problem aloud or to himself or herself <p>Answer</p> <ul style="list-style-type: none">• Answer, or draw, and check• The student thinks of the answer or draws lines to figure out the answer• The student checks his or her drawing and counting <p>Write</p> <ul style="list-style-type: none">• Write the answer• The student writes the answer in the answer space

Figure 2. DRAW and FASTDRAW. Adapted from Harris, Miller, & Mercer, (1995). Teaching initial multiplication skills to students with disabilities in general education classrooms. *Learning Disabilities Research & Practice*, 10(3), 180-195.

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These strategies allow students to focus and complete necessary problem solving skills. All three students showed improvement on the post-test scores on multiplication. Subject 1's scores improved from 50% to 90%, subject 2 improved from 70% to 93.5%, and subject 3 improved from 60% to 100%. This is a small study, but it is important to include due to the improved outcomes for these students.

Although there was not an abundance of research using CRA to teach math to students with significant disabilities, this instructional method was recommended by the NCTM and is presented in various math textbooks and resources for students with MLD. CRA was recommended due to its success with students with MLD.

Schema-Based instruction (SBI). SBI is a way of describing problems that share a common underlying structure using comparable solutions. Marshall (1995) noted that “schemas are the appropriate mechanism for the problem solver to capture both the patterns of relationships as well as their linkages to operations” (p. 67). SBI is a method of linking problem schema to different related elements (e.g., the part-part-whole problem structure). One example is in addition, when knowing the whole and the first factor (part) subtraction is required to find the unknown factor. SBI allows students to begin the task of problem solving by drawing on past experiences, focusing on the problem structure, advancing conceptual understanding and develop acceptable problem solving skills (Marshall, 1995). Others, (e.g.; Mayer, 1999; Riley, Greeno, & Heller, 1983) refer to the essential elements of problem solving model which is made up of four separate but interrelated procedural steps. The aforementioned researchers refer to the steps as schema knowledge, representation, planning, and solution. Montague and Jitendra (2006) enhanced the procedural steps “corresponding conceptual knowledge for each step includes

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schema knowledge, elaboration knowledge, strategic knowledge, and execution knowledge” (p. 54).

The first step in schema knowledge/problem schema identification is to use a pattern or schema recognition to understand problem identification (Mayer, 1999). An example uses the following problem: “Sabrina mowed two times as many yards as Nolan. If Sabrina mowed 14 yards, how many yards did Nolan mow?” To solve this problem the student would have to understand what ‘two times as many as’ means and have the ability to identify the problem as a comparison.

The second step is elaboration knowledge/representation. Students use diagrams or templates to represent the problem from the first step. The information is interpreted explicitly and expanded. This enables the student to create the template for the problem situation. For this example, the following problem will be used: “Craig’s car gets 29 miles to the gallon of gas. He drove his car for three weeks without refueling. Assuming similar driving habits, how many miles can he drive on five gallons of fuel?” To solve this problem, the student must determine that the problem is proportional and then map out the two ratios proportion; that is, ‘29 miles’ to 1 gallon of fuel and ‘ N Miles’ to five gallons of fuel. At this step, all unnecessary information is discarded and the student is able to focus on available prior knowledge.

During the third step, a plan is developed using goals and sub goals. Then the applicable operation is chosen to solve the problem, and a mathematical sentence is written. For example, the student may easily identify the following as a comparison problem: “Sabrina mowed 2 times as many yards as Nolan. Owen mowed two times as many yards as Sabrina. If Owen has mowed 10 yards how many yards has Sabrina mowed?” Yet, some students may struggle with this problem even if they understand elaboration knowledge due to the fact it is highly abstract. This

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problem is highly abstract due to the fact that students have difficulty linking three separate ideas and knowing which two are needed to solve it. Other students may not have ability to solve this type of problem based on their prior experiences involving multi-step problems. Understanding that division is the process used to solve this problem may not be straight forward.

The last step, execution knowledge/solution, involves the techniques needed to perform a process or to use an algorithm. The difference between the previous step and this one is the previous one focuses on a procedural choice and order of operations, whereas this step carries out the plan.

Students use schema-based instruction (SBI) in problem solving to create and develop domain knowledge when prior knowledge is the central focus. Special educators have longed for a clear set of procedures when teaching students with MLD to reduce vagueness. Therefore this strategy has been proven to be effective in teaching students' problem solving (Marshall, 1995, Mayer, 1999, Riley, Greeno, and Heller, 1983).

Mnemonics. Mnemonics may be one of the most thoroughly researched strategies available for students with MLD (Levin, 1993). Mnemonics help students recall information that otherwise might not be remembered, due to brain's capacity of not retaining information. However, there is not all-inclusive data on whether mnemonics has the potential to "close the gap" between students with and without disabilities (Brigham & Brigham, 2001). Another question that is unanswered relating to mnemonics is how many mnemonic devices can be learned and used within a given amount of time? Scruggs and Mastropieri (1992), state that more must be learned about the utilization, maintenance, and application of students implementing mnemonics independently.

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Mnemonics are devices structured in ways to help students remember and recall information. With mnemonics teaching, one associates presentation of important information with unambiguous strategies for recall. Levin (1993), states this procedure has been well researched and validated for students with high-incidence disabilities, particularly students with learning disabilities, as well as for typical students at all levels of education. This strategy is important for increasing students' understanding of new vocabulary, remembering factual information, answering questions, and demonstrating comprehension of skills (Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985). This strategy has been proven to be successful with students with or without disabilities and in kindergarten through grade 12 (http://www.k8accesscenter.org/training_resources/mnemonics_math.asp) Mnemonics provides visual or verbal prompts for students so they retain important information. Learning something new is like adding a thread to a web and for students with memory challenges or processing disorders, a mnemonic device becomes a tool to link new and old ideas (<http://www.ldonline.org/article/15577/>). Scruggs and Mastropieri (1989) used mnemonic strategies with college undergraduates learning foreign language vocabulary. Later research extended to the use of mnemonics with younger students with learning disabilities. Recently a study was completed using mnemonics to study and recall paintings and artists. Each of these studies showed a correlation of students learning to that of higher test scores (Carney & Levin, 1991). Three types of mnemonics are effective in teaching mathematics. They are keyword, pegword, and letter.

Keyword. The keyword strategy appears to work best when students are learning new information (Scruggs & Mastropieri, 1989). Wang and Thomas (2000) showed that key word mnemonics was not durable over time when retention interval was manipulated. Other studies

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(e.g. McDaniel & Pressley, 1987; Pressley, Levin & Delaney, 1982) found long-term benefits using the keyword method. One keyword mnemonic used by DeLashmutt (2007) is correct placement of numerator and denominators in fractions. She used the variable N for numerator and D for denominator. DeLashmutt (2007) used a map and explained that the top of the map is always North so the top number is called the numerator and D is for Dakota which is the denominator.

Pegword. Another type of mnemonics strategy is pegword. This strategy is beneficial when teaching students information in a specific order or when information involves numbers (Scruggs & Mastropieri, 1989). Students must first learn the pegwords and how to use them, before the mnemonic can be taught. DeLashmutt's (2007) students had difficulty discriminating between proper and improper fractions. By using a snow cone representation of an improper fraction students understood that the snow cone is bigger on top, thus eliminating the confusion between the two types of fractions.

First letter mnemonics, acronyms, and acrostics. The first letter strategy cues students in completing problem solving steps. One popular first letter mnemonic in mathematics is used for solving order of operations, Please Excuse My Dear Aunt Sally which stands for parenthesis, exponents, multiplication, division, add, and subtract. STAR is another first letter mnemonic used by older students with MLD to solve steps and sub-steps of problem solving (Maccini & Hughes, 2000; Maccini & Ruhl, 2000). STAR represents Search the word problem, Translate the words into an equation in picture form, Answer the problem, and Review the solution.

Self-regulation. Self-regulation is a strategy used to help students regulate their cognitive activities when performing mathematical problem solving processes which underlies the executive functioning which is associated with metacognition (Flavell, 1976). Metacognition is

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the ability to understand one's cognitive weaknesses and strengths as well as self-regulation which guides students in the coordination while engaged in cognitive activities (Wong, 1999). Meta-analysis of group and single subject studies conducted with students with MLD revealed that self-regulation is an effective instructional strategy (Swanson, 1999; Swanson & Sachs-Lee, 2000). Montague, (2008) stated that "cognitive strategy instruction to improve mathematical problem solving for students with LD appears to qualify as an evidence-based practice" (p. 43). Self-regulation instruction, includes numerous research-based practices, including cueing, modeling, verbal rehearsal, and feedback are the bases for cognitive instruction. Self-regulation is designed and organized with step-by-step instructions, using specific cues and prompts, which typically lead to mastery of new concepts, skills, and applications and eventually automaticity of responses (Montague, 2007).

Pape (1998, 2001) examined the behavior of 80 middle school students' self-regulation skills. Through the research 74% of the students' demonstrated little or no direct approach to problem solving, 26% of the students were successful in using well-formed problem solving methods. Students who were successful with problem solving had the ability to transform problems into coherent mental problems. Self-regulation provides the training needed to become proficient in problem solving (Schoenfeld, 1983). Schoenfeld suggests that mathematics instruction has customarily been taught using algorithms rather than strategic methods. After instruction students solve mathematics problems that follow the instruction that has been taught, therefore asking students to only follow a set of procedures, this often leads to misconceptions. Noting this set of procedures might work for this set of problems, but may not work for the next set (Pape & Smith, 2002). Teachers are responsible for developing students' problem solving skills and conceptual understanding.

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Self-regulation may be taught to students via modeling. Teachers demonstrate the correct method for using self-regulation, which includes using self-talk and a self-monitoring checklist (see Figure 3).

Math Problem-Solving Processes and Strategies
READ (for understanding) Say: Read the problem. If I don't understand, read it again. Ask: Have I read and understood the problem? Check: For understanding as I solve the problem.
PARAPHRASE (use own words) Say: Underline the important information. Put the problem in my own words. Ask: Have I underlined the important information? What is the question? What am I looking for? Check: That the information goes with the question.
VISUALIZE (a picture or a diagram) Say: Make a drawing or a diagram. Show the relationships among the problem parts. Ask: Does the picture fit the problem? Did I show the relationships? Check: The picture against the problem information.
HYPOTHESIZE (a plan to solve the problem) Say: Decide how many steps and operations are needed. Write the operation symbols (+, -, x, and /). Ask: If I..., what will I get? If I ..., then what do I need to do next? How many steps are needed? Check: That the plan makes sense.
ESTIMATE (predict the answer) Say: Round the numbers, do the problem in my head, and write the estimate. Ask: Did I round up and down? Did I write the estimate? Check: That I used the important information.
COMPUTE (do the arithmetic) Say: Do the operations in the right order. Ask: How does my answer compare with my estimate? Does my answer make sense? Are the decimals or money signs in the right places? Check: That all the operations were done in the right order.
CHECK (make sure everything is right) Say: Check the plan to make sure it is right. Check the computation. Ask: Have I checked every step? Have I checked the computation? Is my answer right? Check: That everything is right. If not, go back. Ask for help if I need it.

Figure 3. A script used by students during self-instruction and self-questioning. From Montague, Warger, and Morgan (2006). Replicated with permission.

One self-regulation strategy includes guided steps for teachers to model and students to understand, learn, and model. Step one requires students to read and paraphrase the problem. In

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the second step students organize the information into meaningful information, by using representational figures. The third step is to develop a plan on how to solve the problem. Finally, the last step is to solve the problem and check to see if the answer makes sense (Montague, 2007).

Learning Environments

It may be postulated that there are multiple types of learning environments for students with disabilities, but for this paper I will be addressing two. They include the resource room and inclusion within the regular education classroom. Each environment is unique and students' cognitive level determines the most optimal location of instruction. This section will address resource room and inclusion classroom. Students are to be included to their maximum potential in the regular education mathematics classroom. Since Congress passed the *Education for All Handicapped Children Act* (Public Law 94-142), in 1975 more students are being educated alongside their nondisabled peers than ever.

Inclusion classroom. Inclusion is described as a philosophy. This philosophy is based on two arguments. The first argument is isolating students in separate classrooms or programs deny them educational rich experiences. Secondly, isolating students with learning disabilities has not resulted in adequate education (Friend & Cook, 1993; Parmar, 2006; Robertson, Valentine, 1999). Within this environment the mathematics teacher is the facilitator. According to NCTM, (2000); NCLB (2010), classrooms are taught by teachers that are highly qualified. Highly qualified refers to a teacher that has at least a bachelor's degree, fully licensed in the state in which they teach and prove to know the subject they teach (NCLB, 2010).

DeSimone and Parmar (2006) surveyed 228 middle school mathematics teachers in 19 states. They found the majority supported the idea of inclusion, but they did not want the

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students in their classrooms. Mathematics teachers feel the pressure of strict emphasis middle school administrators place on teachers, content-area curriculum, instructional modifications and adaptations that are necessary for students with special needs and they are often sacrificed and ignored (Vaughn & Schumm, 1994; Zigmond, Levin, & Laurie, 1985). Some mathematics teachers believe that they lack necessary training in working with students with disabilities, resources, training and time to put into practice needed to make inclusion successful for the students and teachers (Vaughn & Schumm, 1994).

In one study, Campbell, Gilmore, and Cuskelly (2003) found the teachers' developed positive attitudes about working with students with disabilities after participating in a semester long field experience and formal instruction. They were skillfully trained to teach subject material, but lack the necessary skills when it comes to working with students on IEPs. These same teachers believe that the general education classroom is not the appropriate placement, but however, did support inclusive setting (Campbell et al., 2003). DeSimone and Parmar (2006) found that middle school mathematics teachers, as content-area specialists, felt responsible for developing student mastery, but did not feel responsible for differentiating instruction to meet diverse learning needs. Building conceptual learning with students is difficult, but it is more difficult to do so with students with MLD.

Campbell, et al. (2003), found that increased positive attitudes toward students with disabilities resulted from participation in a full semester course that included structured field work experiences and formal instruction. The mathematics teacher is skillfully trained to teach the subject material, but may lack necessary skills when it comes to working with students with Individual Education Plan (IEP) (Allsopp, Lovin, Green, & Savage-Davis, 2003). According to DeSimone and Parmar (2006) there are disadvantages to inclusion for students with disabilities.

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The studies included along with current trends in special education suggest there are common criticisms for inclusion. The criticisms come in the form of disadvantages for both the teacher and the students. One criticism is the teacher to student ratio; students with disabilities are required to work on mathematics on their own while the teacher is working with others. Often this situation is not ideal because students with MLD require immediate feedback and corrective interaction from the teacher. A second criticism of inclusion is that students with disabilities may require more time to process answers due to their low processing speed index thus placing higher demands for wait time on the teacher and regular education students. The next criticism is mathematics teachers do not have the time to slow down their pace of instruction, thus moving too quickly for the student with disability to keep up, much less understand new concepts being taught each day. The fourth criticism is that students with MLD require modifications, accommodations, and other teaching strategies to develop their learning of mathematics. In an extensive study by Vaughn and Schumm (1994), it was found that teachers did not take the needs of their students with MLD into account when planning lessons. Rather they planned for the class as a whole. This method could exempt students with MLD from their IDEA mandated services.

Inclusion advocates are using court decisions to determine that students with disabilities are already at a disadvantage because of their disability, therefore, they should not be secluded from their peers (Kolstad, Wilkinson, & Briggs, 1997; Shanker 1995) The skills they learn while being included will be advantageous to their success in society. The skills learned in the inclusion environment include perseverance, self-awareness, and coping strategies. These skills along with understanding their disability and how it will affect their life are necessary for students with disabilities. Mathematics teachers must understand the unique learning styles of

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students with MLD, special education curricular and instructional strategies, including how to improve and convey functional skills instruction, and complexities of home/school collaboration (Field, LeRoy, & Rivera, 1994). Graham, Bellert, Thomas, and Pegg (2007) make this point in their study: "...the intent of inclusion is undeniably positive, it is questionable whether classroom teachers always have the time and strategic resources necessary to meet the complex learning needs of students experiencing LD" (p. 410).

Resource rooms. A resource room is a classroom where a special education teacher works with an individual student or small group of students, using a modified curriculum, accommodations, and other teaching strategies, which work more efficiently with students with MLD. Students who require intensive help in mathematics or other subject are placed in a resource room for the subject (<http://definitions.uslegal.com/r/resource-room-education/>). Special education teachers provide specially designed instruction that meets the unique needs of an exceptional child that requires special materials and special teaching techniques (Algozzine, Morsink, & Algozzine, 1988). In this environment, the special education teacher is responsible for teaching the mathematics, reading, language arts, and others.

Students may invest up to 79% of school day in regular education classes and then go to the resource room for needed extensive instruction in one or more subject area. When students with MLD are being educated in the resource room, it is imperative that the special education teacher use the same scope and sequence, NCTM standards, and assessment guidelines (Hawkins, 2007). According to Brownell, Sindelar, Kiely, and Danielson (2010) "In knowing how disability-related problems can derail learning and how research-based strategies can be implemented to intervene, special education teachers must be highly qualified in the core content areas they teach" (p. 359). Furthermore, the combination of highly qualified special education

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teacher and mathematics teacher has the knowledge of the mathematics subject matter and the techniques and strategies.

Woodward and Brown (2006) conducted two studies on curricula and found special education teachers use research-based principles when working with the special needs population. More so, students with learning disabilities need a more direct approach to solving the content in mathematics. The results from the study completed by Vlachou, Didaskalou, and Argyrakouli (2006) indicate that 53.7% of the students preferred the resource room compared to 38.9% the regular classroom. These students felt that they learned more effectively in the resource room because the student population is smaller and they received more interactions with the teacher. Also the students in the resource room felt more relaxed to ask questions and solicit help when needed.

However, according to Shanker (1995) the resource room is being eliminated due to economic reasons, but seventeen years later and this environment is being used. Stating that districts, school boards, and state departments have the agenda of full inclusion based on the expense of special education, “These services have become a crushing financial burden, especially because Congress has never appropriated funding at the level promised by P.L. 94-142, leaving states and local school boards to shoulder most of those costs” (Shanker, 1995, p. 18). Three main reasons for receiving help from the resource room teacher are: one the amount of help they received, two the teacher taught in a way that they learned more effectively, and three the personal qualities of the special education teacher. Students with disabilities typically learn mathematics concepts at a slower pace than what is used in a regular mathematics classroom. The students cannot keep up with the rigors of learning a new concept each day.

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Most students with unique needs require additional time to conceptualize these new concepts due to the manner in which they learn. Thus it makes sense to provide the concepts in small chunks. Students need time to recall concepts learned previously. Students with special needs are more segregated in the middle school regular education classroom than in the resource room. These students do not want to be singled out by having someone from the resource room to help them within the regular education classroom. It may be possible that the social stigma attached to a stand-alone aid is negative. While in the resource room the playing field is leveled. Everyone in this environment is there because they learn mathematics differently. Within the resource rooms the either one-on-one, small group setting allows the special education teacher to monitor and rectify conceptual and procedural errors, immediate feedback, and skill review, time practice and re-teach, and validate appropriate interventions. Effectively, the “gap” between their achievement levels and those of their peers without LD widens year after year (Graham, Bellert, Thomas, & Pegg, 2007). Through research explanations for students’ lack of learning and understanding is related to the methods used to teach and the type of curriculum used, rather than what schema the student brings to the mathematics. Therefore, the more advanced the concepts the bigger the gap becomes.

Chapter 3

Conclusions

Implications

With the introduction of NCLB and my knowledge of Annual Yearly Progress (AYP) I have been trying to understand how to best educate students with MLD. As a teacher over the last seven years, I have had many questions about AYP, NCLB, IDEA, and students with MLD. Often these questions remained unanswered by schools' administrators, leaving teachers, such as myself, wondering and trying to make sense of the reported data. It is difficult, in the fall of each new school year, to hear from administrators that the students with disabilities did not make AYP on their state assessment. However these same students demonstrate growth on their district Measure of Academic Progress (MAP).

These unanswered questions mystified me and had me wondering what I could do to assist my students with MLD to be successful and demonstrate their conceptual understanding of mathematics and the world in which they live. Throughout this literature review I answered the following questions. 1) What are the best practices and strategies for teaching mathematics to students with MLDs? 2) What does the research tell us about the differences between inclusion and resource instruction?

Past

Before beginning this literature review I had strong beliefs about special education, students, and mathematics. I believed that all students with MLD belonged in the resource room for mathematics instruction that was provided by a highly qualified special education teacher. I felt that I could provide what the students with MLDs needed to be successful and make AYP.

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To help the students be more successful I was providing extra time, more drill and practice, ample review of new skills, all on a curriculum that was at least one or more grade levels below their peers. I also knew that what was being taught in the mathematics classroom was too academically complex for the students I worked with in the resource room. In addition to that, I also knew the students with MLD would not be able to keep up with the high expectations of the mathematics teacher coupled with the quick pace and rigorous curriculum.

Present

After completing this literature review and a personal discussion with David Allsopp, I now have different beliefs about where to best educate students with MLD. In a correspondence with Allsopp he mentioned that it is not the place where the instruction takes place, but how the instruction is presented, that makes the difference in level of comprehension and learning (personal communication, November 15, 2011). This statement validates the need to reassess my current teaching methods because effectively educating students with disabilities takes more than a one size fits all approach. Mathematics teachers and special education teachers should keep in mind that they may have to try different strategies before discovering the one that works best for the individual student.

The strategies addressed in the literature review included CRA, SBI, mnemonics, and self-regulation. All of these strategies can be modified to fit the lesson, students' needs, and grade levels. I understand that teachers cannot do all of the strategies, all of the time, with all of the students, however, individual needs must be taken into account when determining what will provide optimal learning experiences. Individual students have unique learning needs which depend on their abilities, background, experiences, skills and willingness to learn. I know that the most important element in teaching students mathematics is to take into account each student's

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least restrictive environment and to determine where they will make the most growth in their conceptual learning. The Individuals with Disabilities Education Act, No Child Left Behind, and National Council Teachers of Mathematics state that students must be educated in the least restrictive environment and have exposure to meaningful mathematics. Whether the decision is to educate students in the resource room or the mathematics classroom, factors that help facilitate authentic learning are not predicated on drill and practice. In fact true progress is likely contingent upon using the combination of NCTM Principles and Standards document, having a highly qualified teacher in the classroom, implementing a research-based curriculum, and using multiple teaching strategies.

Future

Looking to the future, if I want to help my students develop a deeper level of conceptual learning, it is my obligation to expose them to grade level mathematics using the standards and practices, research-based curriculum, and applying different strategies. As a highly qualified mathematics teacher and special education teacher it is imperative to have discussions about research and what IDEA, NCLB, and NCTM state about the learning of students with MLD. Having these discussions with other mathematics and special education teachers places everyone on the same level or special education teachers increases the likelihood that everyone is on the same page and encourages professional growth in knowledge of where education is today and where it should go in the future.

In building these discussions, I have begun and will continue until changes are made and we look at each student as an individual. These changes are not for the teachers, rather for the students, their conceptual understanding, and AYP. After decisions are made a plan is

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imperative. The plan should include staff development on types of strategies and how to implement them in the classroom as well as how to best meet the needs of students with MLD.

In the last chapter of this literature review I have discussed my past, present, and future beliefs. I have also discussed what I now know after researching the topics of researched-based strategies, CRA, SBI, mnemonics, self-regulation and the inclusion and resource environments. I have laid out my plan to make necessary changes in my classroom and building in general.

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