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The effects of the integration of mathematics within children's literature on early numeracy skills of young children with disabilities

Katherine B. Green

ACCEPTANCE

This dissertation, THE EFFECTS OF THE INTEGRATION OF MATHEMATICS WITHIN CHILDREN'S LITERATURE ON EARLY NUMERACY SKILLS OF YOUNG CHILDREN WITH DISABILITIES, by KATHERINE BRAND GREEN, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University. The Dissertation Advisory Committee and the student's Department Chair, as representatives of the faculty, certify that this dissertation has met all standards of excellence and scholarship as determined by the faculty. The Dean of the College of Education concurs.

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ABSTRACT

THE EFFECTS OF THE INTEGRATION OF MATHEMATICS WITHIN CHILDREN'S LITERATURE ON EARLY NUMERACY SKILLS OF YOUNG CHILDREN WITH DISABILITIES
by
Katherine B. Green

Math skills are critical for future success in school (Eccles, 1997), as school-entry math knowledge is the strongest predictor of later academic achievement (Claessens, Duncan, & Engel, 2009). Researchers have found that teachers of young children spend less time teaching mathematics than other subject areas (Phillips & Meloy, 2012), and there is a lack of formal early mathematics instruction for young children's understanding of early numeracy (Chard et al., 2008). However, preschoolers are developmentally ready for mathematics and are more able to learn math concepts than previously believed (Balfanz, Ginsburg, & Greenes, 2003). While there is a recent increase of literature on math with young children, there is a scarcity of research related to young children with disabilities in the field of mathematics, particularly utilizing evidence based interventions. The current study investigates one intervention integrating mathematics within children's literature for preschoolers with disabilities.

This study was a quasi-experimental group design, with one treatment group and one comparison group (N = 50 participants). Targeted early numeracy skills included: (1) one-to-one correspondence, (2) quantity comparison, and (3) numeral identification. The 20-minute intervention was conducted three days per week for six weeks; the comparison group received a typical small group storybook reading of the same literature book with no elaborations. The *Test of Early Mathematics Ability, Third Edition* (TEMA-3; Ginsburg & Baroody, 2003) was used as a pre and post standardized assessment, and analyzed using one-way ANCOVAs controlling for pretest scores. The *Preschool Numeracy Indicators* (PNI; Floyd, Hojnoski, & Key, 2006) was used as a weekly curriculum based measurement and analyzed by one-way ANCOVAS and by individual and group means for descriptive data. After the intervention, the children in the treatment group scored significantly higher in the areas of total math ability, quantity comparison, and one-to-one counting fluency than the comparison group. Implications include possibilities for further integrating mathematics within literature for preschoolers with disabilities, the benefits of intentional storybook selection for this type of intervention, and the recognition of the importance of introducing mathematical topics to preschoolers with disabilities in order of developmental cognitive readiness.

THE EFFECTS OF THE INTEGRATION OF MATHEMATICS WITHIN CHILDREN'S LITERATURE ON EARLY NUMERACY SKILLS OF YOUNG CHILDREN WITH DISABILITIES

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Katherine B. Green

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ABBREVIATIONS

ADHD	Attention Deficit Hyperactivity Disorder
BMLK	Big Math for Little Kids
CAI	Computer Assisted Instruction
CBM	Curriculum Based Measurement
CMIS	Children’s Math Interest Self-Report
CTD	Constant Time Delay
ECME	Early Childhood Mathematics Education
ECLS-K	Early Childhood Longitudinal Study – Kindergarten
ELM	Early Learning in Mathematics
FASD	Fetal Alcohol Spectrum Disorders
GA DOE	Georgia Department of Education
ID	Intellectual disabilities
IEP	Individualized Education Plan
LIS	Level of Interest Survey
MD	Math Difficulties
MD/RD	Math difficulties along with reading difficulties
MID	Mild Intellectual Disabilities
MLD	Math Learning Disability
NAEYC	National Association for the Education of Young Children
NCTM	National Council of Teachers of Mathematics
NF1	Neurofibromatosis Type 1
NJCLD	National Joint Committee on Learning Disabilities

NRC	National Research Council
OECD	Organisation for Economic Co-operation and Development
OTIS	Overall Teacher Interest Survey
PALS	Peer Assisted Learning Strategies
PNI	Preschool Numeracy Indicators
RD	Reading Difficulties
RTI	Response to Intervention
SD	Standard Deviations
SDD	Significant Developmental Delay
SFAW	Scott Foresman-Addison Wesley Mathematics
SM	Selective Mutism
TBI	Traumatic Brain Injury
TEMA	Test of Early Mathematical Ability
TEMA-2	Test of Early Mathematics Ability, Second Edition
TEMA-3	Test of Early Mathematics Ability, Third Edition

CHAPTER 1

STATEMENT OF THE PROBLEM

Introduction

School-entry mathematics knowledge, specifically the knowledge and understanding of numbers and ordinality, is the strongest predictor of later academic achievement (Claessens, Duncan, & Engel, 2009; Duncan et al. 2007). Although early numeracy has not received the attention in the research literature that emergent literacy has, researchers have found that preschoolers are developmentally ready for mathematics (Arnold, Fisher, Doctoroff, & Dobbs, 2002; Balfanz, Ginsburg, & Greenes, 2003) and are able to learn more than previously believed (e.g., Greenes, 1999). Early Intervention (Gersten, Jordan, & Flojo, 2005) and improving classroom quality (Peisner-Feinberg et al., 2001) can improve later math achievement. While there is a recent increase of literature on math with young children, there is a scarcity of research related to young children with disabilities in the field of mathematics, particularly utilizing evidence based interventions.

Although early childhood content has included the area of mathematics for over 200 years (Balfanz, 1999), interest in early childhood mathematics education (ECME) either increases or wanes in the United States, partly as a result of social conditions. ECME is currently of interest once again (Ginsburg, Lee, & Boyd, 2008; Sarama & Clements, 2009). Sarama and Clements (2009) suggested several reasons for the current renewed interest in ECME, including (1) increased enrollment of children in early education programs (U.S. Department of Education, 2000); (2) increased importance of mathematics in technological careers; (3) unfavorable comparisons in math scores of students (as young as three to five years old) in the United States compared to other developed countries (Starkey et al., 1999; Stigler, Lee, & Stevenson, 1990; Yuzawa, Bart, Kinne, Sukemune, & Kataoka, 1999); (4) knowledge gaps on math scores between socioeconomic groups within the United States; (5) increased recognition of the innate mathematical competencies of young children; and (6) strong correlations between early mathematics knowledge and later school achievement (Claessens et al., 2009; Denton & West, 2002; Duncan et al., 2007).

Young children typically learn mathematics from informal everyday learning opportunities (Baroody, Lai, & Mix, 2006; Ginsburg, Cannon, Eisenband, & Pappas, 2006), such as through play and exploring their environment. Early childhood, particularly the preschool years, is an advantageous time to introduce children to more formal mathematical operations, as young children have a spontaneous interest in mathematics (Gelman, 1980; Saxe, Guberman, & Gearhart, 1987; Seo & Ginsburg, 2004) and preschoolers exhibit competence in mathematics, such as the basic elements of adding and subtracting (Brush, 1978), understanding spatial relations (Clements, 1999a), and counting (Irwin & Burgham, 1992; Saxe et al., 1987). Yet there is often a gap between children's informal mathematical knowledge and formal schooling opportunities (Griffin & Case, 1997; Griffin, Case, & Siegler, 1994). Researching ECME for young children with disabilities is of importance as young children with math difficulties or at risk for math difficulties can achieve rapid growth in early numeracy skills with effective interventions (Vukovic, 2012). Although, interventions may require different approaches for different children's needs (Fuchs et al., 2010), researchers have found that early interventions in mathematics can improve children's mathematical achievement (e.g., Avant & Heller, 2011; Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Bryant, Bryant, Gersten, Scammacca, Funk, et al., 2008; Bryant et al., 2011; Daughtery, Grisham-Brown, & Hemmeter, 2001; Fuchs, Fuchs, & Compton, 2012; Fuchs et al., 2005; Fuchs, Fuchs, & Karns, 2001; Kroesbergen & van Luit, 2003; Murphy, Bates, & Anderson, 1984; Scott, 1993; Seo & Bryant, 2012; Simon & Hanrahan, 2004; Van Luit & Schopman, 2000).

Significance of the Problem

Similar to difficulties with reading, difficulty with learning mathematics is associated with serious lifelong challenges (e.g., National Mathematics Advisory Panel, 2008; Rivera-Batiz, 1992), as math skills are critical for future success in school, as well as science and technology careers (Clark, 1988). Career options are more limited for children who have deficiencies in mathematics (Eccles, 1997), leading to future negative economic consequences, such as jobs with decreased wages, and continuing cycles of poverty (Caspi, Elder, & Bem, 1987; Feldman & Wentzel, 1990; Hinshaw, 1992; Kazdin, 1985; Tremblay et al., 1992). Concerns are expressed regarding children's mathematics performance specifically in the United States (e.g., Geary, 1996; Hanushek, Peterson, & Woessmann, 2010). According to the Organisation for Economic Co-operation and Development's (OECD; 2010) international report of children's mathematics performance, students in the United States ranked significantly below the average of 70 countries in mathematics performance. This math achievement gap between the United States and other countries begins in the preschool and kindergarten years (Miller & Parades, 1996). Further, the prevalence of mathematics difficulties is high in the United States, with estimates of 5% and 9% of school aged children reported to have academic challenges in mathematics (e.g., Dirks, Spyer, van Lieshout, & de Sonneville, 2008; Geary, Hoard, Nugent, & Bailey, 2012; Shalev, Auerbach, Manor, & Gross-Tsur, 2000). Having math challenges in the early years can affect later math achievement. Morgan, Farkas, and Wu (2009) found that within a national representative sample of elementary-aged students, the students who demonstrated mathematical performance in the lowest 10th percentile at both the beginning and end of kindergarten had a 70% chance of remaining in the lowest 10th percentile in the fifth grade. This difficulty in math achievement has negative outcomes into adulthood. For example, Gerardi, Goette, and Meier (2010) found a relationship between the number of recent mortgage foreclosures and deficiencies in basic mathematic calculations of the mortgage owners.

The issue of lowered achievement in mathematics in the United States can be attributed to several factors, including: 1) teachers of young children spend less time teaching mathematics than other subject areas, such as literacy (Phillips & Meloy, 2012); 2) teachers may not be well-prepared to teach mathematics (Hill & Ball, 2004; Ma, 1999); 3) expectations may be too low for students, with a curriculum consisting of standards that are not based on research, only briefly address children with disabilities, and lack clarity (Chard & Kame'enui, 1995; Romberg & Kaput, 1999); 4) instruction may be insufficient and based on traditional instruction (Battista, 1999; Geist, 2000); and 5) a lack of formal early mathematics instruction for young children's understanding of early numeracy (Chard et al., 2008). While traditional methods of teaching mathematics such as drills, workbooks, or worksheets may assist children in developing procedural knowledge (i.e., the rules and procedures for performing mathematics tasks), they do not help children acquire conceptual understanding (i.e., understanding the relationships and connections between skills) of mathematics or connect conceptual knowledge to procedural knowledge (Caine & Caine, 1991; Hiebert & Lindquist, 1990; NCTM, 1990). Children with math difficulties typically lack the conceptual understanding of mathematics. Research shows that when teachers neglect the teaching of conceptual knowledge of math or do not connect conceptual to procedural knowledge, children may know what procedures to do, but not understand the meaning of the mathematics (e.g., Kouba, Carpenter, & Swafford, 1989).

Although students may perform well in the short term, teaching only procedural knowledge can have many long term effects for students' mathematics performance (Kouba et al. 1988a, 1988b; NCTM, 1990). Teaching methods, such as using worksheets and workbooks with very young children, fail in encouraging children to solve problems creatively, critically, and logically, or to pursue mathematics learning with enthusiasm (Hong, 1996), and are not developmentally appropriate for young children (Bredekamp & Rosegrant, 1992). It is possible that teachers continue to use approaches that are not developmentally appropriate for children due to the lack of an alternative approach that would not require them to make major changes in their current teaching methods (Hong, 1996). Teachers must find creative, meaningful, and relevant activities to promote motivation for learning mathematics skills as well as conceptual and procedural understanding of mathematics (Jennings, Jennings, Richey, & Dixon-Krauss, 1992).

It is well-documented that preschoolers enter school with some mathematical knowledge (Baroody et al., 2006; Ginsburg et al. , 2006). However, there is a substantial variability in the levels of children's mathematical knowledge and understanding in the preschool years (e.g., Ginsburg, Klein, & Starkey, 1998; Ginsburg & Russell, 1981;

Hughes, 1981, 1986; Young-Loveridge, 1991). Children who are developmentally behind peers at school entry may become even further behind as the years progress, so that the achievement gap between the least and most competent students in mathematics increases over time (e.g., Fogelman, 1983). There is a lack of empirical research on mathematics interventions for preschoolers with disabilities, and many high-quality math programs are not explicit enough to meet the needs of children who are at risk for academic failure or have disabilities (Doabler et al., 2012). It is documented that high-quality, explicit, mathematics instruction may prevent math difficulties and promote mathematical outcomes (Agondi & Harris, 2010; Chard et al., 2008; Clarke et al., 2011). This evidence supports the possible benefits of focusing on mathematics instruction in the preschool years for children with disabilities.

Research Questions

This study investigated the effects of an intervention integrating mathematics within children's literature on the early numeracy skills of preschoolers with disabilities. Specifically, this study examined total math ability and the early numeracy skills of one-to-one correspondence, quantity comparisons (e.g., more, less), and numeral identification.

Research Question One

Will using a mathematics intervention of shared storybook readings and related activities promote total mathematical ability skills of preschoolers with disabilities?

Research Question Two

Will using a mathematics intervention of shared storybook readings and related activities promote the one-to-one correspondence skills of preschoolers with disabilities?

Research Question Three

Will using a mathematics intervention of shared storybook readings and related activities promote the quantity comparison skills of preschoolers with disabilities?

Research Question Four

Will using a mathematics intervention of shared storybook readings and related activities promote the numeral identification skills of preschoolers with disabilities?

CHAPTER 2

REVIEW OF THE LITERATURE

Young children have the capability and potential to learn complex and sophisticated mathematical concepts (Balfanz et al., 2003; Baroody, 2004; Clarke, Clarke, & Cheeseman, 2006; Fuson, 2004; Geary, 1994; NRC, 2009; Sarama & Clements, 2009). Early math achievement predicts not only elementary school math achievement (Claessens et al., 2009; Jordan, Kaplan, Locuniak, & Ramineni, 2007; Krajewski & Schneider, 2009), but also high school math (NMAP, 2008; NRC, 2009), and total academic achievement (Claessens et al., 2009; Jordan et al., 2007). This chapter will review the theoretical foundations of the mathematics intervention for the current study; the importance of mathematics for young children; the foundations and learning trajectories of mathematics for typically developing young children; research regarding the instructional practices, knowledge, beliefs, and attitudes of early childhood mathematics educators; and math interventions for typically developing young children. This chapter will then continue with characteristics of young children with math difficulties and/or disabilities, math instruction for children with math difficulties, and math interventions for preschoolers and early elementary aged children with disabilities. Finally, this chapter will conclude with how language and literacy are connected with mathematics, a review of the integration of mathematics within literature in early childhood, including suggested methods of integrating the two content areas. The terms mathematics and math will be used interchangeably, as well as the terms early numeracy and early math skills.

Theoretical Foundations

Early mathematical interventions can help preschoolers develop a mathematical foundation, as well as increase the quality of the mathematics classroom environment (Clements & Sarama, 2008). The National Association for the Education of Young Children (NAEYC; 2009) encourages the use of naturalistic approaches when teaching young children. The use of naturalistic approaches is based on the learning philosophy of constructivism and social constructivism (e.g., Piaget, 1964; Vygotsky, 1978). However, research suggests that some children, particularly those with disabilities, learn better with explicit and direct instruction (Lane, Carter, Pierson, & Glaeser 2006), stemming from the behaviorist philosophy. Odom and Wolery (2003) reported that Early Intervention and Early Childhood Special Education derived from a variety of theoretical perspectives, particularly behaviorism, but have been influenced by other theories and models, such as constructivism and social constructivism. This current study has been influenced by and will combine three theoretical perspectives in order to meet the needs of young children with disabilities in mathematical instruction: constructivism, social constructivism, and the explicit and direct instruction of behaviorism.

Constructivism

Influenced by the work of Piaget, many mathematics educators recognize that children actively construct mathematical knowledge as they interpret experiences, reflect on their actions (Richards & von Glasersfeld, 1980; von Glasersfeld, 1981), and create a theory that makes sense to them (Cobb, 1994). Children construct their reality through their experiences and reflections on their actions (Richards & von Glasersfeld, 1980; von Glasersfeld, 1981). Constructivists from the 1800s to the present believe that children are not empty vessels for knowledge to be transferred directly by teachers; rather, children are active knowledge constructors (Ginsburg & Seo, 1999). Children reinvent and experience mathematics in their own individual ways (Piaget, 1977), even before entering formal schooling (Gelman & Gallistel, 1986; Ginsburg, 1989) with a natural curiosity for mathematical concepts such as finding patterns and solving problems (Baroody, 2000). Further, from this perspective, learning should be naturalistic and contextual (e.g., Cobb, 1995). Thus, teachers must understand and respect the different ways children construct knowledge and prepare the appropriate conditions for children to construct their own knowledge without downplaying the subject matter of the mathematical content (Ginsburg & Seo, 1999). Teachers may also guide their teaching and curriculum, as well as evaluate student achievement by listening and observing the mathematical activities of the children in their classroom (Steffe & Kieran, 1994).

Picture books may provide an environment in which children can actively construct their own mathematical knowledge (Phillips & Croswell, 1994). Through integrating mathematics within children's literature, the literature becomes the context that all children in the classroom experience, and mathematics can be experienced and constructed naturally through questioning and experience (Whitin, 2002). Children may attempt to resolve cognitive conflicts that arise in the story through the text or pictures, process new information by connecting it to prior knowledge, and reflect on the content learned (van den Heuvel-Panhuizen & van den Boogaard, 2008). Through this construction of knowledge, children achieve a higher and deeper level of understanding by developing new mathematical ideas, structures, and schemas (Elia, van den Heuvel-Panhuizen, & Georgiou, 2010).

Social Constructivism

Until the mid-1990s, the radical constructivist theory of learning (e.g., Von Glaserfeld, 1982) was the prominent theory in mathematics education (Anderson, Anderson, & Shapiro, 2004). However, some researchers and theorists currently conceptualize mathematical learning within the social constructivist framework. Social constructivism recognizes that children may acquire knowledge as a result of social interaction, enabling children to communicate their knowledge with others and stimulate reflection (Vygotsky 1978, 1987). From this perspective, learning is viewed as a social activity in which language and communication play a key role (Rogoff, 1990; Sfard, Nesher, Streefland, Cobb, & Mason, 1998), and children build their knowledge and understanding through the help of more proficient others. Young children begin to understand their world through their social interactions with a significant other (Rogoff, 1990), and gradually rely less on more competent others as they begin to internalize the mathematical processes (Sfard et al., 1998). From this perspective, mathematics is seen as a content area that is embedded in and influenced by social and cultural practices (Anderson, Anderson, & Shapiro, 2005). This theoretical perspective emphasizes the use of teaching within a child's zone of proximal development and scaffolding the cognitive processes of the learner (Arias de Sanchez, 2010; Vygotsky, 1987). Further, as a social practice, early mathematics should be part of an integrated curriculum that is designed to help each child reach his or her potential, rather than isolating mathematics to an academic content area (Arias de Sanchez, 2010).

Behaviorism

Many researchers have found that children with disabilities, particularly those with math disabilities, experience the most success when taught directly, explicitly, and systematically, as influenced by the behaviorist philosophy (e.g., Gersten et al., 2009; Kroesbergen & Van Luit, 2003). Direct instruction is the explicit teaching of rules and strategies combined with modeling, immediate corrective feedback through guided practice, and successive approximations (Joyce, Weil, & Calhoon, 2000). Explicit teaching of mathematical content includes highly structured sequential instruction of skills to help children understand the critical features of the content (Gersten et al., 2009; Hudson & Miller, 2006). In other words, teachers teach the most essential skills in the most efficient and effective method possible (Carnine, Silbert, Kame'enui, & Tarver, 2004). Within this instructional approach, the teacher leads the instruction, determines the instructional goals and pace, chooses the appropriate materials, and provides immediate corrective feedback to the student. Tasks are broken down into smaller skills and are sequenced to allow for student mastery of prerequisite skills before moving on to more difficult tasks (Joyce et al., 2000). In a meta-analysis of mathematics interventions, Kroesbergen and van Luit (2003), found direct instruction approaches to be the most effective methods for teaching students with disabilities. Other meta-analyses and studies have found similar effects with the use of direct instruction (Carnine, 1997; Gersten et al, 2009; Swanson, Carson, & Lee, 1996; Swanson & Hoskyn, 1998).

Although direct instruction research is not rooted in child development or mathematics education, several special education researchers (e.g., Owen & Fuchs, 2002; Woodward, 2006; Xin, Jitendra, & Deatline-Buchman, 2005) have examined integrating explicit instruction with child development and mathematics education (Gersten et al., 2009). In early childhood special education, researchers agree that many children learn best with a combination of explicit instruction and naturalistic learning, particularly children who are at risk or have disabilities (Lonigan, Farver, Phillips, & Clancy-Menchetti, 2011; Wolery & Hemmeter, 2011). Constructivism and social constructivism are not readily found in special education research and teaching. Gersten and Chard (1999) suggested that looking at these cognitive perspectives can and should have a profound impact on how mathematics is taught to individuals with disabilities, as these perspectives can assist in enhancing the special education mathematical perspective. This “hybrid” notion of combining behaviorist, constructivist, and social constructivist viewpoints for children with disabilities allows for skill instruction within meaningful contexts (Goldman & Hasselbring, 1997) and will be utilized in the current study.

Importance of Math for Young Children

The knowledge of mathematics is an important tool that helps facilitate a person’s daily living (Arias de Sanchez, 2010). Claessens, Duncan, and Engel (2009) reported that not only were school entry math skills, such as knowledge of numbers and ordinality highly predictive of fifth grade math skills, but they were predictive of later reading success as well. These authors also noted that kindergarten mathematical knowledge was the most important set of skills for later achievement, followed by kindergarten literacy, and attention skills, respectively.

The need for mathematical knowledge and achievement extends beyond an individual child’s success in school. Excelling in mathematics is of importance to our nation, as well (Ginsburg, Lee, et al., 2008). Compared to other developed counties, the

United States ranks below other countries in mathematics performance (Baldi, Jin, Skemer, Green, & Herget, 2007; OECD, 2010; Provasnik et al., 2012), with this gap beginning as young as the preschool years (Miller & Parades, 1996). Future careers in mathematics, technology, and science are contingent on mathematical knowledge and success (Clark, 1988), and these career opportunities will be limited for children with mathematical difficulties (Eccles, 1997). Without mathematical success, our nation's children may experience limited career opportunities which can lead to a lack of economic success and technological advances.

With the importance of early math skills to the child's academic success and the nation's economic success, it is important that research interventions help all children gain a better understand of early numeracy skills (Clements & Sarama, 2011). Introducing mathematics at an early age may be beneficial, as many children have confidence in themselves as learners and expect to perform well in school (Stipek & Ryan, 1997). High-quality preschool education can improve math and literacy competencies for all children (Bridges, Fuller, Rumberger, & Tran, 2004), with the greatest gain for children who enter preschool at ages two or three (Loeb, Bridges, Bassok, Fuller, & Rumberger, 2007). Further, research shows that if children are actively engaged in meaningful and enjoyable math activities, they will likely continue to engage in mathematics in later years (Seefeldt & Galper, 2008; Van de Walle & Lovin, 2006; NRC, 2001). Clements (2001) indicated that intentionally teaching early mathematics is important for preschoolers because currently the early childhood curriculum is limited in mathematics; teachers may be able to narrow the mathematics achievement gap between children from low-SES homes and mid- to high-SES homes; teachers can foster, nurture, and encourage young children's natural curiosity in mathematics as they facilitate learning; and children's brains undergo significant developmental changes in the early years that are better stimulated with complex and engaging mathematics activities rather than rote counting or drilling.

Foundations and Learning Trajectories of Mathematics for Typically Developing Young Children

Many young children enter school having a variety of experiences with informal mathematics and exhibit sophisticated and broad mathematical knowledge before formal schooling (e.g., ideas of more and less, shape, location, position) (Anderson, 1997; Baroody et al., 2006; Clements & Sarama, 2007b; Ginsburg et al., 2006; Ginsburg, Lee, et al., 2008; Kostelnik, Soderman, & Whiren, 2007; Young-Loveridge, 1989). Yet, as with other content areas, there is great variability in the rate at which young children develop and understand early mathematical knowledge and concepts (Bowman, Donovan, & Burns, 2001; Kraner, 1977). This variability may be due to several factors, including interactions and relationships with significant adults in or outside the home (Aubrey, Bottle, & Godfrey, 2003). Fortunately, effective primary and preschool experiences can be positive influences on children's mathematical performances (Melhuish et al., 2008). Other influences on later mathematical achievement include socioeconomic status (Anders et al., 2012; Melhuish et al., 2008; Case & Griffin, 1990; Case, Griffin, & Kelly, 1999), mother's education level (Anders et al., 2012; Melhuish et al., 2008), gender (Anders et al., 2012), home learning environment (Anders et al., 2012; Aubrey et al., 2003; Kleemans, Peeters, Segers, & Verhoeven, 2012; Melhuish et al., 2008), and early mathematical knowledge (Stevenson & Newman, 1986). This review now turns to the foundations of early mathematics knowledge and skills.

There are key foundational skills that young children should master before understanding more complex mathematical skills. The NAEYC and NCTM (2002) suggested that foundational mathematics curriculum focus on five broad content areas: Number and Operations; Geometry and Spatial Sense; Measurement; Algebra; Data Analysis and Probability, with the strongest focus on Number and Operations, and Geometry (NCTM, 2006). Early mathematical concepts that have been found to specifically relate to later math achievement are included in the Number and Operations area, particularly including the mastery of number sense (Clements, 1999b; Groffman, 2009; Jordan et al., 2007; Robinson, Menchetti & Torgesen, 2002; Vukovic, 2012). Although not considered a curriculum focus area, another element of mathematics to take into consideration is the concept of mathematical power (Baroody, 2000; Griffin, 2003).

Number and Operations

Number Sense. The NCTM (2006) noted that the domain of number and operations for preschoolers includes the development of number sense and the understanding of whole numbers, concepts of correspondence, counting, cardinality, and comparison. Each of these skills may be learned separately, but will connect to each other during the preschool years (cf. Linnell & Fluck, 2001), as each math ability may motivate the learning and use of another skill and become increasingly interrelated (Clements & Sarama, 2009). Researchers have found that children learn number and quantity in a hierarchy (Clements & Sarama, 2007b; Hudson & Miller, 2006), with skills building on each other throughout the early years (e.g., learning of smaller numbers before larger numbers; rote counting one to five may precede one-to-one correspondence).

Researchers agree that the major math concept required for achievement in later mathematics is number sense (Clements, 1999b; Groffman, 2009; Jordan et al., 2007; Robinson et al., 2002; Vukovic, 2012). As number sense has been compared to phonological awareness in reading development, number sense is the foundation of mathematics development (Gersten & Chard, 1999). Defined in a variety of ways, number sense is the understanding of numbers and includes skills such as (1) counting, (2) estimating and judging magnitude, (3) simple computation, and (4) sense of quantity (Gersten et al., 2005). Berch (2005) noted that number sense ranges from the ability to understand the meaning of numbers, to developing strategies to solve complex math problems; from making simplistic comparisons in the magnitude of numbers, to inventing procedures for performing numerical operations. Number sense helps a child conceptually understand mathematics, manipulate numbers, and is a key ingredient for solving basic arithmetic problems (Griffin et al., 1994). When children do not demonstrate adequate number sense abilities, they have difficulties with later math skills, such as memory-based retrieval and counting (e.g., Geary, Bow-Thomas, & Yao, 1992; Geary, Hamson, & Hoard, 2000; Geary, Hoard, Bryd-Craven, Nugent, & Numtee, 2007). Children who fail to acquire adequate number sense capabilities may persist with ineffective strategies and may not develop higher order concepts. Further, when children cannot use memory-based retrieval, they may make more errors, work slower, and have less systematic retrieval speeds than typically developing peers (e.g., Geary, Brown, & Samaranayake, 1991; Geary et al., 2007; Ostad, 1997).

Although there is not a true consensus as to whether children innately possess number sense abilities or if children attain or learn these skills (Ginsburg, 1997; Griffin et al., 1994; Lock, 1996), several early childhood researchers believe that the development of number sense is influenced by environmental dynamics (Gersten & Chard, 1999; Ginsburg, 1997; Griffin et al., 1994) and derived from typical social interaction with others (Ginsburg, 1997). For example, Griffin, Case, and Siegler (1994) found that when entering kindergartners from different socioeconomic backgrounds were asked, "which number is bigger, 5 or 4?," children from high socioeconomic backgrounds answered the question correctly 96% of the time, whereas children from low socioeconomic backgrounds answered the question correctly only 18% of the time. Baroody, Eiland, and Thompson (2009) found that when teaching early mathematics to at-risk preschoolers, number sense could not be imposed on children, rather teachers must assist students in gaining number sense through facilitating the construction of the students' own learning and exploration. Number sense components may include many mathematical concepts such as subitizing, counting, quantity comparison, numeral identification, and basic addition and subtraction.

Subitizing. Subitizing forms a foundation for the knowledge of numbers (Sarama & Clements, 2009), numeration, and calculation (Butterworth, 1999). Subitizing, derived from the word 'suddenly' in Latin, is the quick and accurate ability to recognize small numbers of objects (Copley, 2010; Xu & Spelke, 2000). There are two types of subitizing: perceptual and conceptual (Clements, 1999b). Perceptual subitizing includes the most primitive form and is the recognition of a number of objects without using any other mathematical processes, such as counting. Conceptual subitizing is a more advanced form of mathematical organization and includes the recognition of a number of objects (e.g., dots on a domino) with the understanding that the composite of two dots and two dots equal four dots. Perceptual subitizing assists in the development of number sense, such as acquiring counting skills and in the initial forms of cardinality (Benoit, Lehalle, & Jouen, 2004; Clements, 1999b). Conceptual subitizing also assists in number sense, as well as arithmetic abilities (Clements, 1999b).

Children begin to gain the concept of subitizing at the age of two (Benoit et al., 2004), and by the age of three, many children can subitize a set of numbers from one to five (NRC, 2009). Subitizing may be a more primitive tool than counting for the acquisition of number words, as young children may use subitizing to acquire the cardinal meanings of the first number words, rather than counting (Benoit et al., 2004). The notion that subitizing precedes counting abilities is also supported by more current research (e.g., Hannula, Rasanen, & Lehtinen, 2007; Le Corre, Van de Walle, Brannon, & Carey, 2006), showing it is considered an essential skill in learning to count (Clements, 1999b; Groffman, 2009). Groffman (2009) suggested that years of scientific research have shown that children with poor subitizing skills, also experience difficulties with number sense, basic arithmetic skills, and higher mathematical concepts.

Counting. Counting has been regarded as a foundational skill to assist in building children's quantitative skills (Gelman & Brenneman, 1994). Counting is not simply reciting a string of numbers while pointing to objects; rather, counting requires an understanding of how numbers relate to one another (Curtis, Okamoto, & Weckbacher, 2009). As an important component of number sense, it is believed that children develop counting sequentially and hierarchically (Klahr & Wallace, 1973): (1) children generate the number words in a sequence; (2) number tags are applied one at a time to each number in a set (enumeration); (3) children understand that the last number tag counted is the number of objects in the set (i.e., cardinality principle); and (4) children understand the magnitude of numbers (e.g., five is larger than one) (Baroody, 1987). In time, children begin to understand the principles and rules of counting (Baroody, 1987). As described by Hohmann and Weikert (1998), the counting principles include: (1) *the one-to-one principle*, an understanding of using one number name for each object counted; (2) *the stable-order principle* in which children understand that number names are in a stable order (e.g., "one, two, three"); (3) *the cardinal principle*, the understanding that the last number counted is the number in the set (e.g., "one, two, three . . . there are three bears!"); (4) *the abstraction principle* when children understand that different objects can be counted together, such as red and blue blocks can be counted in the same collection; (5) *the order-relevance principle* when the child understands that regardless of the order of objects, there are always the same number of objects (e.g., five bears are always five bears regardless of the layout of the bears or which bear is counted first). Counting assists other mathematical concepts, as well. The verbal and object counting skills of children ages three-and-a-half and four years of age provide children with more powerful tools for representing and comparing numbers and making comparisons of small sets, which readies them for the same number-name principle (i.e., two collections are equal in number, regardless of the physical features of the objects in the groups) and the larger number principle (i.e., the later number word in the counting sequence, the larger the collection the number represents) (Baroody, 2000). Geary (2004) noted the importance of counting, as weak counting strategies is a key indicator of later difficulties in mathematics.

Baroody (1987) found that by 18 months, children begin to count orally (“one, two, three . . . ”), and that at two years of age children begin to understand and exhibit awareness that counting is used to assign numbers to collections of objects. By two years old, many children have acquired at least one number word, followed by verbal counting and number names at ages two to three (Krajewski & Schneider, 2009; Sarama & Clements, 2009); yet at the age of two children do not yet use these number words in regards to quantity (Gelman & Gallistel, 1986; Krajewski & Schneider, 2009). Children begin to link number words to quantity, or “awareness of numerical quantity” once they understand number words are discrete words and can recite them in an exact numerical sequence (Krajewski & Schneider, 2009). Fuson (1988) found that children’s counting is organized and exhibits the structures of mature counting by the age of three. For example, at the age of three, some children begin counting one to four items and begin to understand the cardinality rule that the last counting word indicates “how many” (NAEYC & NCTM, 2002). Howell and Kemp (2010) found that the preschoolers in their study could rote count to 10, and that over half of the children in their study demonstrated some ability to count backwards, suggesting that the majority of children enter school with higher than expected counting skills. Several researchers found that towards the end of preschool, children are able to count using units other than discrete physical objects (e.g., Shipley & Shepperson, 1990; Sophian & Kailihiwa, 1998). The National Research Council (NRC; 2009) suggested learning trajectories that were more advanced than current ECME research reports. For example, the NRC (2009) suggested that that two-to-three-year-olds can orally count from one to 10, and can count one to six items accurately. At the age of four, children can orally count from one to 39, count one to 15 objects in a row; five-year-olds can count orally to 100 by 10s or 1s, count up to 25 objects in a row, and understand that the teen numbers include 10 as the addend (e.g., 18 is 10 + 8).

Quantity comparison. Within the literature, the terms quantity and magnitude are both used to determine comparisons between two or more sets. For the purposes of this paper, the terms *quantity comparison* will be used to describe the ability to discern which collection of objects has more or less than another collection. A preschooler who understands quantity comparison is able to gauge that three dots is less than five dots, or that ten bears is a lot more than one bear. Identifying equivalent collections is fundamental to understanding about numbers (Baroody, 2000). However, there is a major language component for children to be able to express the difference in quantities. Understanding comparison terms, such as *bigger than, more than, greater than, smaller than, less than, and fewer than* are of great importance when children compare or relate two or more number values (NAEYC, 2009).

Researchers have suggested that infants can discriminate between two collections that vary in number (Antell & Keating, 1983; Bijeljac-Babic, Bertoncini, & Mehler, 1993; Huntley-Fenner, & Cannon, 2000; Lipton & Spelke, 2003; Starkey & Cooper, 1980; Wynn, 1992; Xu, Spelke, & Goddard, 2005). Yet the development of quantity comparison skills occurs around the age of three by children recognizing the equivalence between small collections of objects (Huttenlocher, Jordan, & Levine, 1994). Three-year-old children can compare small collections before they can count them (Baroody, 2000), and label collections of one to three items with the number word (NAEYC & NCTM, 2002). Case and Okamoto (1996) suggested that four and five year olds should be able to compare set sizes and to count small sets. Clements (1984) found that 51% of middle-class four-year-olds were able choose which set of objects included “more.” Kraner (1977) found that at five-and-a-half years of age, children could identify “more than,” and before entering kindergarten, children begin to link number words to quantity (Krajewski & Schneider, 2009). Quantity comparison skills that are mastered before kindergarten entry include (1) the comparisons of more-or-less of small quantities (Kaufmann, Handl, & Thöny, 2003), and (2) the meanings of words for “same,” “different,” and “more” (Baroody, 1987; Baroody & Ginsburg, 1982). Case et al. (cited in Phillips & Crowell, 1994) found that kindergarten children who were mathematically naïve when entering school were able to identify the “bigger group” and understood that the bigger group contained much more than the smaller group; however, they could not stipulate how much bigger one group was from the other. Interestingly, in comparing two sets, many children do not necessarily *count* objects in the two sets in order to compare them (Case & Okamoto, 1996; Curtis et al., 2009), possibly due to strategy choice, and limited processing or working memory (Curtis et al., 2009). Thus, some researchers (e.g., Griffin, Case, & Capodilupo, 1995; Griffin et al., 1994) have found success at teaching quantity comparison and counting independent of each other to lower-performing kindergartners.

Numeral identification. As letter identification is of importance to the alphabetic principle in emergent literacy, an important component of understanding mathematics and numbers is numeral identification (Copley, 2010). Children first recognize numerals as a symbol. Next, the child will connect a meaning to the numeral, and lastly children learn to write out the numeral. Clements and Sarama (2009) suggested that teachers should introduce numerals to children slowly, gradually, and within meaningful contexts, rather than the more traditional procedural methods which require little meaning and conceptual knowledge. This may be accomplished by creating a mathematically-rich environment with numerals and introducing numbers through contexts such as children's literature (Copley, 2010).

Basic addition and subtraction. Before entering school many children develop a spontaneous operational definition of addition and subtraction that they refine and extend over the preschool years (Griffin & Case, 1997; Huttonlocher, Jordan, & Levine, 1994). For example, Huttonlocher, Jordan, and Levine (1994) found that most three-year-old children could accurately solve simple addition and subtraction problems with low numbers, such as 1 + 1 or 2 – 1 by imagining adding one object to another or mentally subtracting one object from two objects, and by the age of four children could mentally solve these problems. Clements and Sarama (2009) suggested that four- and five-year-old children can learn that a whole is made up of smaller parts, eliciting an early basis of addition and subtraction**.** At the age of four, children can decompose and compose numbers six to 10 (NRC, 2009). Yet, these trajectories may vary when assessing children who are at risk for mathematical difficulties or children with disabilities. Baroody, Eland, and Thompson (2009) conducted a nine-month evaluation on the effectiveness of a pre-kindergarten number sense curriculum that first utilized manipulative and game based number sense instruction and then introduced computer aided mental arithmetic training with simple sums with at-risk preschoolers. The authors aimed to evaluate whether a curriculum could assist at-risk preschoolers in developing the relations of simple addition combinations. Baroody et al. found that when the prekindergarten children were not allowed to use objects to count, they struggled in simple addition combinations. This result was true for both children who did and did not master the developmental prerequisites for adding, suggesting that children have major challenges in shifting from concretely solving addition problems to mental addition. Thus, the authors suggested that number sense cannot be imposed on children, particularly for children at risk, and that interventions for at-risk preschoolers should focus on the prerequisites of addition, proceeding to concrete addition only after the prerequisites are mastered. After children achieve concrete addition, then instruction should continue to semi-concrete problems, and teachers should wait to work on mental arithmetic until the children are developmentally ready (Baroody et al., 2009).

Geometry and Spatial Sense

Understanding about shapes assists in cognitive development even beyond geometry (Clements & Samara, 2007b). Initially children typically learn about rigid, two-dimensional shapes, yet with exposure, young children can begin to widen their understanding and schema of shapes (Clements & Sarama, 2007b). Several researchers have reported on the order and age that children acquire shape names. There a consensus that children learn the shape name for circle first, between the years of three and five years of age, and the square between four and five years of age (Clements, Swaminathan, Hannibal, & Sarama, 1999; Fuson & Murray, 1978; Kraner, 1977). The acquisition of the rectangle and triangle shapes is learned between the ages of four and five years, although different children are reported to learn these two shapes in different orders (Clements et al., 1999a; Fuson & Murray, 1978; Kraner, 1977). Further, at three years of age, children begin using shapes separately to create pictures, can match 2-D and 3-D shapes, and describe object locations with spatial words, such as behind and under (NAEYC & NCTM, 2002).

Measurement

Measurement is a skill that is acquired between the skills of counting and knowledge of rational numbers, and may be a foundation of understanding fractions (Sophian, 2002). Measurement directly applies to real-world situations and bridges the realms of geometry and real numbers (Clements & Sarama, 2007b). Children begin expressing their understanding in measurement by using words such as “big, little, and tiny”, and comparing two objects directly by noting their equality or inequality, such as the length of two objects (Boulton-Lewis, Wilss, & Mutch, 1996). Next, children may learn to measure by connecting a number to the length of an object. Language abilities play a large part in the expression of measurement as understanding the difference between terms help children form relationships between counting and measurement (Huntley-Fenner, 2001).

Preschoolers may be developmentally ready to acquire measuring skills, such as understanding the mathematical relationship between unit size and number (Sophian, 2002). Sophian (2002) examined if three- and four-year-old children could make judgments regarding which objects would fit into a container, the smaller objects or the larger objects. After demonstration trials, the children’s judgments about size improved significantly, and the children figured out which objects could fit in to which containers based on size. Three-year-olds may begin to recognize and label concrete attributes to objects (e.g., the stick is long), and compare and sort attributes (NAEYC & NCTM, 2002). By the end of the kindergarten school year, the majority of children (88%) understand the concept of relative size (Denton & West, 2002). However, even though young children may have an intuitive understanding of length, they may experience difficulty mapping words (e.g., long), and using measurement to determine length. Thus, they know that properties of measurement exist and may be able to compare objects directly, but do not know how to use measurements to determine properties (Clements & Sarama, 2007b). According to current research and curriculum guides, measuring should include more than simply using a ruler to measure a pencil, for example; rather children should be acquiring a conceptual basis of measurement for understanding and procedures (Clements & Sarama, 2007b).

Algebra

Algebra for very young children consists of patterns, mathematical situations and structures, models of quantitative relationships, and change (NCTM, 2000). Patterns are the cornerstone of algebraic knowledge (Taylor-Cox, 2003), as these central algebraic concepts build foundations for later mathematical learning (Copley, 2010; Taylor-Cox, 2003). Although very young children are obviously not developmentally ready to learn formal algebra, concepts and ideas such as symbols, representation, patterns, sorting, and graphing can be introduced in the primary grades (Carpenter, Franke, & Levi, 2003; Mason, 2008). By the age of three, many children have been informally introduced to these concepts early in life and can typically recognize and imitate simple repeating patterns (NAEYC & NCTM, 2002). Children first encounter algebraic concepts, specifically patterns, in the home, in their environment, during play, and within stories

(Copley, 2010). One example of a pattern in a child's everyday life includes repeating series, such as day, night, day, night. For toddlers a pattern may be followed in music, movement, and rhythm, such as "clap, tap, clap, tap…" (Taylor-Cox, 2003). Four-year-olds may encounter patterning in block play, such as lining up a series of blocks in the pattern "green, red, blue, green, red, blue…" Patterning for four-year-olds may consist of both size and shape.

Data Analysis and Probability

Although data analysis should not be a focus of mathematical instruction in the early years, teachers may still facilitate concept knowledge in this domain by informally introducing concepts such as problem solving, reasoning, and representation (Copley, 2010). For example, three-year-olds are able to sort objects into groups, while focusing and describing the attributes of the objects (Clements & Sarama, 2007b). Three-year-old children may also be able to count and compare the formed groups of objects, and assist in making simple graphs with actual objects or pictures of objects (e.g., make a graph using actual apples or pictures of apples) (NAEYC & NCTM, 2002). In this domain teachers should focus on the idea of educating children to classify, organize, represent, and use information to ask and answer questions (Clements & Sarama, 2007b).

Mathematical Power

When children experience mathematical power, they exhibit a confidence in mathematics that can lead to undertaking challenging problems and a lifelong love of mathematics (Baroody, 2000). Mathematical power allows children to remember and apply mathematical concepts, and make more connections and efficiently learn new mathematical concepts (Baroody, 2000). Fostering children's mathematical power requires teaching with purposeful, meaningful, and inquiry approaches (Baroody, 2000), thus teaching mathematics within context (Donaldson, 1978; Hughes, 1986). According to Baroody (2000), the components of mathematical power include a positive disposition to learning and using mathematics, understanding mathematics, and developing the ability to engage in mathematical inquiry. Natural sources for incorporating mathematical power in the classroom include integrating children's literature within mathematics, playing mathematical games (Phillips & Anderson, 1993), and providing children with hands-on exploratory activities (Griffin, 2003).

Griffin (2003) suggested the following three instructional strategies to foster the development of mathematical knowledge and competence: (1) provide activities to expose children to quantities, counting numbers, and formal symbols and provide a variety of leveled (particularly complex and higher-order) opportunities for the construction of relationships between quantities, numbers, and symbols; (2) provide opportunities for active and social explorations as well as discussion of mathematical concepts; and (3) instruct and provide activities in a sequential manner for children to use their current understandings to construct new understandings at the next level.

Children acquire an impressive amount of informal math knowledge throughout their early years, even before formal schooling experience. However, children's math knowledge varies greatly at kindergarten school entry, due to a variety of reasons such as preschool experience, SES, and the home learning environment. The NAEYC and NCTM (2002) encourage educators to focus on the big ideas of mathematics: Number and Operations, Geometry and Spatial Sense, Measurement, Algebra, and Data Analysis and Probability, with a particular focus on number sense as it is a recognized indicator of later math achievement (Clements, 1999b; Groffman, 2009; Jordan et al., 2007; Robinson et al., 2002; Vukovic, 2012). Although these math concepts are often taught separately, they interconnect and work together in the acquisition of math proficiency.

Griffin (2003) described two schema structures that four-year-old children have available to them which are not yet connected, thus they can apply one or the other schema at any one time: (1) global quantity schema structure (e.g., which stack of chips has more or less), in which children begin to recognize and understand differences among quantities, and (2) a schema structure of initial counting (e.g., counting by touching objects while saying the number words) (Griffin, 2003). Griffin suggested that children do not yet use their initial counting schema to determine global quantity, as it appears these two schema structures are not quite neurologically connected.

Instructional Practices, Knowledge, Beliefs, and Attitudes of Early Childhood Mathematics Educators

Preschoolers spend much less classroom time engaging in mathematical activities than they do in literacy activities (Layzer, Goodson, & Moss, 1993; Phillips & Meloy, 2012). In homes and family child care centers, mathematics activities were ranked less important than social skills, language, and literacy (Blevins-Knabe, Austin, Musun, Eddy, & Jones, 2000); though parents and child care educators who provided children with the most literacy activities also provided the most mathematical activities (Blevins-Knabe et al., 2000). A recent longitudinal study on preschool quality showed strong positive impacts of preschool classroom quality on math achievement at the age of 11(Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2011); these effects are even stronger than literacy outcomes. The children who attended classrooms of low quality had non-significant mathematical outcomes at the age of 11, the same as if they stayed home during preschool years (Sylva et al., 2011). Anders et al. (2012) found that while the home environment is most important for numeracy skills at preschool entry, it is the preschool setting that shapes the child's further mathematical development.

Preschool math instruction is typically characterized by a narrow range of mathematical content, such as naming common shapes (Graham, Nash, & Paul, 1997) and rote counting to 20 (Ginsburg, Lee, et al., 2008), with minimal focus on conceptual counting, estimation, or the use of proper mathematical terminology (Frede, Jung, Barnett, Lamy, & Figueras, 2007). Yet, preschoolers are able to construct some abstract ideas and have impressive informal mathematical strengths (Baroody, 2000). Unfortunately, early childhood educators are not as comfortable teaching mathematics as they are reading and language skills, as early childhood educators consider mathematics more difficult to teach (Arias de Sanchez, 2010). It is possible that early childhood educators' fear of teaching mathematics is due to their perceived limited knowledge of mathematics (Graham et al.,1997), lack of preparation to teach mathematics (Hill & Ball, 2004; Ma, 1999), or negative attitudes regarding mathematics (Blevins-Knabe et al., 2000).

Ginsburg, Lee, and Boyd (2008) suggested six important components that should be included in early childhood mathematics education (ECME). First, preschool classrooms should be rich in objects and materials that elicit mathematical learning, such as blocks and puzzles. Not only is the physical environment important, but so too is what children do in the environment. Second, children should be able to play and explore in the classroom, to elicit independent learning of everyday mathematics. Third, teachers should take advantage of teachable moments in the classroom, by observing children's play and identifying situations that can be exploited to promote learning. Unfortunately, in many classrooms, teachers miss out on these opportunities and lack engagement with children at free play (Seo & Ginsburg, 2004). Many teachers do not appear to have enough knowledge in mathematics to recognize mathematical concepts in everyday situations (Moseley, 2005). Fourth, teachers should encourage children to engage in classroom projects, such as creating a classroom map (Katz & Chard, 1989), to elicit the mathematical skills of measurement, representation, or spatial concepts. Fifth, teachers should plan and organize for deliberate, intentional teaching of mathematics. Finally, an organized, research based math curriculum is an essential key component to guide all activities and projects (Ginsburg, Lee, et al., 2008; Linder, Powers-Costello, & Stegelin, 2011). In recent years, several curricula and programs in preschool math have been shown to have moderate to high effect sizes in improving the math achievement of young children (e.g., Balfanz et al., 2003; Casey, 2004; Clements & Sarama, 2007a; Ginsburg, Greenes, & Balfanz, 2003; Griffin, 2007; Klein & Starkey, 2002; Sophian, 2004; Starkey & Klein, 2000). These will be discussed later in the section on programs and curricula.

Math Interventions for Typically Developing Young Children

This section will provide an overview of various interventions used with children who are typically developing and children who are at risk for later academic challenges from preschool to third grade. Although researchers have found many predictors and indicators of later math achievement, there have been very few empirical studies on math development and math interventions documenting causal connections in young children (Arnold et al., 2002). Further, researchers have not yet clearly identified the most effective specific features of teaching for helping students develop math skills (Hiebert & Grouws, 2007). Though knowing the specific features of teaching that are the most effective would be useful, the effects of each teaching feature may depend on the system in which it functions, such as in a curriculum (Hiebert & Grouws, 2007). In a review of specific teaching features used in prior research studies that produced high effects, Agodini and Harris (2010) found that interventions that utilized teacher directed approaches such as explicit (Rittle-Johnson, 2006), and didactic (Hopkins, McGillicuddy-De Lisi, & De Lisi, 1997) instruction had positive effects for elementary-aged students, as did student-centered approaches (Fuchs, Fuchs, Finelli, et al., 2006; Muthukrishna & Borkowski, 1995) and peer tutoring such as PALS (Fuchs et al., 1997). Yet for very young children who are at risk for academic difficulties, mathematics should also be systematic (i.e., mastery of prerequisite skills before moving on) (Baroody et al., 2009). Mathematics interventions for typically developing children or children at risk have consisted of integrating mathematics within activities throughout the day (Arnold et al., 2002), as well as teaching mathematics through games (Ainley, 1990; Bjorklund, Hubertz, & Reubens, 2004; Burton, 2010; Cutler, Gilkerson, Parrott, & Bowne, 2003; Ernest, 1986; Gerdes, 2001; Pasnak, Greene, Ferguson, & Levit, 2006; Peters, 1998; Ramani & Siegler, 2008; Siegler & Ramani, 2008, 2009; Williams, 1986); play (Guha, 2002; Vandermaas-Peeler, Nelson, & Bumpass, 2007); peer tutoring (Fuchs et al., 2001); computer assisted instruction (Brinkley & Watson, 1987-88a; Burns, Kanive, & DeGrande, 2012; Clements & Nastasi, 1993; Fuchs, Fuchs, Hamlet, et al., 2006; Hungate, 1982; Kraus, 1981; McGivern et al., 2007); children’s literature (Anderson & Anderson, 1995; Anderson et al., 2004, 2005; Ginsburg et al., 2003; Hong, 1996; Jennings et al., 1992; Skoumpourdi & Mpakopoulou, 2011); family and home environment (Anderson, 1997; Anderson & Anderson, 1995; Anderson et al., 2004, 2005; Vandermaas-Peeler et al., 2007), and through developed programs and curricula (Clements & Sarama, 2007a; Ginsburg et al., 2003; Griffin et al., 1994; Klein, Starkey, Clements, Sarama, & Iyer, 2008; Starkey, Klein, Wakeley, 2004).

Activities Integrated throughout the Day

Arnold et al. (2002) evaluated a math program in Head Start settings with 112 at-risk children in eight classrooms. The teachers were trained in a six-week intervention to incorporate mathematics throughout the regular classroom routine. Teachers in the intervention group chose from the provided math activities, adapted the activities, or created their own activities based on their interests and style, as well as their students' abilities and interests. The first phase of the intervention began with three weeks of circle time math activities once per day. The second phase continued with the circle time activities and added math activities for small groups, transitions, and meal times. Teachers were encouraged to repeat preferred activities. The activity choices incorporated a variety of activities such as books, music, games, discussions, and group projects, with the targeted skills of counting, recognizing and writing numbers, one-to-one correspondence, comparison, change operations, and understanding numbers and quantities. Students' emergent math abilities were assessed with the *Test of Early Mathematics Ability, Second Edition* (TEMA-2; Ginsburg & Baroody, 1990); student interest was measured by teacher report on the Level of Interest Survey (LIS) rating scale, the Relative Interest Survey (RIS), the Overall Teacher Interest Survey (OTIS), and by child report on the Children's Math Interest Self-Report (CMIS), in which the children indicated how much they liked the activities. Teachers were asked to rate their attitudes regarding mathematics by noting to what level they consider teaching math readiness skills “fun,” and how well they taught mathematics in the classroom. All surveys and assessments were administered before and after the 6-week intervention. Results included improved emergent math skills compared with the control group and increased interest in math for students and teachers.

Games

Several authors have studied the use of games to improve children’s mathematical competencies and motivation (Ainley, 1990, Bjorklund et al., 2004; Burton, 2010; Cutler et al., 2003; Ernest, 1986; Gerdes, 2001; Peters, 1998; Williams, 1986). Games can provide a meaningful context to work on fundamental math skills (e.g., counting, addition, subtraction) (Ainley, 1990; Burton, 2010; Cutler et al., 2003), encourage children to understand the element of chance (e.g., games such as Go Fish), and allow children opportunities to communicate mathematically with their peers or teachers (Burton, 2010). Cutler, Gilkerson, Parrott, and Bowne (2003) described how playing mathematical games not only assists children in learning math skills through the natural context of playing games (e.g., one to one correspondence, counting dots on the dice, and spinners for number recognition), but may also create a natural and meaningful context to explore and communicate mathematical concepts and ideas.

Play

Though several studies have examined literacy skills in the context of play for young children, very few researchers have studied early numeracy skills within this context (Vandermaas-Peeler et al., 2007). Block play is often associated with later mathematics skills; however, in a study of 51 preschoolers (22 participants with disabilities), Hanline, Milton, and Phelps (2010) did not find a predictive relationship between level of block play and mathematical abilities of preschoolers. This notion is supported by other researchers who did not find a predictive relationship between preschool construction play and mathematics until children were of middle and high school age (e.g., Stannard, Wolfgang, Jones, & Phelps, 2001; Wolfgang, Stannard, & Jones, 2001), suggesting that the influence of block play on mathematical achievement is not evident until children are required to perform higher level abstract mathematics, such as geometry, trigonometry, and calculus (Hanline et al., 2010).

Peer Tutoring

There are several terms and definitions for peer tutoring, such as mediated instruction, peer learning, peer mentoring, and cooperative learning. The basic philosophy between all of these ideas is that children are working together and helping each other (Topping, 2005). A structured peer tutoring intervention is peer assisted learning strategies (PALS), in which higher achieving students tutor a student that requires more assistance in learning mathematics. The students are provided with a folder and scripted curriculum to follow based on grade level mathematics materials (Fuchs et al., 2001). According to two meta-analytic reviews of PALS interventions for elementary aged students, PALS interventions were most effective for younger (i.e., grades 1-3 rather than 4-6), urban, low-income, and minority students (Ginsburg-Block, Rohrbeck, & Fantuzzo, 2006; Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003). Fuchs et al. (2001) found that teacher-led implementation of PALS twice weekly for 15 weeks was effective in improving whole-number sense for many kindergarten students with and without disabilities. This study also indicated that although not all teachers followed the program with high fidelity, the effects of the study were reliable and showed that this program can be naturally implemented in the classroom. In a first grade PALS 16-week mathematics intervention, Fuchs, Fuchs, Yazdian, and Powell (2002) also found positive effects of PALS on mathematical development for children with and without disabilities. Student participants implemented PALS for 30 minutes, three times per week, in lieu of their daily teacher-directed mathematics instruction.

PALS has also been shown to be more cost-effective in improving mathematical scores of elementary school students than other instructional approaches, such as computer-assisted instruction, class size reduction, and instructional time (Levin, Glass, & Meister, 1987). It is suggested with this intervention, that the "helper student" does not necessarily need to be among the "best students" in the class or the most similar to the professional teacher, rather, the teacher arranges a helper with similar capabilities as the student who needs to be helped (Topping, 2005).

Computer Assisted Instruction

With nearly every elementary and preschool classroom in the United States having access to computers, researchers have shifted their focus from whether computers and technology are developmentally appropriate for children or if technology has value in the classroom, to how computers and technology can help young children make learning gains (Clements, 1995; Clements & Swaminathan, 1995). Not all computer software is created equal or results in academic success (Clements & Sarama, 2003). As many computer assisted instruction (CAI) programs focus on practice drills, the NCTM (1989) recommends that educators not focus solely on the rote practice and isolated facts, but rather emphasize problem solving, number sense, and patterning. It is suggested that drill and practice has a place in CAI, but only after children have mastered the conceptual understanding of the target skills (Hasselbring, Goin, & Bransford, 1988).

Although the large majority of research on CAI is with older elementary students (Fuchs, Fuchs, Hamlet, et al., 2006), researchers have utilized this modern-day technology to assist young children in learning mathematics, and have found positive effects and benefits for the use of CAI, including improved motivation of academic work (Clements & Sarama, 2003, 2008), as well as creative mathematical thinking (Clements, 1986, 1995; Clements & Sarama, 2003). CAI has been used to support children's competence in skills such as counting (Clements & Nastasi, 1993; Hungate, 1982; McGivern et al., 2007); sorting (Brinkley & Watson, 1987-88a; Clements & Nastasi, 1993); numeral identification (McGivern et al., 2007); geometric knowledge (Clements & Sarama, 1997); and addition combinations (Baroody et al., 2009; Fuchs, Fuchs, Hamlet et al., 2006; Kraus, 1981). Clements and Sarama (2009) suggested that there are different approaches of CAI programs, such as a computer management system that keeps track of child progress and instruction (e.g., *Building Blocks*), computer games, and computer logo environments (e.g., Turtle Geometry; Papert, 1980).

Baroody et al. (2009) evaluated discovery-learning CAI within a curriculum (*Everyday Mathematics)* with preschoolers in a Head Start setting. The authors attempted to help develop the students' addition and subtraction skills. The first phase of the curriculum consisted mostly of manual games, while the second phase consisted of computer instruction for approximately 30 minutes, three times per week for 10 weeks. At-risk preschoolers made significant gains on number sense with the *Everyday*

Mathematics curricula and intensive, targeted small group and individual tutoring. Yet, some goals for the study (e.g., teaching the number before *n* skill, which is the prerequisite for the *n* – 1 skill) had to be taken out, as the participants experienced confusion with the new skills before mastery of prerequisite skills (e.g., number after *n).*

Burns, Kanive, and DeGrande (2012) evaluated the use of a supplemental computer software program for at-risk third and fourth grade children to practice mathematics facts three times per week for eight to fifteen weeks on computational fluency. Compared to the control group that received much less time with the CAI, the intervention group experienced significantly larger gains in math fluency scores. McGivern et al. (2007) found that after an average of 27 twenty minute sessions over a 14 week period, children in Head Start classrooms that played a preliteracy and premath computer game improved their mathematics skills of number recognition and counting compared to children who did not have access to CAI.

Additional classroom benefits of the use of CAI include the ability of children to adapt and operate virtual manipulatives (Clements & Sarama, 2009). For example, in some programs, children can change the sizes, colors, and shapes of the computerized manipulatives, as well as create or use manipulatives that are not provided in the classroom. Further, whereas typical classroom manipulatives have to be broken down to clean up, a computer program may allow students to save their work and return to it another time. Researchers and teachers should note that using CAI may require additional time to teach the child to use the computer and/or program, particularly for young children from disadvantaged backgrounds who may have limited exposure to computers and/or particular programs.

Children's Literature

Researchers have found many benefits to integrating mathematics within children's literature. Children have been found to experience increased interest in mathematics and improve their mathematical knowledge in the areas of measurement (Van den Heuvel-Panhuizen, & Iliada, 2011; Whitin & Gary, 1994), geometry (Casey, Erkut, Ceder, & Young, 2008; Hong, 1996; Rosen & Hoffman, 2009; Skoumpourdi & Mpakopoulou, 2011), fractions (e.g., Conaway & Midkiff, 1994), estimation (e.g., Whitin, 1994), math vocabulary (Jennings et al., 1992), classification (Hong, 1996), and number combinations (Hong, 1996).

Skoumbourdi and Mpakopoulou (2011) provided typically developing kindergartners with a shared storybook reading with a researcher-made picture book and related activities. The authors found that the storybook and activity intervention assisted typically developing kindergarteners with improving their abilities to identify solid shapes and provide real-life examples of the plane figures. In a five-month-long intervention, Jennings, Jennings, Richey, and Dixon-Krauss (1992) found that after a storybook reading with an implicit mathematical focus and complementary activities, vocabulary skills and interest in mathematics improved in typically developing kindergarteners.

Similarly, Hong (1996) analyzed the effectiveness of using children's literature with complementary mathematics activities during free play with 57 typically developing kindergarteners. The students in the control group experienced a typical story time and were provided with opportunities to play with mathematical materials unrelated to their story. Hong found that the children in the experimental group spent more time in the math corner and chose to play with the mathematics materials during free play more than the children in the control group. The experimental group also experienced higher qualitative results in classification, number combination, and shape tasks. Geometry was also found to improve with a children's literature – mathematics integration curricula, *'Round the Rug* (Casey, 2004) when compared to hands-on activities alone.

The integration of literature with mathematics has also been used for improving kindergartener's performance of measuring length (Van den Heuvel-Panhuizen & Iliada, 2011). Within three months typically developing kindergartens were read eight stories addressing the concept of length using implicit teaching methods. Although the kindergartener's performance of length measurement improved, the effects were weak. The authors suggested the participants may have had better performance if the lessons had been taught more explicitly.

Family and Home Environment

For young children, there is some research examining children's exposure to prenumeracy skills in the home environment. Home environments and the significant adults in a child's life highly influence the children's mathematical knowledge (Anders et al., 2012; Aubrey et al., 2003; Blevins-Knabe & Musun-Miller, 1996; Melhuish et al., 2008), and the way children engage in mathematical experiences (Aubrey et al, 2003). Home mathematics interventions include play-based (Vandermaas-Peeler et al., 2007), and literature-based math interventions (e.g., Anderson, 1997; Anderson & Anderson, 1995; Anderson et al., 2004, 2005; Vandermaas-Peeler et al., 2007).

Vandermaas-Peeler, Nelson, and Bumpass (2007) observed videotaped sessions of twenty-six mothers who read a story to their 4-year-old children and then completed a

15-minute play activity related to a post office with accompanying materials (e.g., mailbox, mail carrier bag, cash register, scanner, play money, credit card). The parents were not informed that this was a study regarding mathematics. Results suggested that numeracy related parent-child interactions supported a cultural, conceptual, and procedural understanding of numeracy; however, much of the play was literacy-related, such as writing a letter. Similar to Anderson's (1997) study of documenting parent-child interactions integrating literature and mathematics, parents in this study initiated the majority of the numeracy interactions. Mathematical topics included concepts such as quantity, size comparison, buying, selling, and the market value of goods, with a lack of engagement in counting or adding.

Integrating literacy and mathematics has been noted as an intervention that families can use to promote mathematical knowledge with their children through shared storybook readings (e.g., Anderson, 1997; Anderson & Anderson, 1995; Anderson et al., 2004, 2005). Within the studies in the home environment, the mathematical concepts elicited through the integration of mathematics and literature included counting, and naming shapes and numbers (Anderson, 1997), as well as describing size, subitizing, and counting (Anderson et al., 2004). For example, Anderson, Anderson, and Shapiro (2005) evaluated parent-child dyads in reading a story, along with analyzing the mathematical discourse between the adult and child. The majority of families engaged in mathematical discourse when reading the researcher-chosen stories. Although the amount of discussion regarding math concepts varied greatly between dyads, the authors found that children's literature is a viable medium for parents to call attention to mathematical vocabulary and concepts.

Starkey and Klein (2000) noted that families are underutilized and educators should foster parental support to assist in achieving school readiness for young children at risk. In their study, Starkey and Klein found that parents of children in Head Start were willing and able to support their children's mathematical development when they were provided training.

Programs and Curricula

Other researched interventions include math curricula and programs which have positive effects as determined by scientific evaluation. Research based on these curricula and programs demonstrate that young children are able to improve and increase their math competence with adequate instruction (Griffin, 2003). Curricula specific for preschool mathematics include: *Pre-K Mathematics Curriculum* (Klein & Starkey, 2002), *Building Blocks* (Clements & Sarama, 2007a), *Big Math for Little Kids* (BMLK; Balfanz et al., 2003; Ginsburg et al., 2003), *'Round the Rug Math* (Casey, 2004), Measurement-based approach (Sophian, 2004), *Number Worlds* (Griffin, 2007), and the *Berkeley Maths Readiness Project* (Starkey & Klein, 2000). Additionally, the *High/Scope* curriculum (Hohmann & Weikart, 2002) is being updated and a version called *Numbers Plus* has a focus on numbers, but activities are also included that focus on shape, measurement, algebra (patterning), and data analysis.

The three federally funded curricula: *Pre-K Mathematics Curriculum*, *Building Blocks*, and *BMLK* are all similar in that they utilize multiple contexts to teach mathematics, such as small group and large group activities, contain professional development for the teachers, and are comprehensive in covering multiple domains in mathematics (e.g., number and operation, geometry, measurement, patterning). However, these curricula differ from each other in other ways. For example, *PreK Math* and *Building Blocks* include computer software, while *BMLK* does not. The evaluation of these curricula used different mathematical assessments as the outcome variable. *PreK Math* and *Building Blocks* both used assessments developed by the curriculum's developers, whereas *BMLK* used the mathematics assessment developed for the Early Childhood Longitudinal Study. When evaluated within prekindergarten and kindergarten low-income classrooms (e.g., Head Start), the three mathematics curricula resulted in moderate to large effects when compared with typical classroom curricula (e.g., *Creative Curriculum, High/Scope, Montessori*), with *Building Blocks* (Clements & Sarama, 2007a) and *PreK Math* (Klein & Starkey, 2002) resulting in the highest effects, followed by *BMLK* (i.e., 1.07, .55, .43 respectively) (see, Ginsburg, Lewis, & Clements, 2008).

The *'Round the Rug* curriculum (Casey, 2004), funded by the National Science Foundation, is a supplemental language-arts and mathematics curriculum designed to promote children's understanding of mathematical concepts such as patterning, geometry, measurement, and graphs. Teachers read the developer-written books that integrate story-telling with mathematics. This curriculum was evaluated for the mathematical domain of geometry, and the researchers found that story-telling and hands-on activities promoted greater mastery of geometry than hands-on materials alone. The Measurement-Based curriculum by Catherine Sophian consists of weekly activities for parents and teachers to complete with their three- and four-year-olds, with a focus on measurement. When used with two- to four-year-old children in Head Start centers, the curriculum had small positive effects by the end of the school year.

There are several published curricula and programs for typically developing elementary aged children. *Early Learning in Mathematics* (ELM; Chard et al., 2008) is a mathematics program designed to specifically enhance kindergartners' number sense. This program includes daily 30-minute lessons that incorporate activities among number and operations, geometry, measurement, and vocabulary. Chard et al. (2008) found positive effects for the students of the classrooms who utilized this program versus the comparison groups. Agodini & Harris (2010) noted that in an evaluation of four elementary school math curricula at the first grade level for students attending low socioeconomic schools, student math achievement was higher with the groups that used *Math Expressions* (Fuson, 2006) and *Saxon* (Larson, 2004) than the groups who received *Investigations* (Russell et al., 2006) and *Scott Foresman-Addison Wesley Mathematics* (SFAW; Charles et al., 2005) based on the math assessment developed for the Early Childhood Longitudinal Study – Kindergarten Class of 1998-99 (ECLS-K; West, Denton, & Germino-Hausken, 2000). However, it is important to note that with the Saxon curriculum, teachers spend approximately one additional hour per week on math instruction compared to the other curriculum areas.

Several interventions designed for young children incorporate the learning of mathematics within natural contexts, such as through play, games, and literature in classrooms or in the home. Other interventions for young children incorporated a more formalized instruction for mathematics such as computer assisted instruction, peer tutoring strategies, or through commercialized classroom curricula. All interventions showed positive effects for young children. An analysis of all interventions suggests that when children are provided with opportunities to explore mathematics in the classroom or home environment, children become more competent in mathematics.

Characteristics of Young Children with Math Difficulties and/or Disabilities

Children with mathematical difficulties (MD) are those struggling with mathematics for any reason, usually defined as those performing below the 35 percentile on standardized tests (Clements & Sarama, 2009), whereas a child with a mathematics learning disability (MLD) has a memory or cognitive deficit that interferes with his or her learning of mathematical concepts or procedures in one or more domain of mathematics (Geary, 2004). Children with math learning disabilities tend to have persistent math achievement scores at or below the 10^{th} national percentile (Berch & Mazzocco, 2007; Jordan, Hanich, & Kaplan, 2003; Jordan & Montani, 1997; Murphy, Mazzocco, Hanich, & Early, 2007). Geary, Hoard, Nugent, and Bailey (2012) suggested that approximately seven percent of students will have a math learning disability, and ten percent of children will exhibit persistent math difficulties. It is difficult to determine if a young child's difficulties are temporary or mild or if they will be persistent due to a cognitive or memory deficit (i.e., MLD) (NJCLD, 2006). Therefore, to be consistent with current literature, in this paper, MD will be used to describe any child who struggles with mathematics, and MLD will be used to describe children with a diagnosed specific math learning disability (Fuchs et al., 2012; Gersten et al., 2005).

Although research is unclear on the specific etiology of MD, we know that risk factors for MD in young children include (1) perinatal conditions (e.g., low Apgar scores, low birth weight, hospitalization in a neonatal intensive care unit, chronic otitis media resulting in intermittent hearing loss); (2) genetic or environmental conditions (e.g., family history of disability, prenatal exposure to drugs or alcohol, exposure to environmental toxins, limited language exposure, poverty); (3) delays in developmental milestones; and/or (4) delays in attention or behavioral skills (NJCLD, 2006). In contrast to typically developing peers, children with math difficulties may be characterized by difficulty in number sense tasks (e.g., counting, recognizing numbers, and connecting how numbers exist in the real world), a high frequency of procedural errors, difficulty in representation and retrieval of arithmetic facts, sorting and the logical organization of objects, difficulty with symbolic or visual representations or coding numerical information for storage capacity in their working memory, poor memory for numbers, inadequate use of strategies for solving math tasks, and deficits in generalization and transfer of new knowledge (Geary, 1993; Geary, Hoard, Byrd-Craven, & DeSoto, 2004; Geary et al., 2012; Goldman, 1989; Mercer, 1997; NCLD, 2006; Rivera, 1997; Shrager & Siegler, 1998; Siegler, 1988).

Some children with math difficulties do not acquire mathematical strategies as effectively as typically developing peers. For example, Siegler (1988) found that children who performed poorly on addition and subtraction problems have not acquired the “min” strategy of starting with the larger number rather than the smaller number when adding digits, such as 8 + 3, which is a strategy and predictor of early mathematics success. Learning a strategy, such as “min” is not easy to teach young children, as it requires a knowledge and understanding of numbers such as problem-solving strategies, verbal comprehension, and automaticity with facts (Gersten & Chard, 1999). Siegler (1988) suggested that teachers should provide students with MD additional or back-up strategies in mathematics. Children with MD have challenges generalizing strategy use and generalize strategies much more slowly than typically developing peers (Shrager & Siegler, 1998). Yet, it should be noted that because a child with MLD does not perform well on one mathematical skill does not mean that he is not proficient in other areas of mathematics (Dowker, 2004). For example, Temple (1991) found that a child who could accurately perform arithmetical calculation tasks could not remember number facts, while another child could remember the number facts, but could not perform the calculation procedures.

Although as a whole, children with disabilities experience lower math achievement and slower math growth than typically developing peers (Wei, Lenz, & Blackorby, 2012), math difficulties manifest differently within specific disabilities groups and with great variability between children (Clements & Sarama, 2009; Wei et al., 2012). For example, children with speech and language impairments (SLI) typically experience the least amount of math challenges when compared to other disability groups (Carlson, Jenkins, Bitterman, & Keller, 2011; Wei et al., 2012). In a longitudinal study of young children with disabilities from ages three to 10, Carlson, Jenkins, Bitterman, and Keller (2011) found that on the *Woodcock Johnson-III Applied Problems*, children with SLI had significantly higher means at the age of three than children with autism or developmental delays. The math achievement gap between the children with SLI and children with developmental delays continued at the age of 10, whereas children with autism caught up with peers with SLI by the age of 10. For all three of the disabilities mentioned, all students experienced growth, yet the rate of change in mathematics slowed down as the children got older (i.e., the rate of growth was 6% from ages 3 to 4, which decreased to 2% for ages eight to nine and nine to ten). In a 2012 study, Wei, Lenz, and Blackorby examined growth trajectories by disability category of children ages seven to 17, and found that children with autism grew much slower in mathematics than any other disability group.

Researchers have compared the mathematical growth between children with MLD and children with Mild Intellectual Disabilities (MID). A common finding is that children MLD out-perform children with MID in math achievement (Caffrey & Fuchs, 2007; Gresham, MacMillan, & Bocian, 1996; Parmar, Cawley, & Miller, 1994; Wei et al., 2012). For example, Parmar, Cawley, and Miller (1994) examined the differences in math abilities in children, ages 8 to 14, with MID and children with MLD. They found that when assessed on the mathematical domains of Basic Concepts, Listening Vocabulary, Problem Solving, and Fractions, children with MLD scored higher and exhibited greater growth than did age-equivalent peers with MID.

Baroody (1986) examined the counting abilities of children with intellectual disabilities (ID) (majority with Down syndrome) with a chronological age of 6 to 12 years and an average cognitive level of four-years. Baroody found that the group was heterogeneous in their counting abilities and strategies. Out of 11 children, the large majority of children exhibited difficulties with the stable-order principle. However, the majority of the students consistently used aspects of the cardinality rule, with the most success in using their fingers rather than objects for counting. Young children with Down syndrome typically exhibit mathematical difficulties with connecting one number word to the next in a counting sequence, known as auditory sequential memory. For example, Porter (1999) found that while children with Down syndrome could maintain one-to-one correspondence, they had difficulty producing a rote counting sequence correctly.

Another example of the variability between different disability groups includes students with diagnosed attention deficit hyperactivity disorder (ADHD). Students with ADHD generally attend to stimuli more frequently than peers without ADHD. Children with ADHD may have difficulty with attending, rehearsing mathematics facts and strategies, and attending to auditory processes (Clements & Sarama, 2009). They also tend to make more errors (Clements & Sarama, 2009). Thus, these students may exhibit challenges with multistep and/or complex problems, and may benefit from CAI (Ford, Poe, & Cox, 1993; Shaw, Grayson, & Lewis, 2005) and calculators (Berch & Mazzocco, 2007). Mazzocco (2001) examined whether five- and six-year-old children with neurofibromatosis type 1 (NF1), and five- to six-year-old girls with Turner syndrome or Fragile X syndrome exhibited indicators of MLD. All three disability types have previously been reported within research literature to have difficulties with mathematics (see, Mazzocco, 2001). After each child in the study completed a battery of psychoeducational and neuropsychological measures, the authors found that the girls with Turner syndrome and girls with Fragile X syndrome exhibited indicators of MLD, with a larger effect size for the females with Turner syndrome. The children with NF1 exhibited a more heterogeneous profile that was not necessarily suggestive of math learning disabilities.

It is well documented that children with traumatic brain injury (TBI) experience some degree of academic and/or language difficulties following the TBI (Vu, Babikian, & Asarnow, 2011).Vu, Babikian, and Asamow (2011) conducted a meta-analysis on the extent of the difficulties at the different times post-injury and at the different severity levels on academic and language outcomes for children with TBI. Vu et al. (2011) found that when compared to typically developing peers, children with mild TBI do not generally show deficits in the academic or language domains; children with moderate TBI exhibited variable outcomes which were dependent on the skills assessed and the time since the injury occurrence, with mild but persistent academic deficits. These children attained academic growth at the same rate of growth as peers, but did not catch up with peers, thus the achievement gap stayed relatively constant over time. Not surprisingly, children with severe TBI exhibited the largest deficits in language and academic outcomes, yet it is notable that although these students did not catch up with peers, they showed the most improvement in math, spelling, reading, comprehension, expressive language, and language pragmatics.

Children with selective mutism (SM) may appear to have deficits or difficulties in mathematics due to their lack of verbalization. SM is a disorder that may appear in the preschool years when the children may be first required to speak outside the home (Cunningham, McHolm, Boyle, & Patel, 2004; Steinhausen & Juzi, 1996). Although the etiology is not well understood (Nowakowski et al., 2009), children with SM have been found to have higher rates of expressive language difficulties, higher anxiety, and developmental delays (Kristensen, 2000; Steinhausen & Juzi, 1996). Nowakowski et al. (2009) examined the receptive language and academic abilities of children with SM (mean age of eight years) and children with high anxiety (mean age of 9.3 years), compared to community controls (mean age of 7.8). The authors found that the children with SM exhibited lower mathematics and language skills than typically developing peers, yet their scores were within an age appropriate receptive vocabulary and academic range, and there were no significant differences between the groups of children with SM, high anxiety, and the community controls. In a similar study by Cunningham, McHolm, Boyle, and Patel (2004), children with SM exhibited no differences in math, reading, and other academic domains from the community controls.

In order to remediate or prevent later mathematical difficulties, researchers and practitioners must know and understand the predictors and indicators of later math challenges in young children with disabilities. Two key indicators for later difficulties in mathematics include performance with early numerical skills and executive functioning (i.e., short-term and working memory).

One key indicator for later challenges in mathematics is difficulty with early numerical skills (Krajewski & Schneider, 2009; Vukovic, 2012), such as the concept of number sense (Jordan et al., 2007; Robinson et al., 2002; Vukovic, 2012). In order for children to complete higher level mathematical concepts such as subtracting using regrouping, children must first understand number sense to solve the problem. Unfortunately, many children never fully acquire number sense and yet they continue on, grade after grade, without the key foundation of mathematics (Gersten & Chard, 1999; Woodward & Howard, 1994). Griffin (1998) demonstrated that teachers could provide guided instruction in number sense to kindergarteners who exhibited deficits in abstract mathematical reasoning in order to develop an integrated schema centering on a mental number line to help students with addition and subtraction.

Another predictor of mathematical achievement in young children is central executive functioning, specifically working and short-term memory (Blair & Razza, 2007; Clark, Pritchard, & Woodward, 2010; English, Barnes, Taylor &, Landry, 2009; Geary, 2004; Geary et al., 2004; Gersten et al., 2005; Kleemans et al., 2012; Rasmussen

& Bisanz, 2011; Toll, Van der ven, Kroesbergen, & Van Luit, 2011; Vukovic, 2012; Welsh, Nix, Blair, Bierman, & Nelson, 2010). Executive functions include the higher control functions that regulate thinking and behavior (Toll et al., 2011), and are the routines responsible for monitoring and regulation of cognitive processes during complex cognitive tasks (Gilbert & Burgess, 2008; Miyake et al., 2000; Van der Sluis, De Jong, & Van der Leij, 2007; Zamarian et al., 2006). Toll, Van der Ven, Kroesbergen, and Van Luit (2011) compared the executive functioning skills of shifting, inhibition, and working memory of 227 first grade children to their mathematical achievement. Toll et al. found that the executive function skill of working memory was associated with lower mathematical achievement, whereas better-developed executive functioning skills provided preschool children with an advantage in math and reading that was maintained until third grade (Bull, Espy, & Wiebe, 2008). Bull and Scerif (2001) found that children with lower mathematical abilities had difficulty maintaining information in working memory, as well as switching and learning new strategies once a favored strategy was inhibited.

Executive functioning and working memory deficiencies appear to be associated with mathematics challenges for children with Fetal Alcohol Spectrum Disorders (FASD). For example, Rasmussen and Bisanz (2011) studied the performance of four-to-six-year-old children with FASD on the mathematical skills of applied problems and quantitative concepts, and the three components of working memory (i.e., visuospatial sketchpad: holding and manipulating visual-spatial information; phonological loop: maintaining and rehearsing verbal information; and central executive: attentional controlling system). The children with FASD showed deficits with both types of mathematical problems as compared to typically developing peers. The children with FASD experienced particular difficulty with phonological working memory and central executive working memory as they related to mathematics compared to typically developing peers. It is possible that the issue with working memory is maintaining information within the working memory, rather than the size of the working memory span (Murphy et al., 2007).

In summary, children who exhibit MD are those children who experience difficulties in math performance. Research is unclear on the specific etiologies of children with difficulties in mathematics, but risk factors may include perinatal conditions, genetic or environmental conditions, delays in developmental milestones, and delays in attention or behavioral skills (NJCLD, 2006). The characteristics of children who experience math difficulties include difficulties with number sense, high frequency of procedural errors, difficulty with retrieving math facts, difficulty with symbolic representations, and deficits in central executive functioning, generalization, and transfer of knowledge and strategies (Geary, 1993; Geary et al., 2004; Geary et al., 2012; Goldman, 1989; Mercer, 1997; Rivera, 1997; Shrager & Siegler, 1998; Siegler, 1988). We know through research that math difficulties manifest differently with a variety of primary disabilities such as autism, Down syndrome, FASD, and ADHD. This paper will now turn to math instruction and interventions for young children with MD.

Math Instruction for Children with Math Difficulties

Researchers have found that there is often a poor fit between the mathematics instruction and the learning abilities and characteristics of students with math difficulties (Baker, Kame'enui, & Simmons, 1998; Carnine, Jones, & Dixon, 1994). Carnine, Jones, and Dixon (1994) found that the rate of mathematics instruction can be too rapid for some students and may lack in sufficient explanation, activities, practice, and review. By instructing students too quickly or at inappropriate levels, teachers are not ensuring conceptual understanding of mathematical concepts before moving on to other skills (Baroody, 1987). Appropriate teaching, though, may prevent mathematical difficulties (Dowker, 2004). Formal instruction should build on a child's informal math knowledge and strengths at the appropriate academic level and pace in order to reduce gaps in learning and learning problems.

Often, special education mathematics instruction focuses on computation and instructing through repeated practice of math facts with limited opportunity for children to verbalize or communicate their reasoning and receive teacher feedback on the growth of their learning (Gersten & Chard, 1999). Procedural (i.e., knowing how to perform the task) and conceptual (i.e., understanding why) knowledge should be integrated (Baroody, 2003; Siegler, 1988) and learned together, as one may influence the other in learning and therefore encourage math proficiencies (Doabler et al., 2012). For example, understanding the correct procedure may help a child develop the understanding of the underlying concept (Rittle-Johnson & Alibali, 1999). Further, the generalization and transfer of newly learned knowledge may not occur until numerical and arithmetical knowledge becomes meaningful to the child (Kaufmann et al., 2003). For typically developing children, conceptual and procedural understanding for number combinations may be sufficient, as many typically developing children rely on memory-based retrieval of answers. However, a focus on conceptual skills alone will likely not result in efficient strategies for some children with MD. These children may require explicit, skill-based instruction on efficient strategies and intensive drill and practice (Fuchs et al., 2010).

As recommended by the NAEYC and NCTM (2002), young children should learn to communicate mathematical ideas. Teachers should provide frequent opportunities for children to verbalize and communicate their understandings, findings, and rationales for their strategies used in mathematics (Case, 1998; Griffin, 1998). Though the research is very limited regarding young children with disabilities, there are reports on how elementary-aged children with learning disabilities, attention deficit hyperactivity disorder, and severe motor disabilities successfully communicated their mathematical thinking in verbal and written forms (Borasi, Kort, Leonard, & Stone, 1993).

Several design principles of instruction may improve the quality of instruction for children with learning difficulties and include (1) focusing on the big ideas, such as prioritizing the most essential information, that are significant to the content learned (Carnine et al., 2004; Doabler et al., 2012); (2) pre-teaching requisite skills required for the understanding of new material (Doabler et al., 2012); (3) using conspicuous strategy instruction, such as teaching effective strategies that help students understand in the simplest way (Carnine, 1997); (4) making efficient use of time (e.g., abandoning low-priority objectives, easing into complex strategies, organizational tools) (Carnine, 1997); (5) giving clear and explicit instruction (Carnine, 1997; Hudson & Miller, 2006; Gersten et al., 2009; Kroesbergen & Van Luit, 2003; Lane et al., 2006); (6) providing appropriate practice and review (Archer & Hughes, 2010; Carnine, 1997; Hudson & Miller, 2006); (7) modeling, demonstrating tasks, and scaffolding instruction by supporting and facilitating the student's mathematical proficiency, such as the "I do it, We do it, You do it" approach where the teacher demonstrates the task first, the teacher guides the student in practice opportunities, and the teacher provides the student independent opportunities to perform the task (Archer & Hughes, 2010; Chard & Kame'enui, 1995); and (8) providing immediate corrective feedback (Doabler et al., 2012; Hudson & Miller, 2006). Gersten and Chard (1999) noted specifically that instruction for young children should promote understanding and development of number sense.

Math Interventions for Preschoolers and Early Elementary Aged Children with Disabilities

Young students with difficulties in mathematics typically require mathematics interventions (Kroesbergen & van Luit, 2003), and remediation has been shown to be effective (Fuchs et al., 2010). For example, Vukovic (2012) found that kindergarteners who exhibited low number sense and low phonological skills achieved rapid growth with mathematics intervention, suggesting the importance of intervention in early numerical skills. Remediation for children with MD can be efficacious, yet individual children may require different approaches to meet their needs (Fuchs et al., 2010). There is not one best way to improve mathematical knowledge with young children, due to the individual differences between children with disabilities (Gersten et al., 2005).

Interventions for Preschoolers with Disabilities

The large majority of preschool interventions for children with math difficulties were designed for children who are at-risk for academic challenges, such as children who come from lower socio-economic backgrounds (e.g., interventions described previously) (Dowker, 2004). There is a paucity of research on mathematics interventions specific to preschoolers with disabilities. The mathematics interventions that included preschoolers with disabilities utilized constant time delay (Daughtery et al., 2001) or self-instruction (Murphy et al., 1984).

Constant Time Delay. Daughtery, Grisham-Brown, and Hemmeter (2001) found positive results when embedding constant time delay (CTD) within classroom activities and routines to teach the targeted skill of counting. CTD is a controlling prompt that is systematically faded over time so that the stimulus control is transferred to the discriminative stimulus (Wolery, Ault, Gast, Doyle, & Mills, 1990). These authors also assessed the nontarget skill of color identification, by using the color as the antecedent before the number (e.g., give me one red block). A multiple-probe design across numbers replicated across children was used. The three preschool participants all exhibited speech and language delays and attended a half-day inclusive preschool program five days a week. The intervention consisted of the researcher asking the child to either give the researcher a certain number of objects from one to ten, or to name the number of objects from one to ten that she placed in front of the child. The method in which the child completed the task (e.g., verbal or receptive) was based on the child's speech and language abilities. Instruction began on the lowest number missed from one to ten. The number missed and the alternate numbers became the target numbers for each child (i.e., targeted numbers 3, 5, and 7 for two students, and 5, 7, and 9 for one student). Training for the students occurred within a 3-hour time period during the school day, with the students participating in eight trials per session. The three-hour session consisted of activities such as center time, small group, and meals or snack time. The researcher conducted the trials when the students were engaged in an activity that naturally provided an opportunity for counting, such as adding blocks to a tower in the block center. The delay interval was faded from zero seconds before prompting (e.g., visual or verbal prompts) to three seconds. The intervention was effective in teaching the target numbers to all three participants.

Self-Instruction Training. Murphy, Bates, and Anderson (1984) examined the effect of a self-instruction training sequence with nine preschool students with disabilities for the purpose of improving the preschoolers' ability to count a requested number of blocks from one to ten. The researchers used a four-step self-instruction program to teach the children. First, the researcher performed the task and used overt self-instructions while the student observed for the first day. Then the student performed the task under the overt directions of the researchers on days two and three while on the next three days, the student performed the task while overtly self-instructing with occasional prompting by the researcher. On the final four days of training, the student performed the task while being encouraged to use a quiet voice and lastly, using private speech. After a multiple-baseline analysis, the authors found that eight of nine students improved their accuracy in counting objects with generalization to functional objects and maintenance at a six-month follow-up assessment.

Interventions for Early Elementary Students with Math Difficulties

The research literature on children ages five through eight with math difficulties outlines clear instructional patterns that are effective for this population: explicit, systematic, and direct instruction (see, Bryant et al., 2011; Gersten et al., 2009;

Kroesbergen & Van Luit, 2003). In a meta-analysis of 58 studies of mathematics interventions for elementary students with disabilities, Kroesbergen and van Luit (2003) found that students with MD perform better with instruction from an adult or teacher, rather than a peer tutor or through computer software. Kroesbergen and van Luit (2003) found the most influential aspects of mathematics interventions included the duration of the intervention, and the method of the intervention, specifically Direct Instruction (for basic math facts) and self-instruction (for problem-solving skills). The majority of the studies in the meta-analysis focused on the basic skills of math instruction, rather than preparatory mathematics and problem solving. Of those three domains, the interventions that focused on basic skills were the most effective.

When developing interventions for students with MD, Bryant et al. (2011) suggested that interventions should include small group instruction, engaging activities, and systematic instruction for the development of conceptual knowledge and procedural fluency, sufficient time for students to understand mathematical concepts and operations, and possibly supportive coaching for the teacher. For young children with developmental dyscalculia, it was suggested that explicit teaching of basic numeracy skills, as well as the conceptual knowledge of these skills, are key features of an intervention program (Kaufmann et al.,2003).

The large majority of interventions for students with MD have examined the use of small group tutoring (Bryant, Bryant, Gersten, Scammacca, Chavez, 2008; Bryant, Bryant, Gersten, Scammacca, Funk, et al., 2008; Bryant et al., 2011; Fuchs et al., 2012; Fuchs et al., 2005), peer tutoring strategies (Fuchs et al., 2001), computer assisted instruction (Fuchs, Fuchs, Hamlet, et al., 2006; Seo & Bryant, 2012), simultaneous prompting (Akmanoglu & Batu, 2004), and programs or curricula (Avant & Heller, 2011; Scott, 1993; Simon & Hanrahan, 2004; Van Luit & Schopman, 2000).

Small Group Tutoring. Current research has shown the promising effectiveness of small-group tutoring for children with MD (Fuchs et al., 2012). Tutoring associated with positive student outcomes typically consists of explicit instruction, conceptual and procedural understanding instruction and, efficient strategy instruction, while embedding regular, strategic, and cumulative practice (Fuchs et al., 2012). This strategy has been used with literacy for years, but has not been used as often for mathematics (Burton, 2010). Small group instruction is an essential component within the response to intervention (RTI) framework, a tiered intervention approach designed to prevent academic difficulties and enhance validity of the identification of learning disabilities (Fuchs & Vaughn, 2012). Within the RTI framework, teachers should utilize small group interventions for students who do not respond to the universal teaching strategies. In fact, it was proposed by Ball and Trammell (2011) that within the preschool RTI framework, small group instruction be incorporated within tier one (i.e., universal tier) instruction, as part of the everyday classroom routine, such as center time, suggesting that small group instruction become a regular part of the day. It was proposed that small group instruction would provide all students with intensive instruction, as well as supplementary support leading to increased direct instruction and engagement in academic tasks (e.g., Gettinger & Stroiber, 2007). Small group teaching allows for better communication between peers and teachers, along with more personal attention from the teacher, tailored instruction to specific needs or learning styles, and informal assessment of the students mathematical understanding (Burton, 2010).

Fuchs et al. (2005) examined the effects of small group tutoring on first grade students at risk for mathematical difficulties using a program named *Number Rockets* (Fuchs et al., 2005). These students received small group tutoring three times per week for 16 weeks. The tutoring session was divided up with 30 minutes devoted to numeracy concepts and 10 minutes to addition and subtraction facts using computer assisted instruction (CAI), focusing specifically on number concepts and operations. The students in the treatment group performed significantly better than did those in the comparison group on concepts and applications and story problems. For the addition and subtraction fact fluency, both groups scored comparably. This study was extended by Rolfhus and colleagues (2012) by increasing the number of schools to 76 schools in four districts in four states. Rolfhus et al. (2012) also extended the type of tutors by employing tutors with a range of experience from the local community, provided additional professional development, and included the use of the *Test of Early Mathematics Achievement-3* (TEMA-3; Ginsburg & Baroody, 2003) because of the broad measure of mathematics achievement the TEMA-3 assesses. Rolfhus et al. found that the at-risk students benefited from the use of *Number Rockets* intervention, with statistically significant higher performance on the TEMA-3.

Bryant, Bryant, Gersten, Scammacca, and Chavez (2008) examined the effects of small group mathematics booster lessons focusing on number concepts and operations for three to four days for 15 minutes per session for 18 weeks for first and second graders. Results did not show significant effects for the first graders, though the students' small group performance indicated that they understood the target concepts. The authors proposed that the reason for the lack of significance was due to lack of time to practice.

There were significant effects for the second grade participants. In a follow-up study, Bryant, Bryant, Gersten, Scammacca, Funk, et al. (2008) designed a similar booster lesson as the prior study, however this study only included first grade students and consisted of 20-minute sessions four days per week for 23 weeks, five weeks longer than the previous study. The authors increased the duration of the intervention by five minutes and refined the lessons from the prior study. Significant positive program effects were found for the first grade intervention using explicit, strategic instruction in number sense tasks and arithmetic combinations.

Bryant et al. (2011) examined tier two RTI interventions that focused on conceptual, strategic, and procedural knowledge of number and operations, including problem solving for first grade students who struggle in mathematics. The treatment group participated in 25 minute tutoring sessions for 4 days per week across 19 weeks resulting in significantly higher achievement scores as demonstrated on progress monitoring measures in number sequences, place value, and addition and subtraction combinations. The authors attribute the significant effects to increased length in tutoring sessions, carefully constructed problems with multiple and visual representations, and purposeful meaningful practice.

Peer Tutoring. Peer tutoring is an intervention that has been examined for improving children's math skills. Peer tutoring consists of children role-taking as either the tutor or the tutee, focusing on specific content and guided to interact and tutor each other (Topping, 2005). Peer Assisted Learning Strategies (PALS) is a researched-based example of peer tutoring. As previously discussed, PALS is another strategy used to improve mathematics skills for children with and without disabilities. In this strategy, children are paired based on ability and they reciprocate tutoring roles while increasing opportunities to respond using a specific curricula (McMaster, Fuchs, & Fuchs, 2007). In the same study as previously discussed with typically developing peers, Fuchs et al. (2001) found that teacher-implemented PALS effects were strong for kindergarten children with disabilities, exceeding the mean growth of their typically developing peers. Results of several meta-analyses, though, have found that this strategy was not as effective as direct, explicit instruction for students with disabilities (Butler, Miller, Lee, & Pierce, 2001; Kroesbergen & Van Luit, 2003). According to a research synthesis on peer mediated interventions, the interventions with elementary students average moderate effect sizes (i.e. .57), with the effect size higher for students at risk than for students with disabilities (Kunsch, Jitendra, & Sood, 2007).

Computer Assisted Instruction. Fuchs, Fuchs, Hamlet, et al. (2006) evaluated CAI with first graders at risk for concurrent learning disabilities in mathematics and reading to enhance arithmetic number combination skills. Thirty-three first graders were randomly assigned to one of two conditions: math CAI (n = 16) or spelling CAI (n = 17). The students participated with the CAI (referred to as math FLASH or spelling FLASH) for fifty 10-minute sessions over 18 weeks. Fuchs, Fuchs, Hamlet, et al. (2006) found significant effects on addition number combination skills, but not subtraction combination skills, which the authors contribute to a methodological limitation of the students having fewer opportunities to practice the subtraction during the CAI. Second graders who used a mathematics computer program reviewing missing addend addition programs for approximately an hour (total) over a 2-week period experienced significantly more success and proficiency on basic addition facts than children who played a general computer program (i.e., Hangman) (Kraus, 1981). The experimental group responded correctly to approximately twice as many problems as the control group on a basic math facts speed test.

Seo and Bryant (2012) evaluated a CAI program, *Math Explorer,* with 2nd and 3rd graders with MD, for enhancing one-step addition and subtraction word problem-solving skills, resulting in positive findings for solving the word problems with the CAI. This program implemented explicit step-by-step instructional modeling of cognitive and metacognitive strategies, guided and independent practice sessions, and representational tools. However, similar to peer mediated learning, several reviews of literature have found that CAI was not as effective as direct, explicit instruction for students with disabilities (Butler et al., 2001; Kroesbergen & Van Luit, 2003).

Simultaneous Prompting. Simultaneous prompting has been used to teach children with autism (ages 6 to 17) to point to numerals (Akmanoglu & Batu, 2004). Simultaneous prompting is when a teacher presents a controlling prompt (i.e., a prompt that ensures a correct response) at the exact same time as the stimulus being taught (i.e., simultaneously). In a multi-probe design across behaviors, Akmanoglu and Batu (2004) found that when using simultaneous prompting, the individuals with autism acquired, maintained, and generalized numeral identification of the numerals one through ten.

Programs and Curricula. Several programs have been designed specifically for students with disabilities in mathematics. Van Luit and Schopman (2000) evaluated the Early Numeracy Program with 124 Dutch kindergartners with special needs; half of the participants were assigned to the intervention group with the other half assigned to the comparison group. The Early Numeracy Program consists of 20 lessons with instructional plans and activities to assist children in learning to count one through 15. For six months, the intervention group participated in the program for two half-hour sessions per week in groups of three outside the classroom. The intervention group received no other math instruction in the classroom, while the comparison group participated in a standard mathematics curriculum. The program utilized methods such as strategy training including explanations for using certain strategies; connections with the child's prior knowledge; and repetition, organization, and realistic problems to make the content more meaningful for the student. With a variety of materials, the instruction alternated between concrete, semi-concrete, and abstract representations of objects. Data were analyzed by using *t* tests. Results indicated that the treatment group experienced a significant improvement in early numeracy, including comparison, using number names, counting, and a general understanding of number based on the *Utrecht Test for Number Sense* (Van Luit, Van de Rijt, & Pennings, 1994) as compared to the control group. Yet, no difference was found in the transfer of learned strategies, which the authors contribute to the lack of explicit instruction in this area.

Touch Math (Bullock, Pierce, & McClelland, 1989) is a multi-sensory mathematics program designed for children with disabilities, using the visual, auditory, and tactile modes, combined with a counting technique to teach mathematics operations. The students are taught to touch designated spots on a written numeral card while counting each spot (e.g., the numeral 4 has four touch spots). This program has been evaluated by researchers to evaluate different aspects of addition and subtraction with students with disabilities with positive results (e.g., Avant & Heller, 2011; Pupo & Hanrahan, 2000; Scott, 1993; Simon & Hanrahan, 2004). Scott (1993) evaluated the use of *Touch Math* with three elementary students with mild disabilities (i.e., learning disabilities and intellectual delays) using the counting technique for addition and subtraction problem. Using a multiple-probe design across math skills, results included significant gains in acquisition of the target skills, as well as maintenance of mastery skills and generalization of novel math problems. In an evaluation of *Touch Math* on basic addition skills with eight-year-old children with mild intellectual disabilities, Calik and Kargin (2010) found that students were able to improve basic summation skills within ten sessions through direct instruction, modeling, and immediate corrective feedback. All three students maintained the math skills and the participants' teachers found *Touch Math* to be a socially valid program in the classroom.

Avant and Heller (2011) examined *Touch Math* with three early elementary students with physical disabilities (i.e., 1st grader who had a prior stroke as the result of an arteriovenous malformation, a 2nd grader with spina bifida, and a 3rd grader with cerebral palsy) on the ability to complete sums to 20 and generalize the use of *Touch Math* from a one-to-one setting to their regular math class. Using a multiprobe multiple baseline design, all three students were able to improve computation skills by completing basic sums to 20 and generalizing the strategies to their regular math class.

Consensus for effective interventions and instructional strategies for children with disabilities is that instruction must be explicit, direct, and systematic. Interventions that have shown positive effects for children with disabilities include small group instruction, commercialized programs, peer tutoring, simultaneous prompting, and CAI. Concurrently, educators are encouraged to include more conceptual knowledge, as well as procedural knowledge in math instruction for children with disabilities. Moreover, with the current focus on educating children with disabilities in classrooms with typically developing peers, it is of importance to consider interventions that can be implemented in the general education classroom.

Connection between Language, Literacy, and Mathematics

Several researchers have noted the relationship between mathematics and language and literacy. These two content areas are related from the very early years of childhood (McClelland et al., 2007; Welsh et al., 2010), and are predictive of each other in later years (Duncan et al., 2007; Juel, 1988). It may even be possible that the two domains assist in the development of each other (Purpura, Hume, Sims, & Lonigan, 2011), as children who have difficulties in one domain will likely have difficulties in the other domain (Barberisi, Katusic, Colligan, Weaver, & Jacobsen, 2005). Yet, the relationship between the specific components of emergent literacy, language, and early numeracy and how they influence each other is still unclear within the literature (Purpura et al., 2011).

The Influence of Language with Mathematics

Ginsburg (1989) suggested that mathematics education is also education in language and literacy. The development of language skills affects mathematical development, as children are unable to complete the mathematical tasks if they do not understand the language behind the task. Although Campisi, Serbin, Stack, Schwartzman, and Ledingham (2009) did not find a correlation between at-risk preschool children's language and later math abilities, language is a necessary component in expressing and justifying mathematical thinking, and becomes more complex as children begin learning the symbols of mathematics, such as +, -, or = (Ginsburg et al., 2008). The language and literacy components that appear to have the highest correlation with mathematical skills include the child's vocabulary, phonological processing, phonological awareness, and the verbal language of the classroom environment.

In order to complete math tasks, children must be able to understand the foundational vocabulary of mathematics (e.g., more, less, as many, alike, different, first, last, whole, around, above, below), as the understanding of these words is not only necessary for the skills of equality, addition, and subtraction (Padula & Stacey, 1990), but for language development, as well (Balfanz et al., 2003). The semantics of mathematics can become increasingly complex as many terms are used interchangeably (e.g., plus, add, together) (Purpura et al., 2011). Kraner (1977) found that math skills may be further compromised by language (i.e., vocabulary) as quantitative concepts are mastered 12 months after the acquisition of the vocabulary of that concept (Kraner, 1977). Another example of how vocabulary affects mathematics includes Bruce and Threlfall's study (2004) in which preschoolers were found to establish the cardinal aspects of number before ordinality, partly due to the vocabulary of the positional words.

Math and language are not only linked in vocabulary and semantics, but in phonological processing, as well. Although the relationship between phonological processing and mathematics is not well understood, researchers agree that phonological processing influences mathematics (e.g., Hecht, Torgeson, Wagner, & Rashotte, 2001; Jordan, Kaplan, & Hanich, 2002; Simmons & Singleton, 2008). For example, Vukovic (2012) found that phonological processing and early numeracy skills helped explain the mathematical growth and achievement of young children, and weak phonological processing underlies learning difficulties of children with a combination of math difficulties and reading difficulties (Robinson et al., 2002).

The language in mathematics is also evident in a study conducted by Klibanoff, Levine, Huttenlocher, Vasilyeva, and Hedges (2006) on teachers' math talk. Klibanoff et al. (2006) measured preschool students' math achievement in the fall and spring of one school year, and observed and audio-taped a 3-hour class session in the winter. Participating teachers were unaware of the specific purpose of the study. Klibanoff et al. discovered that the amount of teacher math-related talk was significantly related to the students' mathematical knowledge and performance over the course of the year.

Reading Difficulties and Mathematics

Although less is known regarding the relationship between literacy and mathematics (Vukovic, 2012), researchers have found a link between early literacy and early mathematical development (Duncan et al., 2007; Hecht et al., 2001; Hooper, Roberts, Sideris, Burchinal, & Zeisel, 2010; Lee, Ng, & Ng, 2009). Children who exhibit learning disabilities in mathematics typically exhibit poor reading skills (Geary, 1993; Geary et al., 2012; Jordan et al., 2003), as correlations between the math and reading scores average approximately .60 in elementary school and adolescence (Hecht et al., 2001; Lee et al., 2009). In fact, researchers have found that between 57% and 64% of children with math learning disabilities will have disabilities in reading (Barbareski, Katusic, Colligan, Weaver, & Jacobson, 2005). Gersten, Jordan, and Flojo (2005) suggested that the presence of reading difficulties (RD) appears related to slower mathematical progress. Children with math difficulties along with reading difficulties (MD/RD) experience more severe math difficulties (Geary, 1993) and slower mathematical development (Jordan et al., 2003) than do children with MD alone. The distinction between children with MD alone and MD/RD is apparent as young as five years of age, when children with MD/RD show core deficits in number sense tasks such as number knowledge, counting, and arithmetic (Clements & Sarama, 2009). Children with MD/RD have difficulties particularly with memorizing math facts, completing multistep calculations, and understanding word problems, whereas children with MD only generally have difficulty with conceptual mathematical concepts (Pennington, 1991). Having MD without RD is advantageous for the development of math skills. For example, students with MD only use more efficient counting strategies (Geary et al., 2000; Geary et al., 2007; Jordan & Hanich, 2000) and perform better on untimed number combination tasks (Andersson & Lyxell, 2007; Hanich, Jordan, Kaplan, & Dick, 2001; Jordan & Hanich, 2000; Jordan & Montani, 1997) than do children with MD/RD. The unique characteristics between MD/RD and MD alone demonstrate the complexities of the relationship between mathematics and language and literacy.

Interestingly, phonological awareness, regarded as a necessary component for emergent reading, has been found to be a significant predictor of mathematics skills for elementary children with MLD (Bryant, MacLean, Bradley, & Crossland, 1990; Wise et al., 2008). More recently, Purpura, Hume, Sims, and Lonigan (2011) found that preschoolers' vocabulary and print knowledge skills were uniquely predictive of later mathematical achievement, not phonological awareness. Although phonological awareness was correlated to later numeracy skills, the predictive relationship was accounted for by vocabulary and print knowledge. Krajewski (2008) hypothesized that the reading and mathematics relationship is based on the application of the phonological awareness principle to learning the words in a number sequence in the basic levels of mathematics (Krajewski, 2008; Krajewski & Schneider, 2009).

Integrating Mathematics within Literature in Early Childhood

Integrating mathematics within literature has been effective in improving the math abilities of young children. This section will give an overview of the benefits of integrating mathematics within literature, the empirical research on integrating mathematics within children's literature, types of children's literature that can be used for this type of intervention, and methods for incorporating mathematics within literature.

The Benefits of Integrating Mathematics within Literature

Over two decades ago, NCTM (1989) published the Curriculum and Evaluation Standards for School Mathematics calling for a vigorous reform in mathematics instruction, and urging educators to make mathematics instruction meaningful to students and to encourage students to be active learners. The 2000 publication of the Principles and Standards for School Mathematics (NCTM) continued to urge educators to encourage active learning in mathematics. Using children's literature for teaching mathematics can provide children mathematical experiences based on problems and situations of interest to students (Haury, 2001), and allows opportunities for children to actively construct mathematical ideas and promote critical thinking by providing a forum for teachers and students to ask questions, elicit discussion, and make personal connections (Anderson et al., 2004; Hoffman, 2002; Murphy, 2000; Whitin, 2002). This intervention offers a way to naturally construct mathematical knowledge (Ojose, 2008), rather than using a skill or drill approach to teaching. Integrating mathematics within literature holds promise for children to be actively engaged learners (Hoffman, 2002), and improve math abilities. In addition, when teachers teach mathematics through children's literature, they are teaching math in meaningful and contextual ways, making connections between content areas, increasing levels of motivation, and encouraging communication of math knowledge (Hoffman, 2002).

Putting mathematics into a meaningful context. Haury (2001) suggested that the key reason behind connecting literature and mathematics is to provide students with a context. Without providing a context for children to learn math, instruction may be reduced to simply paper and pencil arithmetic. Providing a context for learning mathematics helps children realize that mathematics is a natural and necessary aspect of our world (Anderson et al., 2004; Haury, 2001; Jacobs & Rak, 1997; Melser & Leitze, 1999; Padula & Stacey, 1990; Whitin & Wilde, 1992). Teaching mathematics within a context demonstrates to children how mathematics is applied in the real world (Braddon, Hall, & Taylor, 1993). Students may also then be more engaged in mathematics (Zazkis & Liljedahl, 2009) by making the learning more meaningful and creating personal connections, which in turn may improve behavior during mathematics (Hoffman, 2002).

Integrating content areas. Integrating content areas is encouraged by the NCTM (2000). Merging the content areas of mathematics with literacy encourages the developmentally appropriate practice of integrating content areas (Anderson et al., 2005; Hong, 1996; NAEYC, 2009; Zazkis & Liljedahl, 2009), particularly important when working with young children. The integration of mathematics within literature may be a promising intervention for not only increasing mathematical knowledge in young children, but enhancing emergent literacy and language skills, as well (Ojose, 2008; Whitin & Whitin, 2004). Another advantage of integrating mathematics within literature is that children may begin to build their confidence in both subject areas instead of focusing on their strengths and weaknesses by subject area (Thrailkill, 1994), and may develop positive attitudes towards mathematics (Griffiths & Clyne, 1991). This integration may ease anxiety towards mathematics, as well as promote the enjoyment of children's confidence in mathematics (Schiro, 1997, see pg. 2; Zarkis & Liljedahl, 2009).

Increasing student interest and motivation. Creating academic interest was documented as the most important problem in education (O'Flahaven et al., 1992), and early interest in mathematics is an important predictor of later skills (Crain-Thoreson & Dale, 1992; Manning & Manning, 1984; Scarborough, Dobrich, & Hager, 1991; Stipek & Ryan, 1997; Thomas, 1984; Wells, 1985). The mathematics-literature connection motivates students (Jennings et al., 1992; Usnick & McCarthy, 1998; Zazkis & Liljedahl, 2009) by making the content meaningful, as well as provoking interest, as many storybooks are geared towards the interest areas and contexts to engage children (Arnold et al., 2002; Hong, 1996; Jennings et al., 1992; Welchman-Tischler, 1992).

Communicating about mathematics. Integrating mathematics into literature allows for the natural communication regarding mathematics as mathematical concepts are presented as words, not numbers (Hoffman, 2002). This integration may foster communication, problem solving (Harland, 1990), reasoning, mathematical thinking, critique, and comparisons and contrasts regarding mathematics (Ducolon, 2000). From children's responses to questions and discussion regarding the literature, teachers are able to learn about children's reasoning and understanding regarding mathematical content (Lewis, Long, & Mackay, 1993). The literature itself allows for mathematical discourse and conversations between the adult and child (Van den Heuvel-Panhuizen & Van den

Boogaard, 2008; Anderson et al., 2004), which assists learners in better understanding of the mathematical concepts. Teachers may also elicit communication in mathematics by using books that require problem solving tasks and by choosing literature that promotes stimuli for thinking, listening, and speaking about mathematics (Lewis et al., 1993).

Empirical Research on Integrating Mathematics within Literature

Empirical research supports the premise that mathematics can be effectively integrated within children's literature (Anderson & Anderson, 1995; Balfanz et al., 2003; Jennings et al., 1992; Hong, 1996; Skoumpourdi and Mpakopoulou, 2011; Van den Heuvel-Panhuizen & Iliada, 2011). There are an increasing number of empirical studies of literature-based mathematics, yet there is a lack of notable published studies using this approach with students with disabilities. Researchers have examined the integration of literature and mathematics as a vehicle for teaching mathematical concepts, such as introducing manipulatives (Anderson et al., 2004); counting (Anderson, 1997; Anderson et al., 2004); measurement (Van den Heuvel-Panhuizen, & Iliada, 2011; Whitin & Gary, 1994); geometry (Anderson et al., 2005; Hong, 1996; Rosen & Hoffman, 2009; Skoumpourdi & Mpakopoulou, 2011); fractions (Conaway & Midkiff, 1994); estimation (Whitin, 1994); mathematical vocabulary (Anderson, Anderson & Shapiro, 2004, 2005; Jennings et al., 2002); classification (Hong, 1996); numeral identification (Young-Loveridge, 2004); number sequence (Young-Loveridge, 2004); mathematical discourse (Anderson & Anderson, 1995); problem solving (Anderson & Anderson, 1995); and to introduce mathematical vocabulary (Anderson et al., 2005; Griffiths & Clyne, 1991; Satariano, 1994; Welchman-Tischler, 1992).

Researchers have examined the effects of integrating literacy and mathematics with young typically developing children in the home environment (e.g., Anderson & Anderson, 1995; Anderson et al., 2004; Anderson et al., 2005), as well as in classroom environments (e.g., Hong, 1996; Jennings et al., 1992; Skoumpourdi & Mpakopoulou, 2011). In the home environment, Anderson and Anderson (1995) found that mathematical learning could be supported and mediated through shared storybook readings with a preschool aged female. The authors noted that while the book served as a context for mathematical concepts, shared storybook reading provided opportunities for engagement in mathematical discourse through parent-child interaction, and mathematical behaviors such as demonstrating, sharing, and exploring mathematical ideas and concepts (e.g., reasoning, patterning, problem solving). Anderson et al. (2005) studied parents who read two children's literature books with implicit mathematical foci to their typically developing four-year-old children. These authors found that all but one of the 39 families engaged in mathematical talk throughout the story. The concepts of size and number were the most frequent mathematical topics to arise within the reading while concepts of shape occurred infrequently. These authors concluded that shared storybook reading holds potential as a platform for children to naturally learn mathematical vocabulary and concepts. In a similar study, Anderson, Anderson, and Shapiro (2004) reported that of four parent-child dyads, the parents initiated the math talk in half of the dyads, and the children initiated the talk in the other half, demonstrating that mathematical discourse may be co-constructed with the reading and discussions. It is plausible that the different concepts discussed between parents and their children depended on the book being read. Anderson (1997) found that children talked about numbers differently when a storybook was present, versus a workbook. In the workbook when asked how many of an object the child would say “1, 2, 3, 4”; however, in the storybook when asked how many of an object the child said “2” or “4.”

There have also been several empirical studies regarding the integration of mathematics and literature conducted in the classroom setting. Skoumpourdi and Mpakopoulou (2011) developed a picture book for teaching the mathematical domain of pre-formal geometry. After a one-time shared storybook reading with related activities, typically developing kindergarteners were able to identify solid shapes and give appropriate examples within their everyday lives. In a five-month-long intervention, Jennings et al., (1992) found that when kindergarten teachers read literature books with an implicit mathematical focus and incorporated complementary activities relating to the story, vocabulary skills and interest in mathematics improved. The authors found significant effects in achievement on the *Test of Early Mathematical Ability* (TEMA; Ginsburg & Baroody, 1983), but not on the *Metropolitan Readiness Test*. At the end of the intervention period, the experimental group made math connections in other literature, increased mathematic communication between students, and incorporated mathematics language, skills, and vocabulary into other content areas.

Hong (1996) analyzed the effectiveness of using children’s literature to promote mathematics learning with 57 typically developing Korean kindergarteners assigned to experimental or control groups. Children in the experimental group received a math related storybook reading with discussion and were provided with mathematics materials related to the storybook content during free play. The control group experienced a typical story time and had the opportunity to play with mathematical materials unrelated to the storybook content. The children in the experimental group chose more mathematics tasks during free play, spent more time in the math corner, and experienced higher qualitative results in classification, number combination, and shape tasks, but only achieved slightly higher scores on the standardized measure, possibly due to both groups completing homework that was similar to the achievement test items.

Van den Heuvel-Panhuizen and Iliada (2011) evaluated the effects of integrating mathematics and literature on typically developing kindergarteners' performance of measuring length. Within a three month period, the children were read aloud eight books that implicitly addressed length elements within the stories and were taught by incidental and implicit learning. The children were assessed prior to and following the intervention on length measuring tasks. The post assessment resulted in significant, yet weak effects for the intervention. The authors concluded that for stronger effects, the intervention should have been longer due to the implicit and incidental nature of the intervention.

In another study, Young-Loveridge (2004) explored the effectiveness of an early numeracy program that employed authentic number books and games for five-year-old children. The number books were chosen based on the importance of mathematical content within the book and the games were chosen based on the outcome of "chance." The children were paired and pulled out of the room for 30 minutes each week day for seven weeks for the math intervention, which incorporated the use of stories, rhymes, and games. The results of the program included significantly higher achievement by the intervention group in number sequence, stylized number patterns, numeral identification (particularly single digit and teen numerals), making small collection of objects, and addition of two collections (e.g., 3 and 2, 6 and 3) with a very large effect size (1.99).

Young-Loveridge suggested that the large effect size was possibly due to children working in pairs with a specialist, rather than a program that relied on professional development with teachers to change classroom practices or outcomes for children in mathematics.

Some researchers reported that children can even discover the mathematics in a storybook with little or no assistance from adults. Van den Heuvel-Panhuizen and Van den Boogaard (2008) sought to examine four typically developing kindergarteners' cognitive activity that was evoked by children's literature and explore the way mathematics was naturally elicited, with limited assistance of the adult reader. The researchers found that when the children in their study were given a book with implicit mathematical elements and a cognitively engaged reader, that the children initiated their own mathematical thinking with minimal adult assistance.

Classroom curricula have been developed to promote the integration of mathematics and literacy. *'Round the Rug Math* series (Casey, 2004), as described earlier, is a supplementary mathematics curriculum for early childhood classrooms (grades Pre-K to Grade 2) based upon mathematics instruction in the form of epic adventurous tales that were written for the purpose of teaching mathematical content (Casey, Kersh, & Young, 2004). The curriculum was developed to introduce mathematical concepts sequentially and link mathematics to literacy, as well as other content areas. Erkut (2003) found children who received instruction with this curriculum experienced significant improvement in geometry skills as compared to students who received the same geometry content without the integration of the storybooks. Another curriculum, *Big Math for Little Kids* (Ginsburg et al., 2003), uses author-developed children's literature and activities to develop ideas on early mathematical content such as numbers, shapes, measurement, number operations, patterns, and spatial concepts for prekindergarten and kindergarten children. This curriculum was designed to help develop children's math language, such as math vocabulary and terminology, and emphasizes the repetition of activities for children who require additional assistance or more time to develop the math concepts. Balfanz, Ginsburg, and Greenes (2003) found that mathematics and literacy complement each other, and that mathematical activities can play a key role in the development of literacy skills, such as with positional terms (e.g., on, under, next to), comparison terms (e.g., bigger, smaller, more, less) making predictions, and explaining rationales. Thus, these authors suggest using storybooks when teaching mathematic concepts and skills.

Types of Books to Use for Integrating Children's Literature within Mathematics

Different books can produce differences in discourse, remarks, and the types of mathematics skills elicited (Anderson et al., 2005). There are differing opinions from researchers in how to choose children's literature books for the integration of mathematics. With the increasing popularity of the concept of integrating mathematics into children's literature, publishers have added several mathematical trade books allowing several options of books for teachers to choose from.

Storybooks may have a mathematical focus that is implicit, explicit, or both (Padula, 2004). Whereas some researchers believe that the mathematics in literature should be visible in text and illustrations (Schiro, 1997), others have found that children as young as five years of age can identify mathematical concepts and ideas from children's literature with an implicit focus (van den Heuvel-Panhuizen & van den Boogaard, 2008). The books teachers and parents use to elicit mathematical discourse are important. For example, in a study that observed a parent-child reading of storybooks, Anderson et al (2005) found that when parents read the book *Swimmy* (Lionni, 1963) to their four-year-old children, parents and children discussed math concepts three times more than in the book *Mr. McMouse* (Lionni, 1992). Further, during the storybook *Swimmy,* the concept of size was discussed significantly more than any other concept, which was a central concept necessary to make meaning of the story (Anderson et al., 2005). Elia, van den Heuvel-Panhuizen, and Georgiou (2010) examined the mathematical role of pictures in a story that was created to elicit mathematical thinking with four preschool children. The children were unfamiliar with the story, and the story was designed to teach the skill of counting backwards. The adult reader read the book to each child individually and provided the children multiple opportunities to react to the story and discuss throughout the reading. The children's responses were videotaped or written down. The analysis suggested that while the book elicited mathematical thinking, as intended, the children communicated about spatial and topical concepts, counting, and subitizing rather than the skill the book was designed for (i.e. counting backwards).

Illustrations serve a key role in mathematical discourse as a large amount of mathematical talk centers on the pictures in the books (Anderson et al., 2005; Padula, 2004). Illustrations in many picture books have an important role regarding the context of the story and may even add details (Stewig, 1992). Children even construct meaning through the relationship between the text and picture (Sipe, 1998). These images may also elicit mathematical information to help children understand the content of the story (Elia et al., 2010). When appropriate illustrations are included, mathematical talk may center around the pictures, eliciting additional mathematical content (Anderson et al., 2005). Some researchers have found that picture books, whether designed to explicitly teach mathematics or with an implicit math focus, can evoke mathematical thinking (e.g., Elia et al., 2010; Van den Heuvel-Panhuizen & Van den Boogaard, 2008).

Wilburne, Keat, and Napoli (2011) suggested three successful approaches teachers may use when selecting literature to integrate within mathematics. One approach includes reading through the storybook to find opportunities for mathematical questioning. Effective questioning should not simply ask for one word answers, such as "how many pencils are in the box" or "what is this shape;" rather, questions should evoke higher level thinking, such as "why is the answer four?" Another approach to selecting literature for mathematics is to consider the story elements, such as the plot, theme, setting, and characters to discover how mathematical questioning can be posed. For example, does the plot of the story consist of a logical sequence or order? Does the plot allow for prediction? Do the characters allow for problem solving situations? The third approach requires the teacher to determine the mathematical standards to teach first, and then attempt to connect the standards within the story. Wilburne et al. (2011) suggested that teachers should read through the literature first to discover the mathematical connections, as many stories do not include explicitly presented mathematics. Once the storybook is chosen, the teacher may select characters and situations that the students can help solve.

Several researchers have categorized children's literature to assist teachers in selecting the appropriate books for the skills they are targeting (e.g., Gailey, 1993; Padula, 2004; Whitin & Whitin, 2004). For example, Gailey (1993) characterized trade books based on broad categories (i.e., number books, informational books, counting books, miscellaneous books), whereas Whitin and Whitin (2004) divided books by mathematical domains (i.e., counting, number operations, informational, measurement, geometry, and classification). Padula (2004) characterized and described ten different types of mathematical storybooks to inform teachers of the variety of books that are available for teaching mathematics: ideas about arithmetic, relational terms, recipe books, sequential thinking, logic, patterns, series, picture books, problem solving, and those that reinforce math concepts. Books in the *ideas about arithmetic* category include the mathematical skills of counting, addition, subtraction, multiplication, and division facts. Padula highlighted books such as *The Very Hungry Caterpillar* (Carle, 1987) with the simple counting activities of cardinal, ordinal numbers, and one-to-one correspondence, and Anno's *Magic Seeds* (Anno, 1995) which uses arithmetic through a narrative, as well as counting ordinal and cardinal numbers and to multiply and subtract. *Six Foolish Fisherman* (Elkin, 1968) was highlighted in this category for counting, with its possibilities of solving problems, retelling the story, and graphing. Books suggested by other authors in this category include *Mouse Count* (Walsh, 1995), *Ten Apples on Top* (LeSieg, 1961), *Anno's Counting Book* (Anno, 1977), *Goldilocks and the Three Bears,* and *Bears on Wheels* (Berenstain, 1969) (Copley, 1999, 2010; Griffiths & Clyne, 1991; Satariano, 1994; Welchman-Tischler, 1992; Whitin & Whitin, 2004). Books categorized in the *relational terms* category consist of books rich in spatial terms, such as "in," "under," "above;" quantity terms "more," "less," "most," "few," and "fewer;" and time concepts "before," "after," "day," and "week." Padula highlights *Rosie's Walk* (Hutchins, 1968) and Berenstains' (1971) book, *Bears in the Night*, for introducing positional and spatial relations terms in fun and amusing ways. *Recipe Books* can consist of an actual children's recipe book or books that contain just one recipe in the book. Recipes are suggested for middle- and upper-primary elementary children for measuring mass, volume, capacity, time, as well as work on fractions and ratios. Padula suggested two books in this category, *The Grandma Poss Cookbook* (Vivas, 1985), and *Mr. Wolf's Pancakes* (Fearnley, 1999). Each book uses measuring terms and time units.

Books that encourage *sequential thinking* include books that simply have a sequencing of events for a child to follow, such as *Anno's Counting Book* (Anno, 1977) that can be arranged in order from zero to 12, and *All in a Day* (Anno, 1986) which utilizes the concept of time. Books that require *logic* or logical thinking include books such as *Alice's Adventures in Wonderland* (1992) which requires logic within the story. Books in the *patterns* category consist of books that encourage children to recognize patterns within the book or nature. Padula mentioned that many of the books regarding shapes and counting for preschoolers are also rich in patterns. For example, Anno's *Math Games II* (1989) encourages patterns and counting for young children, while the *Mysterious Multiplying Jar* (Anno, 1983) for older children shows the patterns behind factorials. Some math trade books are written in a *series*, such as *MathStart,* which includes topics on patterns, comparisons, directions, and shapes. Padula characterized *picture books*, as books that do not contain a strong story line, but are more used for factual information. This categorization emphasizes that many books can be used to teach mathematics, such as *Mission to Mars*, (Branley, 2002) in which children can make spaceships, create a space map showing Mars, the Moon, and Earth, as well as graph the length of the journey from Earth to the Moon compared to Earth to Mars. Problem solving allows a context for children to interact with mathematics. Books in the *problem* *solving* category encourage children to use critical thinking skills to solve the characters' problems. For example, *Maths Curse* (Scieszka & Smith, 1995) requires children to journey with a boy who thinks of every event in his day as a math problem to be solved. Another example is *Counting on Frank* (Clement, 1991) which is about a boy with a large dog who problem solves hypothetical situations, such as how many of his dogs would fit in his bathroom, how long it would take to flood the bathroom, and how many humpback whales would fit inside his house. Lastly, books may be categorized as *those that reinforce math concepts*, such as measuring volume in *Mr. Archimedes' Bath* (Allen, 1980), and teaching relations between mass and capacity in *Who Sank the Boat?* (Allen, 1988). Some books may contain mathematical inaccuracies. Hoffman (2002) notes that even if there is a mathematical inaccuracy in a storybook, it does not mean the book should be abandoned. The educator may choose to attempt to "fix the problem" by making verbal clarifications or explanation or by altering the text or graphics, or adding equations or algorithms.

There are a variety of ways to assess books for effective integration of mathematics. For example, Hellwig, Monroe, and Jacobs (2000) provided teachers with an evaluation scale to help teachers choose appropriate high quality mathematics trade books. The identified key criteria include: (1) accuracy of the mathematics information; (2) visual and verbal appeal of format and presentation; (3) literature allowing learners to make meaningful connections between mathematics and their own experiences; (4) level of appeal to a wide range of audiences and abilities; and (5) presence of the "wow" factor of richness beyond the predicted or expected. Whitin and Whitin (2004) also developed a set of criteria for teachers to assess the quality of the chosen books. Their criteria identified four aspects they consider mathematics related children's literature book should demonstrate including: (1) mathematical integrity (i.e., the mathematical components of the book are accurate), (2) potential for varied responses (i.e., the tone of the book is invitational rather than didactic), (3) aesthetic dimension (i.e., reader's awareness and appreciation for the form and design), and (4) ethic, gender, and cultural inclusiveness (promotes racial, cultural, and gender equity without stereotyping).

Methods for Incorporating Mathematics within Literature

After choosing a book to read, several researchers have shared suggestions on how to integrate mathematics within children's literature. Recently, Wilburne et al. (2011) suggested that when planning for the integration of mathematics within children's literature, teachers should first focus on student interests, such as which problems would be most engaging and interesting. Second, teachers should introduce the story by allowing the children to make predictions; discuss the illustrations, characters, and settings; and then read focusing on the central story elements and comprehension development. Next, teachers should re-read the story focusing on mathematical concepts and higher order thinking. Research supports reading a story several times to increase the students' understanding of the story and to further develop the mathematical concepts (Anderson & Anderson, 1995; Borasi, Sheedy, & Siegal, 1990). Borasi, Sheedy, and Siegal (1990) suggested that reading books more than once allows for readers to focus on different aspects of the story. For example, the first reading may just give an exploration of the mathematical potential of the story, but the second reading may allow for highlighting the mathematical content that the students may have overlooked the first time.

Many researchers have also taken the approach of using literature to create supplementary mathematics activities to teach mathematical concepts to young children. Providing children with hands-on, explicit mathematically focused activities is supported by several researchers to help children understand mathematical concepts (Fogelberg et al., 2008) and to eliminate the limited ability to convey three-dimensional information within a story book (Kolstad & Briggs, 1996). Using hands-on activities such as manipulatives allows for the mastery of concepts, as well as building interest and making the mathematics meaningful to students (Kolstad & Briggs, 1996). Other extension activities may also include games. Cutler et al. (2003) described how to create mathematical games based on children's literature. They suggested selecting the book based on mathematical concepts the children are ready to learn, determining the developmental level of the children, and then selecting the game based on the children's developmental level and attention span. They also suggested creating your own game so that it is flexible and can grow with the children.

Setting up a story-related mathematics center in an early childhood classroom has been used by several researchers who integrated literacy and mathematics. For example, after the storybook reading and story-related math activities in kindergarten classrooms, Hong (1996) made a story-related mathematics center for children to explore during free play. Similarly, in Jennings et al. (1992) study, after story time with a mathematically-focused book, kindergarten participants were presented with explicit, book-related mathematical activities (e.g., measuring parts of body or objects with a tape measure), discussion of the book, and an opportunity to play in the imaginative center with book-related manipulatives and materials during free play.

In sum, integrating mathematics within children's literature has been an effective intervention for improving children's mathematics achievement in a natural context that encourages active and engaged learning. This intervention has been used to improve children's math skills in measurement (Van den Heuvel-Panhuizen, & Iliada, 2011; Whitin & Gary, 1994), geometry (Casey et al., 2008; Hong, 1996; Rosen & Hoffman, 2009; Skoumpourdi & Mpakopoulou, 2011), fractions (e.g., Conaway & Midkiff, 1994), estimation (e.g., Whitin, 1994), math vocabulary (Jennings et al., 1992); classification (Hong, 1996), and number combinations (Hong, 1996). However, there is no published literature on this intervention for young children with disabilities. In fact, there is a great lack of published literature on any math interventions for young children with disabilities. Through current research, we have learned how important early mathematics is for later school achievement and beyond, and that early intervention can improve math achievement in later years. The intervention of integrating mathematics within children's literature allows for teachers to meet the current instruction recommendations by the NAEYC and NCTM while helping young children achieve mathematics proficiency.

Purpose

Research on mathematical interventions for young children with disabilities is emerging. It is of primary interest for teachers to know which methods of mathematics instruction are most effective, under what circumstances, and how the methods should be used (Ginsburg et al., 2008). Researchers have found that integrating mathematics within children's literature results in positive mathematical achievement for typically developing peers and children who are at risk (Hong, 1996; Jennings et al., 1992; Skoumpourdi & Mpakopoulou, 2011). However, there is no existing literature regarding this intervention with preschoolers with disabilities in the classroom setting. The purpose of this study is to examine the effects of an intervention that integrates mathematics within children's literature on the early numeracy skills of preschoolers with disabilities.

CHAPTER 3

METHODOLOGY

This quasi-experimental study examined the effects of an intervention that integrated mathematics within literature on the early numeracy skills of preschool children with disabilities. The data collected were analyzed using ANCOVAs to determine if the 6-week intervention promoted math achievement in three- to five-year-old children with a variety of disabilities in self-contained preschool special needs classrooms.

Variables

Statement and Operational Definitions of the Independent Variable

The independent variable included in this investigation was the intervention of integrating mathematics within shared storybook reading and follow-up activities. This intervention consisted of an interactive shared storybook reading including mathematical content through scripted questioning and discussions and story-related mathematical activities after the reading of the story (see Appendix A).

Shared storybook reading was defined as an adult-led storybook reading that encouraged student participation and interaction by eliciting questions and conversations. Due to the range of verbalizations expected (i.e., non-verbal to age appropriate communication abilities), a variety of responses were anticipated and encouraged. Three books were selected based on prior research and published materials on the integration of literature and mathematics and chosen based on the nature of the book lending itself to target skills of (1) one-to-one correspondence, (2) quantity comparison, and (3) numeral identification (see Appendix A).

The story-related mathematical activities included activities such as short stories, rhymes, manipulatives, felt board activities, and craft activities that related to the story content and targeted skills (see Appendix A).

Statement and Operational Definitions of Dependent Variables

The dependent variables addressed within the research questions included the participants' academic scores on the *Test of Early Mathematics Ability, Third Edition* (TEMA-3; Ginsburg & Baroody, 2003) and scores on the *Preschool Numeracy Indicators* (PNI; Floyd, Hojnoski, & Key, 2006) in total mathematical ability and three areas of the Number and Operations domain: (1) one-to-one correspondence, (2) quantity comparisons, and (3) numeral identification (called number naming fluency in the PNI). Due to the likelihood of some children exhibiting delayed verbal skills, all tasks allowed for nonverbal responses.

Total math ability was defined as the total assessment score as measured by the TEMA-3 total math ability score.

One-to-one correspondence skills were defined as the accurate demonstration of a child matching each object in the first group with exactly one object in the second group, while each object in the second group had to be matched with exactly one object in the first group (Heddens & Speer, 1992). One-to-one correspondence skills were measured by the TEMA-3, item number five, and the PNI one-to-one counting fluency task.

Quantity comparisons were defined as the accurate demonstration of a child gesturing, pointing, touching, or verbalizing which group has "more" or "less" objects, as defined by the task. Quantity comparison skills were measured by the TEMA-3, item number four and the PNI quantity comparison task.

Numeral identification skills were defined as the accurate demonstration of a child gesturing, pointing, or touching the correct numeral in an array of three numerals on the first opportunity, or verbalizing the number name of a numeral. Numeral identification skills were measured by the TEMA-3, item number 14, and the PNI numeral naming task.

Research Questions

Research Question One

Will using a mathematics intervention of shared storybook readings and related activities promote total mathematical ability skills of preschoolers with disabilities?

Research Question Two

Will using a mathematics intervention of shared storybook readings and related activities promote the one-to-one correspondence skills of preschoolers with disabilities?

Research Question Three

Will using a mathematics intervention of shared storybook readings and related activities promote the quantity comparison skills of preschoolers with disabilities?

Research Question Four

Will using a mathematics intervention of shared storybook readings and related activities promote the numeral identification skills of preschoolers with disabilities?

Participants

The participants in this study included 50 preschoolers, ages three-to-five-years-old with disabilities. All children were identified based on their eligibility of special education by state standards. Inclusionary criteria included eligibility of special education, and participation in a self-contained special needs classroom in a specified school district in a southeastern state for at least one hour per day for a minimum of three days per week. Exclusionary criteria consisted of children who did not speak English as their primary language, had severe vision impairments, were Deaf, or had severe motor difficulties to the extent that the child was unable to indicate responses either by physically pointing, grasping, gesturing, or verbalizing responses even with an adaptive device or an augmentative and alternative communication device. Based on a random assignment of classrooms using Research Randomizer (http://www.randomizer.org/), the students in half of the classrooms received the intervention (treatment group; n = 24), while students in the other half received a typical small group storybook reading of the same literature book with no math elaborations (comparison group; n = 26). If the child refused to participate in the activities, he or she was excused from the intervention that day. If a child refused to join the group or participate for more than 50% of the sessions, or if the child was absent for more than 50% of the sessions, his or her data were deleted from the study. The treatment and comparison classrooms were matched based on SES status of the school (i.e., determined by the number of children in the school receiving free and reduced lunches).

All participants had special education eligibility in the category of significant developmental delay (SDD). Although not a term used in all states, this is a broad eligibility category that encompasses children, ages three through nine years, with a wide range of disabilities. In the state that this research project occurred, preschoolers are examined in five domain areas: self-help/adaptive, motor, communication, social/emotional/behavioral, and cognition. A child may qualify for SDD if his or her evaluation results in two standard deviations (SD) in one area below the mean or if two areas are 1.5 SD below the national norms according to the assessments used, and if this delay may cause negative affects in age appropriate activities (GA DOE, 2012). Due to the heterogeneous nature of children with SDD, descriptive data were obtained on each participant through teacher interview and included school eligibility category, medical diagnoses, current individualized education plan (IEP) goal domains, current special education services, age, race, and gender (see Appendix B). In order to obtain descriptive data on each classroom teacher, teachers were asked to fill out a short demographic form requesting their age, gender, college degree(s), teaching certification(s), total years of teaching experience, years of teaching experience in preschool special needs, current classroom curriculum, and additional or supplemental curricula used in the classroom (see Appendix C).

Setting

This study was conducted in the ten self-contained preschool special needs classrooms (i.e., 5 treatment and 5 comparison) in a suburban school district of a southeastern state. Each preschool special needs classroom was in a different school building. The intervention was conducted by the primary investigator and two research assistants within the regular school day, either in the corner of the classroom or in a location just outside the classroom. The children were grouped by the classroom teacher into groups of two to four students. As is well documented in the literature, small groups of children are recommended for effective interventions, particularly for children with disabilities (Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Bryant, Bryant, Gersten, Scammacca, Funk, et al., 2008; Bryant et al., 2011; Fuchs et al., 2012; Fuchs et al., 2005), and there is a need for more research interventions utilizing small groups with younger children (Dowker, 2004). Further, Bryant et al. (2011) suggested that interventions for young children should not only include small group instruction, but also engaging activities, systematic instruction for the development of conceptual knowledge and procedural fluency, and sufficient time for students to understand mathematical concepts and operations, as well.

Measures

The *Test of Early Mathematics Ability, Third Edition* (TEMA-3; Ginsburg & Baroody, 2003) was used as a pre and post assessment to assess mathematical ability of all children in both groups. The TEMA-3 is a math assessment for children as young as three years of age. This test measures concepts such as measuring magnitude, counting, calculation, number comparison, numeral writing and recognition, and number facts. The TEMA-3 was chosen because it can be used with young children, is reliable with reported internal consistency of above .92, and takes approximately 20 minutes to administer. This assessment is widely used in assessing young children in mathematics. In addition, the skills tested are comprised of the Number and Operations curriculum strand (National Council of Teachers of Mathematics, 2000).

The *Preschool Numeracy Indicators* (PNI; Floyd et al., 2006; http://www.memphis.edu/psychology/people/faculty/rfloyd/pni/index.php) was used to assess all children's number sense development at the beginning and end of the intervention, as well as student progress monitoring every other week (see Appendix D). This curriculum based measurement (CBM) consists of four measures linked to components of number sense (1) one-to-one correspondence counting fluency, (2) quantity comparison fluency, (3) number naming fluency, and (4) oral counting fluency. The former three components were used for this study. The one-to-one correspondence counting fluency task requires the student to point to and count the dots presented on a page in four rows of five. The students are given a maximum of 30 seconds to complete the task. The quantity comparison task requires students to identify the set with more dots from the two sets on the same page. Each set consists of one to six dots, and up to 30 pages are presented in one minute. The students respond by pointing to the larger set (Floyd et al., 2006). The number naming fluency task requires the student to name the numerals 0 – 20 as they are presented one at a time in random sequence for one minute. Test-retest reliability for the PNI varies by sub-test: one-to-one correspondence (.62), quantity comparison (.89), and number naming (.91).

The Cronbach's alpha statistic was calculated to determine the internal consistency of the PNI and TEMA-3 test items for the sample in the current study. Alpha values range from 0.00 to 1.00, with values of .9 and higher considered to represent high internal consistency (Portney & Watkins, 2009). Results from the Cronbach's alpha show that the PNI had acceptable internal consistency with the estimated alpha level of .71, and the TEMA-3 with good internal consistency with the estimated alpha level of .83.

Materials

This intervention introduced one children's storybook with related activities every two weeks for a total of 18 sessions (three main storybooks overall, three times per week for two weeks per story). The children's literature chosen had an implicit math focus, rather than a mathematics trade book or a book with a clear explicit mathematical purpose. The rationale for using a storybook with an implicit mathematical focus was to find typical books that are in teachers' classroom libraries and read to children at a typical storytime reading. Pentimonti, Zucker, and Justice (2011) found that of all the books read aloud by preschool teachers, books featuring math concepts represent only 9.4% of the books read, while narrative books represented 85.8% of the books read aloud. Therefore, in order to integrate mathematics within literature in a format that teachers can use on a daily basis, this intervention was based on books that teachers are comfortable with reading and that are quality children's literature. Books used included *The Snowy Day* (Keats, 1962), *Goldilocks and the Three Bears,* and *The Very Hungry Caterpillar,* (Carle, 1987). Every two weeks the books and activities changed. The books were adapted for durability and ease of use for the students, by cutting the book from the binding, laminating the pages, placing the pages into a 3-ring binder, and placing the covers of the books on the front and back of the binders, as implemented by Browder, Lee, and Mims (2011) in an intervention of shared storybook reading with young children with multiple and severe disabilities. In order to ensure that all children in the treatment group received the same type of storybook experience, questions, notes of interest, and main ideas were labeled throughout the storybook. Students that required assistive technology were allowed to use any classroom-provided assistive technology, such as alternative augmentative devices, or fine motor or gross motor equipment, for the storybook reading and related activities. Activities were also included as part of the intervention. All math activities were based off prior research interventions, programs, and curricula. Each activity focused on at least one of the target objectives. For example, 5-frame cards were used for organizing manipulatives, one-to-one correspondence, and counting. Number cards were used for children to choose a card with a numeral then select the number of objects (e.g., fruits, bears, links) that corresponded to the numeral on the card. The children then compared quantities of objects with each other. The felt board was also used to compare quantities, such as the quantity of fruits (e.g., apples versus oranges) the caterpillar ate from *The Very Hungry Caterpillar* (Carle, 1987). Many activities worked towards several targeted objectives (see Appendix A).

In sum, the list of materials used included the TEMA-3 and the PNI with protocols, three main books and activity notebooks with manipulatives and related materials for the six-week intervention for the researcher and each research assistant.

Pilot Study

The researcher piloted all storybooks and activities with two small groups of three young children of different ability levels, ages three to four, prior to the commencement of the current research study. Materials, activities, and questions were adjusted for the current investigation based on participant feedback and reaction to the activities. For example, the researcher decreased the time spent on reading the storybook on the fourth, fifth, and sixth sessions from 8-10 minutes to 5-8 minutes. The researcher also learned that for the short time frame of the session, games and activities should be easy to understand, efficient, and have a strong focus on the targeted objectives. Some planned activities in the pilot study proved to be too difficult for the children to understand, such as a chart designed to show how the number of objects relates to the corresponding numeral, and were eliminated.

Research Design

This study was a quasi-experimental group design, with one treatment group and one comparison group. The treatment group consisted of 24 participants from five classrooms, while the comparison group consisted of 26 participants from another five classrooms (N = 50 participants). Participating children from all ten self-contained preschool special needs classrooms in one school district were randomly assigned to one of the two conditions.

Procedures

Before the intervention began, the student PI collected consents of participation from all teachers, and parental permissions from all students who qualified for the research study based on the inclusionary criteria. Descriptive data were obtained on each participant by teacher interview including school eligibility category, medical diagnoses, current IEP goal domains, current special education services, age, gender, and race (see Appendix B).

The intervention team consisted of the student PI and one research assistant. The assessment team consisted of the intervention team with one additional research assistant. Both research assistants were experienced in working with young children with disabilities. The research assistant on the intervention team has a Bachelor's of Science degree and certificate in Early Childhood Education with eight years experience teaching early elementary aged children with and without disabilities. The research assistant on the assessment team has Bachelor's of Science and Master's of Science degrees in Speech-Language Pathology, along with the Preschool Handicapped Endorsement. She has four years teaching young children with disabilities and seven years serving on an assessment team. The student PI provided the two research assistants with two half-day trainings. Day one consisted of trainings on the assessments. The researcher and research assistants practiced the assessments to reach 90% inter-observer reliability. If the reliability had ever been less than 90%, the researcher and research assistants would have re-trained. Day two included training on the intervention, shared storybook reading, and how to implement the activities, including strategies for scaffolding and adapting the materials, as needed. The intervention research assistant was provided with the children's literature books with scripted questions, materials for the math activities, and activity notebooks. The materials for the math activities included manipulatives (i.e., counting bears, plastic links, and snapping cubes), felt board story characters, and art activities. The activity notebooks included lesson plans for each intervention session and sheets. The researcher and intervention research assistant practiced one lesson plan to reach 90% fidelity on the fidelity checklist (see Appendix E). If fidelity had ever been less than 90%, the researcher and research assistants would have re-trained.

Scores on the TEMA-3 and the PNI were collected from student participants at the beginning of the study and following completion of the intervention. The week before intervention began, the TEMA-3 and the PNI were administered to all consented participants. These assessments took approximately 20-25 minutes to administer to each participant; the assessments were divided into shorter time increments as needed. These same procedures were completed the week after the conclusion of the intervention. The children in the treatment group also received the PNI every two weeks to monitor and measure progress.

The children in the treatment group were assigned to small groups by the classroom teacher. The small groups remained consistent throughout the intervention. Three sessions per week for approximately 20 minutes per session, each small group was provided with 1) a review of math concepts from the prior session; 2) shared storybook reading by the researcher or the research assistant with guided math questions and elaborations; and 3) one small group explicit math activity such as a felt board activity, game, student-created story, or play with manipulatives. Each session closed with a review of comprehension and math concepts from the story. The sessions occurred in a corner of a classroom or within close proximity of the classroom to reduce distractions as necessary. The storybooks changed every two weeks.

Specifically, the researcher and research assistant implemented the procedures in the following method with the treatment group: 1) invited children to join a small group storybook reading and activities; 2) briefly built rapport with the participants by completing introductions for the first session, then at later sessions asking how the children were doing, commenting on observed classroom activities or the child's day (e.g., artwork, stories read, songs sang); 3) reviewed concepts from prior lessons; 4) read the story as directed on the lesson plans with the guided questions and math elaborations (e.g., first lesson consisted of a picture walk and a typical reading; second through sixth lessons consisted of readings focused on math concepts); 5) completed activities as directed on the lesson plans through an explicit and direct instruction model (i.e., reviewed prior concepts, taught target concepts by instructor-modeling, instructor-guided small group practice, followed by participant-independent practice); and 6) closed session with a review of target concepts. On the final session of each book, the researcher or research assistants conducted the PNI CBM for all students individually at the end of the session.

The comparison group received one small group shared storybook reading by the researcher or research assistant with the same book as the experimental group, but with no elaborations or questions regarding the math within the book, and no related activities.

The duration of the intervention (six weeks) is consistent with current literature. For example, in a similar study on mathematics activities in a Head Start setting, Arnold, Fisher, Doctoroff, and Dobbs (2002) conducted a six-week study to determine if math activities throughout the day increased math achievement and interest in math. Similarly, Young-Loveridge (2004) conducted a seven-week study on the use of number games and literature on kindergartener's mathematical abilities.

Fidelity

The intervention team for this intervention included one researcher and one research assistant. The researcher and research assistant conducted fidelity checks for 20% of intervention sessions using a checklist that was created for the shared storybook readings and the related activities (see Appendix E). The researcher and research assistant also abided by a daily fidelity checklist, which recorded the book they read, the activities they provided to the children, and which participants attended the session. The researcher and research assistant both completed CITI training, and the researcher trained the research assistant on the intervention and the fidelity checklist. Results of the fidelity checklist revealed that the assistant and researcher completed the intervention with an average of 97% fidelity.

Inter-observer Reliability

The assessment team for this intervention included the two persons on the intervention team and an additional research assistant. The two research assistants completed CITI training and were trained by the researcher on both assessments through demonstration and practice in the scoring procedures. Inter-observer reliability was conducted for 20% of the assessments by the researcher or a research assistant for a 90% or greater agreement. Inter-observer reliability averaged 93%. Inter-observer reliability was determined by dividing the total number of agreements between all members of the research team by the total number of observations, and then multiplied by 100.

Data Analysis

An ANCOVA test was performed to compare the pretest and posttest gains among the two groups of students. The ANCOVA equated the groups of participants based on the pretest scores. Data were analyzed using SPSS for Windows (IBM, 2012). Data from the TEMA-3 were analyzed by the total math ability standard score and by test items using a one-way ANCOVA design. The PNI scores were analyzed separately by each sub-test using a one-way ANCOVA design. An alpha level of .05 was used on the total math ability of the TEMA-3. The alpha level was adjusted for the specific item analyses on both the TEMA-3 test items and the PNI to .016 alpha level according to Bonferroni adjustment rules (alpha level of .05 divided by three) for each research question. This adjustment assists in decreasing the chance of a Type 1 error in the ANCOVAs. Each child was also assessed one time every two weeks on the PNI measure to document progress. PNI progress monitoring scores were used for descriptive data and were analyzed by comparing mean scores.

CHAPTER FOUR

RESULTS

Demographics

Results are presented for the 50 participants who completed the current study, all of whom were children, ages three to five, with disabilities. The majority of participants of both groups were male (i.e., 78%), and of the Caucasian race (68%). Other races/ethnicities included African American (26%), Hispanic (4%), and Asian (2%). Specifics of the demographics are presented in Table 1. Children attended one of ten preschool special needs classrooms in a southeastern suburban school district consisting of approximately 28,000 students. Each of the ten special needs preschool classrooms were housed in a separate elementary school building. Sixty percent of the classrooms in the treatment group (n = 3) and forty percent of the comparison group classrooms (n = 2) were housed in schools characterized by low socioeconomic status.

Child Characteristics

Parental permission forms were sent home by the classroom teachers to all children who met the inclusionary criteria (i.e., 86 children). Fifty-five children returned their forms (i.e., 64% return rate). Data points of three children were removed from the data set due to absence rates of more than 50% of sessions; data points for two children were removed from the data set due to refusal to participate in more than half of the sessions. The final number of participants consisted of twenty-four (48%) children in the treatment group and twenty-six (or 52%) children in the comparison group. The mean age of participants in each group was four years and five months (see Table 1). All participants had a school eligibility of Significant Developmental Delay (SDD). The majority of participants in both groups also qualified for speech and language impairments (i.e., 66%). Other diagnoses of the participants included autism spectrum disorder, cerebral palsy, hard of hearing, Down syndrome, and mild vision impairments (see Table 1).

Teacher Characteristics

Teacher characteristics were examined for all ten of the classrooms in the study. Overall, the teachers of the children in the comparison classrooms had a higher mean age (i.e., 42.75 years) than the treatment group (i.e., 36 years). Additionally, the comparison group teachers had more teaching experience (i.e., 8.25 years experience) as compared to the teachers in the treatment group (i.e., 6.4 years experience), as well as more teaching experience in preschool special needs (see Table 2). However, there were no significant differences in either the teacher age or years teaching experience between the two groups based on t-tests. All classroom teachers had a minimum of a Bachelors of Science degree with a special education certification and were all considered highly qualified to teach preschool special needs. In both groups, 40% of the teachers held a Masters of Education in Special Education (n = 4), and 40% (n = 2) of the teachers of children in the treatment group held a Specialist of Education degree, though not in Special Education. Preschool special needs teaching experience ranged from one year to nine years.

Although all teachers had access to the DLM Early Childhood Express curriculum (McGraw Hill, 2003), only 20% (n = 1) of the treatment group and 40% (n = 2) of the comparison group teachers reported that they used the curriculum within their classroom. No teachers reported using any other comprehensive classroom curricula, nor any

Table 1

Table of Characteristics of Participants

	Treatment Group				Comparison group				Total			
Characteristic	n	%	M	SD	n	%	M	SD	N	%	M	SD
Age Range	24		5-4	8.12	26		5-4	8.11	50		5-4	8.03
Gender												
Male	17	59			22	82			39	78		
Female	7	41			4	18			11	22		
Eligibility Category												
SDD	24	100			26	100			50	100		
Additional Diagnoses												
Autism Spectrum Disorder	3	12.5			7	26.9			10	20		
Cerebral Palsy	0	0			1	3.8			1	2		
Hard of Hearing	1	4.1			1	3.8			2	4		
Down Syndrome	1	4.1			1	3.8			2	4		
Speech Impairment	18	75			15	57.6			33	66		
Vision Impairment (mild)	2	8.3			0	0			2	4		
Race/Ethnicity												
African American	8	33.3			5	19.2			13	26		

Asian	0	0	1	3.8	1	2
Caucasian	16	66.6	18	69.2	34	68
Hispanic/Latino	0	0	2	7.6	2	4

supplemental math curricula. Supplemental classroom curricula reported included Frog Street Press Literacy Curriculum, Assessment of Basic Language and Learning Skills (ABLLS) curriculum guide, and Handwriting Without Tears (HWT). The majority of classroom teachers in both groups reported using the state pre-kindergarten standards and children's IEP goals to determine the material and activities for the classrooms.

Results of Research Questions

Four research questions were examined for this study. Each research question consisted of one aspect of early numeracy knowledge (i.e., total math ability, one-to-one correspondence, quantity comparison, and numeral identification). The independent variable included in the current investigation was the intervention of integrating mathematics within shared storybook reading and follow-up activities. The intervention included an interactive shared storybook reading including mathematical content through scripted questioning and discussions and story-related mathematical activities after the reading of the story. The dependent variables included the participants' standard scores on the *Test of Early Mathematics Ability, Third Edition* (TEMA-3; Ginsburg & Baroody, 2003) and the calculated scores on *Preschool Numeracy Indicators* (PNI; Floyd et al., 2006) in total math ability and three areas of the Number and Operations domain of mathematics: (1) one-to-one correspondence, (2) quantity comparisons, and (3) numeral identification (called number naming fluency in the PNI). An Analysis of Covariance

Table 2

Teacher Demographics

	Treatment Group				Comparison group				Total			
Characteristic	n	%	M	SD	n	%	M	SD	N	%	M	SD
Age Range	5		36	7.31	5		42.75	9.18	10		39	8.43
Gender												
Female	5	100			5	100			10	100		
Number of Years Teaching Preschool Special Needs	4				7				6.2			
Number of Years Teaching	6.4				8.25				7.2			
College Degree(s)												
Bachelors of Science	5	100			5	100			10	100		
Masters of Education	2	40			2	40			2	40		
Specialist of Education	1	20			0	0			1	10		
Teaching Certification Areas												
Special Education P-12	5	100			5	100			10	100		
Early Childhood Education, P-5	4	80			4	80			8	80		
Classroom												

Curricula						
DLM Early Childhood Exp	1	20	2	40	3	30
Frog Street Press	1	20	0	0	1	10
None Noted	3	60	3	60	6	60
Additional Curricula						
ABLLS	1	20	0	0	1	10
HWT	0	0	1	20	1	10

(ANCOVA) was used to determine differences between posttest scores for the comparison and treatment group on all measures. SPSS for Windows (IBM, 2012) was used as the statistical tool for the analyses. For all ANCOVAs, the pretest scores were held constant as the covariant. An alpha level of .05 was used on the total math ability of the TEMA-3. The alpha level was adjusted for the specific item analyses on both the TEMA-3 and the PNI to .016 alpha level according to Bonferroni adjustment rules (alpha level of .05 divided by three) for each research question. This adjustment assists in decreasing the chance of a Type 1 error in the ANCOVAs. For all analyses, a test of homogeneity of regression was performed. A non-significant result of this analysis assures that the covariate (i.e., pretest scores) and the dependent variable (posttest scores) have similar slopes (i.e., no interaction effect). All analyses were reported with a non-significant test of homogeneity of regression. Effect sizes (Cohen's D index) were calculated for each outcome variable (Cohen, 1992). Effects for each targeted early numeracy task were determined as small (.10), medium (.25), or large (.40) (Cohen, 1992). Further, Levene's test of equality of variance was analyzed on each ANCOVA to meet the assumption that the variances between the samples were equal between the groups. Each analysis met this assumption as well. See Table 3 for means on each measure.

Research Question One. Will using a mathematics intervention of shared storybook readings and related activities promote total mathematical ability skills of preschoolers with disabilities?

Results of Research Question One. The TEMA-3 was used to assess total mathematical ability of all children. Significant differences were found between the two groups for total mathematical ability, with higher scores for the treatment group. The ANCOVA of the math ability scores was significant, $F(1,46) = 13.59$, $p = <.001$, ŋ = .22 (see Table 4). The strength of the relationship between the intervention and the dependent variable was assessed as medium on the dependent measure, holding constant the pretest math achievement scores. The treatment group had the lower pretest mean ($M = 74.46$, $SD = 11.92$), but the higher posttest mean ($M = 82.29$, $SD = 13.66$) and adjusted mean ($M = 83.2$). The comparison group had the higher pretest mean ($M = 76.58$, $SD = 11.97$), and the lower posttest mean ($M = 75.81$, $SD = 11.36$) and adjusted mean ($M = 74.97$). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were significant differences among the pair wise comparison of adjusted means between the two groups ($p = <.001$).

Table 3

Means on TEMA and PNI

		Treatment Group		Comparison Group	
Test Item	*p* Value	Mean Pretest	Mean Adjusted Posttest	Mean Pretest	Mean Adjusted Posttest
TEMA-3 Math Ability Score	<.001**	74.46	83.2	76.58	74.97
One to One Correspondence					
TEMA-3	.062	.17	.38	.23	.15
PNI	<.001**	6.08	9.7	5.54	6.43
Quantity Comparison					
TEMA-3	<.001**	.33	.79	.5	.31
PNI	.01**	7.5	12.47	7.81	8.22
Numeral Identification					
TEMA-3	.21	.33	.64	.5	.49
PNI	.24	7.17	10.34	7.77	8.07
Oral Counting Fluency					
TEMA-3	.066	.33	.79	.5	.58
PNI	.006**	8.83	13.53	8.92	8.74
Cardinality Rule					
TEMA-3	.015**	.21	.54	.19	.24

* = significance at the alpha level of .05, ** = significance at the Bonferroni adjusted level of .016

Table 4

Analysis of Co-Variance for Mathematics Ability by TEMA-3 Math Ability Scores

Source	*SS*	*Df*	*MS*	*F*	*p*	*Effect Size*
TEMA-3	837.33	1	837.33	13.59	<.001**	.22
Error	2895.97	47	61.62			
Total	319460	50				

* = significance at the alpha level of .05, ** = significance at the Bonferroni adjusted level of .016

Research Question Two. Will using a mathematics intervention of shared storybook readings and related activities promote the one-to-one correspondence skills of preschoolers with disabilities?

***Results of Research Question Two*.** For the purpose of this study, the author defined one-to-one correspondence skills as the accurate demonstration of matching each object in the first group with exactly one object in the second group, while each object in the second group is matched with exactly one object in the first group (Heddens & Speer, 1992). Scores on item number five on the TEMA-3 were analyzed for this question. This particular item required the examiner to place a number of tokens (i.e., first trial: 2 tokens, second trial: 4 tokens, third trial: 3 tokens) on a card and cover the tokens with a paper. The participant was required to place the exact number of tokens on his or her paper that the examiner had hidden under the examiner's paper. This skill was repeated twice with a different number of tokens (i.e., four and three tokens respectively). The participants were required to get all three trials correct in order to get credit for the item number (i.e., 1 for all three trials correct, 0 for any trial incorrect). The ANCOVA was not significant for this test item, $F(1,46) = 3.67$, $p = .062$, ŋ = .07 (see Table 5). Of the two groups, the treatment group had the lower pretest mean ($M = .17$, $SD = .38$), and although not significant, the treatment group also had the higher posttest mean ($M = .38$, $SD = .50$) and adjusted mean ($M = .38$). The comparison group had the higher pretest mean ($M = .23$, $SD = .43$), and lower posttest mean ($M = .15$, $SD = .15$), and adjusted posttest mean ($M = .15$). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were no significant differences among the pair wise comparison of adjusted means between the two groups.

The participants were also evaluated on a one-to-one counting fluency task on the PNI for Question Two. On this task the participants were required to count while pointing to each dot on a page of 20 dots. The participants were given up to 60 seconds to complete the task. The ANCOVA was significant for this test item, $F(1,46) = 69.32$, $p = <.001$, ŋ = .6 (see Table 5). The strength of the effect size between the intervention and the dependent variable was assessed as large on the dependent measure, holding constant the pretest math achievement scores. Of the two groups, the treatment group had the higher pretest mean ($M = 6.08$, $SD = 7.19$), posttest mean ($M = 9.92$, $SD = 7.11$) and adjusted mean ($M = 9.7$), whereas the comparison group had the lower pretest mean ($M = 5.54$, $SD = 6.51$), posttest mean ($M = 6.23$, $SD = 6.42$), and adjusted posttest mean ($M = 6.43$). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were significant differences among the pair wise comparison of adjusted means between the two groups ($p = .01$).

Table 5

Analysis of Co-Variance for One-to-One Correspondence

Source	*SS*	*df*	*MS*	*F*	*P*	*Effect Size*
TEMA-3						
Item Number 5	.68	1	.68	3.67	.062	.07
Error	8.69	47	.19			
Total	13	50				
PNI						
One to One Counting Fluency	1306.58	1	1306.58	69.32	<.001**	.6
Error	885.87	47	18.85			
Total	5562	50				

* = significance at the alpha level of .05, ** = significance at the Bonferroni adjusted level of .016

Research Question Three. Will using a mathematics intervention of shared storybook readings and related activities promote the quantity comparison skills of preschoolers with disabilities?

Results of Research Question Three. For the purpose of this study, the author defined quantity comparison skills as the accurate demonstration through gesturing, pointing, touching, or verbalizing which group has "more" objects. Item number four on the TEMA-3 was analyzed separately for this question. This particular item required the participant to view a page divided into two sections, one section having more dots than the other side. The participant was asked to choose the side with more dots. The participant had one practice trial followed by four performance trials to complete the task. The participant was required to get all performance trials correct in order to receive credit for the item (i.e., total task score of 1 for all 4 trials correct, total task score of 0 for any incorrect answers). The ANCOVA was significant for this test item, $F(1,46) = 16.86$, $p = <.001$, ŋ = .26 (see Table 6). The strength of the effect size between the intervention and the dependent variable was assessed as medium on the dependent measure, holding constant the pretest math achievement scores. Of the two groups, the treatment group had the lower pretest mean ($M = .33$, $SD = .48$) and the higher posttest mean ($M = .75$, $SD = .44$) and adjusted mean ($M = .79$). The comparison group had the higher pretest mean ($M = .5$, $SD = .51$) and lower posttest mean ($M = .35$, $SD = .49$) and adjusted mean ($M = .31$). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were significant differences among the pair wise comparison of adjusted means between the two groups ($p = <.001$).

The Quantity Comparison task on the PNI was also analyzed for this question. The PNI was very similar to the TEMA-3 item in that children chose which one of two sides of a page had more dots. However, on the PNI, the children were timed and the number correct within one minute was the final score. The ANCOVA for this test item was significant, $F(1,46) = 6.44$, $p = .01$, ŋ = .12 (see Table 6). The strength of the effect size between the intervention and the dependent variable was assessed as small on the dependent measure, holding constant the pretest math achievement scores. Of the two groups, the treatment group had the lower pretest mean ($M = 7.5$, $SD = 4.63$) and the higher posttest mean ($M = 12.33$, $SD = 7.46$) and adjusted mean ($M = 12.47$). The

Table 6

Analysis of Co-Variance for Quantity Comparison

Source	*SS*	*df*	*MS*	*F*	*p*	*Effect Size*
TEMA-3	.					
Item Number 4	2.81	1	2.81	16.86	<.001**	.26
Error	7.83	47	.17			
Total	27	50				
PNI						
Quantity Comparison	225.1	1	225.1	6.44	.01**	.12
Error	1642.05	47	34.94			
Total	8301	50				

* = significance at the alpha level of .05, ** = significance at the Bonferroni adjusted level of .016

comparison group had the higher pretest mean (*M* = 7.81, *SD* = 6.92) and lower posttest mean (*M* = 8.35, *SD* = 7.90) and adjusted mean (*M* = 8.22). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were significant differences among the pair wise comparison of the adjusted means between the two groups (*p* = .016).

Research Question Four. Will using a mathematics intervention of shared storybook readings and related activities promote the numeral identification skills of preschoolers with disabilities?

Results of Research Question Four. For the purpose of this study, the author defined numeral identification skills as the accurate demonstration through gesturing, pointing, or touching the correct numeral in an array of three numerals on the first opportunity, or verbalizing the number name of a numeral. All participating children were able to verbalize to the extent of naming numerals and counting so no accommodations were used.

Item number fourteen on the TEMA-3 was analyzed for this question. This particular item required the participant to view a page with one number on the page and verbally give the numeral name. The participant was required to get all performance trials correct in order to receive credit for the item (i.e., total task score of 1 for all 3 trials correct, score of 0 for any incorrect answers). The numerals two, five, and six were examined for this task. The ANCOVA for this test item was not significant, $F(1,46) = 1.61$, $p = .21$, ŋ = .03 (see Table 7). Of the two groups, the treatment group had the lower pretest mean ($M = .33$, $SD = .48$), and although not significant, the treatment group had a higher posttest mean ($M = .58$, $SD = .50$) and adjusted mean ($M = .64$). The comparison group had the higher pretest mean ($M = .5$, $SD = .51$), lower posttest mean ($M = .54$, $SD = .51$) and adjusted mean ($M = .49$). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were no significant differences among the pair wise comparison of adjusted means between the two groups.

The number naming PNI subtest was also analyzed using ANCOVAs for this question. This task required participants to name as many numerals from zero to twenty on flashcards within one minute. The numbers were in random order. The ANCOVA for this test item was not significant, $F(1,46) = 1.42$, $p = .24$, ŋ = .03 (see Table 7). The

Table 7

Analysis of Co-Variance for Numeral Identification

Source	*SS*	*Df*	*MS*	*F*	*P*	*Effect Size*
TEMA-3						
Item Number 14	.27	1	.27	1.61	.21	.03
Error	7.75	47	.17			
Total	28	50				
PNI						
Numeral Naming	64.22	1	64.22	1.42	.24	.03
Error	2126.89	47	45.25			
Total	7918	50				

treatment group had the lower pretest mean (*M* = 7.17, *SD* = 6.49), and although not significant, the treatment group had a higher posttest mean (*M* = 10.08, *SD* = 8.27) and adjusted mean (*M* = 10.34). The comparison group had the higher pretest mean (*M* = 7.77, *SD* = 7.31), and lower posttest mean (*M* = 8.31, *SD* = 9.19) and adjusted mean (*M* = 8.07). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were no significant differences among the pair wise comparison of adjusted means between the two groups.

Oral Counting Fluency. Although not a research question, it was interesting to analyze the results of the oral counting fluency items of the TEMA-3 and the PNI. Although the treatment group's scores on the TEMA-3 showed progress, there was no significance on this task between the two groups. On the TEMA-3, the item *A3* was examined for rote counting from one to five. This particular item required the participant to count his or her fingers from one to five. The participant was required to get all performance trials correct in order to receive credit for the item. The ANCOVA for this test item was not significant, $F(1,46) = 3.54$, $p = .066$, ŋ = .07 (see Table 8). The treatment group had the lower pretest mean ($M = .33$, $SD = .48$), but the higher posttest mean ($M = .75$, $SD = .44$) and adjusted mean ($M = .79$). The comparison group had the higher pretest mean ($M = .5$, $SD = .51$), but the lower posttest mean ($M = .62$, $SD = .49$) and adjusted mean ($M = .58$). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were no significant differences among the pair wise comparison of adjusted means between the two groups.

However, there was significance on the PNI oral counting fluency subtest. On the PNI oral counting fluency task, participants were required to orally rote count to the highest number possible without verbal or visual prompting. The ANCOVA for this test item was significant, $F(1,46) = 8.16$, $p = .006$, ŋ = .15 (See Table 8). The strength of the effect size between the intervention and the dependent variable was assessed as small - medium on the dependent measure, holding constant the pretest math achievement scores. The treatment group had the lower pretest mean ($M = 8.83$, $SD = 9.55$), but the higher posttest mean ($M = 13.50$, $SD = 9.42$) and adjusted posttest mean ($M = 13.53$). The comparison group had slightly higher pretest mean ($M = 8.92$, $SD = 8.69$), but the lower posttest mean ($M = 8.77$, $SD = 7.09$) and adjusted posttest mean ($M = 8.74$). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were significant differences in the adjusted means between the two groups ($p = .006$).

Table 8

Analysis of Co-Variance for Oral Counting Fluency

Source	*SS*	*Df*	*MS*	*F*	*P*	*Effect Size*
TEMA-3						
Item Number 3	.52	1	.52	3.54	.066	.07
Error	6.94	47	.148			
Total	34	50				
PNI						
Oral Counting Fluency	285.96	1	285.96	8.16	.006**	.15
Error	1646.72	47	35.04			
Total	9580	50				

* = significance at the alpha level of .05, ** = significance at the Bonferroni adjusted level of .016

Cardinality Rule. Although not a research question, it was interesting to analyze the results of the cardinality rule of the TEMA-3, item *A7.* The PNI did not test for this counting concept. The cardinality rule is defined by counting a number of items and then answering “how many?” objects they counted (Clements & Sarama, 2009).The participants were given one opportunity to state the number of stars (i.e., 5) on a page after counting the five stars. The ANCOVA for this test item was significant, $F(1,46) = 6.37$, $p = .015$, ŋ = .12 (See Table 9). The strength of the effect size between the intervention and the dependent variable was assessed as small on the dependent measure, holding constant the pretest math achievement scores. The treatment group had the higher

Table 9

Analysis of Co-Variance for Mathematics Achievement by TEMA-3 Cardinality Rule

Source	*SS*	*Df*	*MS*	*F*	*P*	*Effect Size*
TEMA-3	1.14	1	1.14	6.37	.015**	.12
Error	8.43	47	.179			
Total	19	50				

pretest mean (*M* = .21, *SD* = .42), and the higher posttest mean (*M* = .54, *SD* = .51) and adjusted posttest mean (*M* = .54). The comparison group had a slightly lower pretest mean (*M* = .19, *SD* = .40), and lower posttest mean (*M* = .23, *SD* = .43) and adjusted posttest mean (*M* = .24). Follow-up tests were conducted to evaluate pair wise differences among the adjusted means. There were significant differences in the adjusted means between the two groups (p = .015).

In summary, the treatment group made larger gains on all tasks on the TEMA-3 and PNI than the comparison group. The areas of significance on the TEMA-3 included: (1) math ability score, (2) quantity comparison, and (3) the cardinality rule. The areas of significance on the PNI included: (1) one-to-one counting fluency, (2) quantity comparison, and (3) oral counting fluency. The areas with the highest effects included (1) one-to-one counting fluency on the PNI, (2) quantity comparison skills on the PNI and TEMA-3, (3) and total math ability on the TEMA-3 (see Table 10).

Table 10

Significance and Effect Sizes on TEMA and PNI

Test Item	*p* Value	Significance	Effect Size
TEMA-3 Math Ability Score	<.001**	Significant	.22
One to One Correspondence			
TEMA-3	.062	Not Significant	.07
PNI	<.001**	Significant	.6
Quantity Comparison			
TEMA-3	<.001**	Significant	.26
PNI	.01**	Significant	.12
Numeral Identification			
TEMA-3	.21	Not Significant	.03
PNI	.24	Not Significant	.03
Oral Counting Fluency			
TEMA-3	.066	Not Significant	.07
PNI	.006**	Significant	.15
Cardinality Rule			
TEMA-3	.015**	Significant	.12

* = significance at the alpha level of .05, ** = significance at the Bonferroni adjusted level of .016

CHAPTER FIVE

DISCUSSION

The purpose of this study was to investigate the effects of an intervention integrating mathematics within children's literature on the early numeracy skills of young children with disabilities. Specifically, this study examined total math ability as well as the early numeracy skills of one-to-one correspondence, quantity comparisons (i.e., "more than"), and numeral identification.

Conclusions

Researchers have found that when typically developing preschoolers were provided with an intervention that integrated math activities within children's literature, preschool children made significant progress in math skills (e.g., Arnold et al., 2002; Hong, 1996; Jennings et al., 1992). The current study found that an intervention that integrated mathematics within children's literature increased mathematical skills for preschoolers with disabilities, particularly in overall math ability, quantity comparisons, counting fluency, and the cardinality rule of counting.

Overall math ability. The preschoolers' total early numeracy ability was assessed using the TEMA-3 *Math Ability* score. The ANCOVA, controlling for the pretest scores, showed a clear statistical significance between the comparison group and the treatment group, indicating that this intervention was highly effective in improving preschoolers' overall early numeracy skills. The significance on the *Total Math Ability* on the TEMA-3 was promising, as the intervention was relatively short (i.e., 6-weeks) and targeted only three specific skills of total early math abilities. Yet, the treatment groups' total mathematics ability was positively influenced.

One-to-One Correspondence. The preschoolers were assessed on their one-to-one correspondence skills by using item number five on the TEMA-3. The treatment group made more progress in this area than the comparison group, though the gains were not significant based on the ANCOVA. Although the intervention targeted one-to-one correspondence skills, as defined in the methods section, the nature of the test item was slightly more challenging and confusing to the young children with disabilities. For the purposes of this study, one-to-one correspondence was defined as the accurate demonstration of a child matching each object in the first group with exactly one object in the second group, while each object in the second group had to be matched with exactly one object in the first group (Heddens & Speer, 1992). This test item on the TEMA-3 added a level of difficulty by requiring the examiner to hide his or her tokens before the child placed the same number of tokens of the examiner on his or her paper. While a few children understood this task, many of the participants appeared confused by the hiding of the tokens. Some children verbally reported that they tried to "trick" the examiner by placing a different number of tokens on their paper, others tried to hide tokens by placing them under their own paper, and others appeared to not understand the task. Further, this task also required short term memorization by the children. Although it is not known whether the children would have experienced more success at this task if the tokens were not hidden, it is believed that if the test item did not have the hidden token feature, the results may have been slightly different. According to Porter's (1999) study that specifically examined children with Down syndrome's early numeracy skills, Porter found that children with Down syndrome experienced a relative strength in one-to-one correspondence; however, in the current study, neither the one participant with Down syndrome in the comparison group nor the one participant with Down syndrome in the treatment group experienced any growth in this area, according to the TEMA-3.

On the PNI, the children were assessed on one-to-one counting fluency skills, in which the treatment group experienced a significant improvement throughout the intervention. Although not a targeted skill for the intervention, oral rote counting and pointing to objects while counting was intentionally modeled by the instructors throughout the storybook reading and activities. The children were also encouraged to count objects by touching each object when naturalistic opportunities occurred during the instruction. The significance on this test item demonstrated the effects of naturalistic opportunities of improving one-to-one counting fluency with this intervention without explicit or direct instruction for the participants in this study.

Quantity Comparison. The quantity comparison task was noted to have small to medium effects for the children in the treatment group on both assessments. There are two reasons the author believes this task had stronger effects with this intervention than some of the other tasks. First, the skill of noting which of the two groups have “more” objects is one of the most fundamental and early developing numeracy skill of the skills targeted for this intervention. Also, as discovered throughout the intervention, this skill was the most natural concept to incorporate in math implicit storybook readings. For example, two of the targeted storybooks had several pictures throughout the book that naturally allowed for discussion of which page or object had more. *The Snowy Day* had some pages with more snowballs or snowflakes than other pages. The caterpillar in *The Very Hungry Caterpillar* ate more fruits than others on the different days of week.

Therefore, this skill was not only addressed in the activities, but also easily targeted during the storybook readings.

Numeral Identification. The results of the numeral identification tasks on both the TEMA-3 and the PNI showed progress with the treatment group, yet did not prove to be significant for this intervention. After the pre-assessment of all children, it was clear that there was a great range in numeral identification abilities. Some children could name numerals one to twenty at pre-assessment, whereas other children could not name any numbers. Some children named the numerals with color names or letters, instead of numerals, suggesting that they did not have foundational numeral discrimination skills. It is believed that numeral identification proved to be challenging in this intervention for two reasons. First, this intervention included children ages three to five. Some of the three-year-old children may not have been developmentally ready for numeral identification skills. To determine if that hypothesis was accurate, the researchers ran an additional analysis on the numeral identification tasks of only four and five year old children. The researchers found that for this analysis, scores for the four- and five-year-old children in the treatment group were significantly higher than the four- and five-year-olds in the comparison group in numeral identification. Second, in using children's literature with an implicit mathematical focus, other than the page numbers, there were no numerals to naturally discuss within the pictures. Therefore, unlike *quantity comparison* skills that were naturally discussed and taught during story time and activities, the numeral identification tasks were only naturally targeted during the activities. It is also possible that given more time, the intervention may have been more effective in this area.

Additional Significant Gains. Although not a targeted area, children in the treatment group made significant progress in the counting skills of oral counting fluency on the PNI and the cardinality rule on the TEMA-3, as noted by ANCOVAs. Oral counting fluency consisted of the children counting from one to the highest number possible without visuals or other assistance. The cardinality rule is defined by children counting a number of items and then answering "how many?" objects they counted (Clements & Sarama, 2009).Although the cardinality rule is a skill that is often neglected in math and counting instruction with preschoolers (Linnell & Fluck, 2001), the treatment group made significant progress in this area, as noted by an ANCOVA on the TEMA-3, test item number seven. It is hypothesized that the ANCOVAs were significant in these areas since counting skills, though not targeted objectives nor explicitly taught, were naturally and intentionally modeled and encouraged throughout the intervention. Porter (1999) noted that while children with Down syndrome vary in ability skills, overall the children they examined had difficulty producing an accurate rote counting sequence, particularly compared to other numeracy-related skills. The current study consisted of one participant with Down syndrome in the comparison group and one in the treatment group. The participant with Down syndrome in the treatment group experienced a gain in rote counting from accurately counting to two at pretest to accurately counting to 19 at posttest. This student also experienced gain in all other numeracy skills. The participant with Down syndrome in the comparison group did not experience any gain throughout the 6-week period. Although certainly not representative of all children with Down syndrome, these findings suggest the potential of early numeracy interventions for young children with Down syndrome.

Summary. As noted by several researchers, math skills are correlated with future success in school (Claessens et al., 2009; Clark, 1988; Duncan et al., 2007; Eccles, 1997). Yet, instruction in mathematics is lacking in preschool classrooms, as compared to other areas such as literacy (Phillips & Meloy, 2012). This study adds to the research base that young children with disabilities are developmentally ready for formal early mathematics instruction, and that young children with disabilities can benefit from a mathematics intervention that integrates mathematics within children's literature.

Interestingly, the majority of children in this study, all of whom had disabilities, improved in their early numeracy skills in a similar order as that of typically developing children. For example, the early numeracy skills targeted for this study included one-to-one correspondence, quantity comparison, and numeral identification skills. It is well-documented that typical children developmentally learn one-to-one correspondence and quantity comparison skills before numeral identification skills (e.g., Clements & Sarama, 2009). In this study, the children with disabilities in the treatment group showed the most growth in quantity comparative skills (i.e., "more"), followed by one-to-one correspondence, then numeral identification. In this study, the exception would be the children reported with a medical diagnosis of autism. Though there were only 10 children with autism in the study (Treatment N = 3, Comparison N = 7), there was a trend that the majority of participants with autism began the study with higher numeral identification skills than children with other diagnoses, and therefore showed little growth in this area from pre to post testing. Interestingly, at the pretest, children with autism experienced the most difficulty with the skill of quantity comparison. According to the PNI, children with autism took almost the entire six weeks to fully master the quantity comparison skills, whereas many of the children without autism mastered this skill much earlier. It is possible that the reason for the struggle of learning quantity comparison skills is due to the linguistic and conceptual nature of the task, whereas numeral identification is a rote, visual, and procedural skill that requires little linguistics or conceptual knowledge to learn and is therefore easier for children with autism. These results are similar to prior research studies in mathematics for children with autism. Dehaene, Spelke, Pinel, Stanescu, and Tsivkin (1999) noted that children use the inferior parietal cortex of both hemispheres of the brain to judge magnitude (e.g., quantity comparison). However, numeral identification skills, or those skills used to recognize numerals in their visual Arabic written form, are located in the occipitotemporal region of both hemispheres. Although not unanimous, many studies have shown that children with autism have highly developed visual learning skills (e.g., Sherer et al., 2001). Therefore, it is understandable that numeral identification skills would be a relative strength for children with autism, whereas quantity comparison might be more difficult. Similar to the current study, although many children with autism start out with lower-achieving math skills, they can catch up with peers, though their growth may be slower than some other disability groups (Carlson, Jenkins, Bitterman, & Keller, 2011; Wei et al., 2012).

Implications

The integration of mathematics within children's literature holds promise to make mathematics instruction more meaningful and engaging to students (Hoffman, 2002; Anderson et al., 2004; Murphy, 2000; Ojose, 2008; Whitin, 2002). Previous research has shown that integrating mathematics instruction within children's literature is effective for improving math abilities for typically developing preschoolers and preschoolers who are considered at-risk (Anderson, 1997; Anderson et al., 2004, Anderson et al., 2005; Casey et al., 2008; Hong, 1996; Jennings et al., 1992; Skoumpourdi & Mpakopoulou, 2011; Van den Heuvel-Panhuizen, & Iliada, 2011; Whitin & Gary, 1994). The current study has now shown that this integration can be beneficial for improving early mathematics skills with preschoolers with disabilities. Implications of this study for classroom teachers include: 1) the possibility of integrating the content areas of literature and mathematics for young children with disabilities, 2) the benefits of the intentional selection of storybooks for this integration, and 3) introducing mathematical topics to preschoolers with disabilities in order of developmental cognitive readiness.

Research has shown that there is a lack of math instruction in many preschool classrooms. Integrating the mathematics instruction within children's literature allowed interventionists in this study to not only provide a shared storybook reading to the children using quality children's literature, but also encouraged the construction of early numeracy concepts. Within twenty minutes per intervention day, three times per week for six weeks, two content areas were targeted: storybook reading and mathematics. Further, since many school districts currently face budget shortfalls, the researcher made it a priority to keep the cost of the materials and books to a minimum when developing this particular intervention. This intervention did not require a costly commercialized program. This intervention was relatively inexpensive since the books and materials used are easily found in preschool classrooms. For example, the manipulatives used were materials that each teacher already had in her classroom (i.e., counting/sorting bears, links, and snapping cubes), the books were already included in the classroom, and were in the repertoire of the teachers' regular story time readings (i.e., *The Snowy Day*, *Goldilocks and the Three Bears*, and *The Very Hungry Caterpillar*). Additionally, all activities were created using typical inexpensive preschool materials: (e.g., plastic bowls, computer paper, construction paper, crayons, magnets, and glue).

The researchers found that when using the intervention of integrating mathematics within children's literature for the purpose of improving early numeracy skills, it is important to be intentional and purposeful in selecting the storybooks, and to consider which books are best for teaching particular skills. For this study, all three early numeracy skills targeted for the intervention (i.e., one-to-one correspondence, quantity comparison, and numeral identification) were taught with each storybook. However, after considering the quality of children's literature, each storybook was chosen for a particular mathematical focus. For example, *The Three Bears* has great potential for one-to-one correspondence, as each bear has his or her own bowl, spoon, chair, and bed. Yet, for *quantity comparison* it is rare that any bear character ever has more or less than the other. Therefore, *The Three Bears* would be best used if discussing the quantity comparison concept of "same." *The Snowy Day* was chosen for quantity comparison. For example, the main character made more snow angels than snowmen, and the amount of snow, snowballs and snowflakes differed on particular pages. Yet, this book was more difficult to use to teach numeral identification and one-to-one correspondence. *The Very Hungry Caterpillar* was chosen for numeral identification. Although the book did not explicitly present numerals, showing the children a numeral while pointing out a particular number of fruits in the book was easily implemented, yet not entirely natural of typical storybook reading. This book also held great promise for *quantity comparison*.

Lastly, implications of this study suggest the similar nature of developmental mathematical milestones of young children with and without disabilities. As previously noted, there is a particular order in which many typically developing children acquire math concepts. Typically developing children acquire one-to-one correspondence and quantity comparison prior to numeral identification (Clements & Sarama, 2009). This study mirrored that same developmental growth for most children with disabilities. It is not to say that teachers should not focus on all math concepts throughout the day, but to recognize that as with typically developing peers, the young children with disabilities in this study may not be cognitively ready for more complex mathematical skills, such as numeral identification before they acquire the prerequisite skills.

Limitations

There are several limitations to this study. These limitations include the length of the intervention, the representativeness and size of the sample, the nature of assessing one-to-one correspondence, knowledge of ongoing classroom math activities, and lack of generalization data.

Length of Intervention. Though the intervention was implemented for six-weeks, three days per week, for twenty minutes per session, the participants in this intervention may have benefitted even further if there had been a longer time-frame. The length of intervention is in line with other studies that have utilized storybook readings as a part of their mathematics intervention (Arnold et al., 2002; Young-Loveridge, 2004); however, some studies that used implicit storybook readings as their sole intervention utilized longer intervention time-lines (e.g., Jennings et al., 1992; Van den Heuvel-Panhuizen & Iliada, 2011). In order to attempt to overcome this limitation, the children in the current study received the intervention three days per week for a focused 20-minute session of instruction.

Representativeness of Sample. Though the potential sample for this study included all preschoolers meeting the inclusionary criteria from one school district in the southeastern region of the United States, the sample is of course not representative of all preschoolers with disabilities. The children's participation was voluntary. The participants' school and classroom teachers were based on geographical location of the children's residence. While the researchers divided schools based on SES status and then randomly assigned the schools to the treatment and comparison groups, certainly SES and other factors may contribute to a lack of representativeness across various income and cultural categories.

Sample Size. The total sample size was 50 students with disabilities in self-contained special needs preschools. It may be difficult to generalize the results of this study based on the relatively small sample size. A larger sample of preschoolers with disabilities may provide additional information regarding the effectiveness of this intervention; however, this is a beginning step to evaluating mathematical interventions with larger groups of preschoolers with disabilities.

One-to-One Correspondence Test Item. Due to the possible lack of proficient verbal language of preschoolers with disabilities, the researchers attempted to choose a test item to measure one-to-one correspondence in a non-verbal manner. The researcher used the TEMA-3 test item number five to assess for one-to-one correspondence. This task proved to be challenging for these preschool children with disabilities. The researchers believe that the task difficulty is possibly due to the directions of the task rather the children's understanding of the concept. The children were more interested in hiding their own tokens, or "tricking" the researcher with the number of tokens on the paper, rather than completing the task appropriately. Further, the PNI examined one-to-one correspondence counting fluency, which differed in the definition used for this study and is reported with only .62 reliability. Therefore, the researchers are not confident in accurately reporting whether the children did or did not make significant progress in this area. In future studies of preschoolers with disabilities, the researchers may need to examine a different measure of one-to-one correspondence.

Knowledge of Ongoing Classroom Math Activities. Although the teachers reported that they did not use a mathematics curriculum in their classroom instruction, there were no data collected regarding the current math practices within the daily activities of the classroom. Within the timeframe the researchers were in the classroom assessing, instructing, or gathering the groups of children, the researchers noted occasional math activities occurring in the classroom, such as counting the numbers on the calendar, matching the corresponding number of objects with the related numeral, and sorting activities.

Lack of Generalization Data. Due to time restraints, there were no generalization data collected on either the intervention or the comparison group.

Future Research Suggestions

Based on the results of the current study, some future research considerations are suggested. Future research areas include replicating this study with a larger sample size, examining additional early numeracy concepts, examining the maintenance of math skills with young children with disabilities over time, implementing this intervention in inclusive settings, analyzing data based on different disability areas, examining the pattern of decreasing posttest mean scores on the comparison group, as well as educating parents and teachers to implement this intervention.

As noted previously, the results of this study may not be generalizable to children with disabilities from other parts of the state or county. It will be important to replicate the current study with young children in various sections of the state or in other states, and also with larger sample sizes to allow for using modeling in data analysis. Although the sample consisted of children from a range of socioeconomic levels, race, and disabilities, the results may vary in urban or more rural environments, as well as with children with different disability areas.

Integrating mathematics within children's literature has been conducted in the math areas of measurement (Van den Heuvel-Panhuizen, & Iliada, 2011; Whitin & Gary, 1994), geometry (Casey et al., 2008; Hong, 1996; Rosen & Hoffman, 2009; Skoumpourdi & Mpakopoulou, 2011), fractions (e.g., Conaway & Midkiff, 1994), estimation (e.g., Whitin, 1994), math vocabulary (Jennings et al., 1992), classification (Hong, 1996), and number combinations (Hong, 1996) with children who are at risk or typically developing. It would be interesting to examine whether preschoolers with disabilities make progress in these mathematical areas, in addition to the early numeracy concepts measured in this study. Further, it would be interesting to measure if children maintained these skills over time.

The current study consisted of preschoolers with a variety of disabilities. Due to the young age of the participants, many children were included in the SDD eligibility group, with no particular diagnoses. Therefore, it was difficult to discern for which groups this intervention was more or less successful. It would be interesting to examine how the current intervention may affect different disability groups on particular tasks and in total mathematical ability.

It was interesting to note that the comparison group's mean scores decreased over the intervention period on several test items and subtests. In future math studies of children with disabilities, it would be noteworthy to examine if decreasing posttest mean scores is a typical pattern of the comparison group and to analyze the factors related with the decreased scores.

Finally, this intervention, though completed during the school day in the school building, was conducted by research interventionists with small groups of students. The authors recognize that the results may vary if this intervention was conducted by the classroom teacher or within inclusive settings. Future studies may want to utilize a teacher for implementation of the intervention. Further, as the home environment and the significant adults in a young child's life highly influence the children's mathematical knowledge (Anders et al., 2012; Aubrey et al., 2003; Blevins-Knabe & Musun-Miller, 1996; Melhuish et al., 2008) and the way children engage in mathematical experiences (Aubrey et al, 2003), it would be interesting to examine parental implementation of this intervention with preschoolers with disabilities in the home environment. Several studies have shown increases in children's mathematical knowledge through parent-led shared storybook readings for typically developing children targeting skills such as naming shapes and numbers as well as size, subitizing, and counting (e.g., Anderson, 1997; Anderson & Anderson, 1995; Anderson et al., 2004, 2005).

Conclusion

In summary, preschool children with disabilities increased their skills in math after an intervention integrating mathematics within children's literature. This study adds to a sparse, but growing, body of literature of intervention mathematics research for young children with disabilities. Although it remains unclear exactly how emergent literacy, language, and early numeracy influence each other (Purpura et al., 2011), this study adds to the literature that supports integration of the content areas of literacy and mathematics. Results of this study demonstrate that children with disabilities can benefit from formal mathematics instruction and math interventions, as well as underscore the potential of teaching and focusing on early numeracy to young children with disabilities.

References

Agondi, R., & Harris, B. (2010). An experimental evaluation of four elementary school math curricula. *Journal of Research on Educational Effectiveness, 3,* 199-253. doi: 10.1080/19345741003770693.

Ainley, J. (1990). Playing games and learning mathematics. In L. P. Steffe & T. Wood (Eds.), *Transforming children's mathematics education: International perspectives* (pp. 84-91). Hillsdale, NJ: Erlbaum.

Akmanoglu, N., & Batu, S. (2004). Teaching pointing to numerals to individuals with autism using simultaneous prompting. *Education and Training in Developmental Disabilities, 39,* 326-336.

Allen, P. (1980). *Mr. Archimede's Bath* (1st U. S. ed.). New York: Lothrop, Lee, & Shephard Books.

Allen, P. (1988). *Who sank the boat?* New York: Putnum & Grosset Group.

Anders, Y., Rossbach, H.-G., Weinert, S., Ebert, S., Kuger, S., Lehrl, S., & von Maurice, J. (2012). Home and preschool learning environments and their relations to the development of early numeracy skills. *Early Childhood Research Quarterly, 27,* 231-244. doi: 10.1016/j.ecresq.2011.08.003.

Anderson, A. (1997). Families and mathematics: A study of parent-child interactions. *Journal for Research in Mathematics Education, 28*, 484-511.

Anderson, A., & Anderson, J. (1995). Learning mathematics through children's literature: A case study. *Canadian Journal of Research in Early Childhood Education, 4,* 1-9.

Anderson, A., Anderson, J., & Shapiro, J. (2004). Mathematical discourse in shared storybook reading. *Journal for Research in Mathematics Education, 35*, 5-33.

Anderson, A., Anderson, J., & Shapiro, J. (2005). Supporting the multiple literacies: Parents' and children's mathematical talk within storybook reading. *Mathematics Education Research Journal, 16,* 5-26.

Andersson, U., & Lyxell, B. (2007). Working memory deficit in children with mathematical difficulties: A general or specific deficit? *Journal of Experimental Child Psychology, 96,* 197-228.

Anno, M. (1977). *Anno's counting book.* New York: Crowell.

Anno, M. (1983). *Anno's mysterious multiplying jar* (1st USA ed.). New York: Philomel Books.

Anno, M. (1986). *All in a day.* New York: Philomel Books.

Anno, M. (1995). *Anno's magic seeds* (1st American Edition). New York: Philomel Books.

Anno, M. (1997). *Anno's math games II.* New York: Philomel.

Antell, S. E., & Keating, D. P. (1983). Perception of numerical invariance in neonates. *Child Development, 54,* 695-701.

Archer, A. L., & Hughes, C. A. (2010). *Explicit Instruction: Effective and efficient teaching.* New York, NY: Guilford Press.

Arias de Sanchez, G. (2010). The use of worksheets in early childhood mathematics education. In R. Doiron & M. Gabriel (Eds.), *Research in early child development in Prince Edward Island: A research monograph* (pp.127–139). Charlottetown, PE: Centre for Education Research, University of Prince Edward Island.

Arnold, D. H., Fisher, P. H., Doctoroff, G. L., & Dobbs, J. (2002). Accelerating math development in Head Start classrooms. *Journal of Educational Psychology, 94*, 762-770.

Aubrey, C., Bottle, G., & Godfrey, G. (2003). Early mathematics in the home and out-of-home contexts. *International Journal of Early Years Education, 11*, 91-103. doi: 10.1080/0966976032000116158

Avant, M. J. T., & Heller, K. W. (2011). Examining the effectiveness of Touch Math with students with physical disabilities. *Remedial and Special Education, 32,* 309-321. doi: 10.1177/0741932510362198

Ayer, F. C. (1925). *Time allotments in the elementary school subjects.* City School Leaflet No. 19. Washington, D.C.: Bureau of Education.

Baker, S. K., Kame'enui, E. J., & Simmons, D. C. (1998). The characteristics of students with diverse learning and curricular needs, (pp. 19-44). In E. J. Kame'enui & D. W. Carnine (Eds.), *Effective teaching strategies that accommodate diverse learners*. Columbus, OH: Merrill.

Baldi, S., Jin, Y., Skemer, M., Green, P.J., & Herget, D. (2007). *Highlights From PISA 2006: Performance of U.S. 15-year-old students in science and mathematics literacy in an international context* (NCES 2008–016). National Center for Education.

Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Balfanz, R. (1999). Why do we teach children so little mathematics? Some historical considerations. In J. V. Copley (Ed.), *Mathematics in the early years* (pp. 3-10). Reston, VA: National Council of Teachers of Mathematics.

Balfanz, R., Ginsburg, H. P., & Greenes, C. (2003). The Big Math for Little Kids early childhood mathematics program. *Teaching Children Mathematics, 9,* 264-268.

Ball, C. R., & Trammell, B. A. (2011). Response-to-intervention in high-risk preschools: Critical issues for implementation. *Psychology in the Schools, 48,* 502-512. doi: 10.1002/pits.20572

Barbareski, W. J., Katusic, S. K., Colligan, R. C., Weaver, A. L., & Jacobsen, S. J. (2005). Math learning disorder: Incidence in a population-based birth cohort, 1976–82, Rochester, Minn. *Ambulatory Pediatrics, 5,* 281–289.

Baroody, A. J. (1986). Basic counting principles used by mentally retarded children. *Journal for Research in Mathematics Education, 17,* 382-389.

Baroody, A. J. (1987). *Children's mathematical thinking: A developmental framework for preschool, primary, and special education teachers.* New York: Teachers College Press.

Baroody, A. J. (2000). Does mathematics instruction for three- to five-year-olds really make sense? *Young Children, 55,* 61-67.

Baroody, A. J. (2003). The development of adaptive expertise and flexibility: The integration of conceptual and procedural knowledge. In A. J. Baroody & A. Dowker (Eds.), *The development of arithmetic concepts and skills: Constructing adaptive expertise studies* (pp. 1-34). Mahwah, NJ: Erlbaum.

Baroody, A. J. (2004). The developmental bases for early childhood number and operations standards. In D. H. Clements, J. Sarama, & A.M, DiBiase (Eds.), *Engaging young children in mathematics: Standards for early childhood mathematics education* (pp.173-219). Mahwah, NJ: Lawrence Erlbaum Associates.

Baroody, A. J., Eiland, M., & Thompson, B. (2009). Fostering at-risk preschoolers' number sense. *Early Education and Development, 20,* 80-128.

Baroody, A. J., & Ginsburg, H. P. (1982). Preschoolers' informal mathematical skills: Research and diagnosis. *American Journal of Diseases of Children, 136*, 195-197.

Baroody, A. J., Lai, M. L., & Mix, K. S. (2006). The development of young children's early number and operation sense and its implications for early childhood education. In O. Saracho & B. Spodek (Eds.), *Handbook of research on the education of young children* (pp. 187-221). Mahwah, NJ: Erlbaum.

Battista, M. T. (1999). The mathematical miseducation of America's youth: Ignoring research and scientific study in education. *Phi Delta Kappan, 80,* 424-433.

Beatty, B. (1995). *Preschool Education in America: The culture of young children from the colonial era to the present.* New Haven: Yale University Press.

Benoit, L., Lehalle, H., & Jouen, F. (2004). Do young children acquire number words through subitizing or counting? *Cognitive Development, 19*, 291-307.

Berch, D. B. (2005). Making sense of number sense: Implications for children with mathematical disabilities. *Journal of Learning Disabilities, 38,* 333-339. doi: 10.1177/00222194050380040901.

Berch, D. B., & Mazzocco, M. M. M. (Eds.). (2007). *Why is math so hard for some children? The nature and origins of mathematical learning difficulties and disabilities.* Baltimore, MD: Paul H. Brooks.

Berenstain, S., & Berenstain, J. (1969). *Bears on wheels.* New York: Random House.

Berenstain, S., & Berenstain, J. (1971). *Bears in the night.* New York: Random House.

Bidwell, J. K., & Clason, R. G. (Eds.) (1970). *Readings in the history of mathematics education.* Washington, D.C.: National Council of Teachers of Mathematics.

Bjorklund, D. E., Hubertz, M. J., & Reubens, A. C. (2004). Young children's arithmetic strategies in social context: How parents contribute to children's strategy development while playing games. *International Journal of Behavioral Development, 28*, 347-357.

Blair, C., & Razza, R. P. (2007) Relating effortful control, executive function, and false-belief understanding to emerging math and literacy ability in kindergarten. *Child Development, 78,* 647–663.

Blevins-Knabe, B., Austin, A. B., Musun, L., Eddy, A., & Jones, R. M. (2000). Family home care providers' and parents' beliefs and practices concerning mathematics with young children. *Early Child Development and Care, 165*, 41-58.

Blevins-Knabe, B., & Musun-Miller, L. (1996). Number use at home by children and their parents and its relationship to early mathematical performance. *Early Development and Parenting, 5,* 35-45.

Borasi, R., Kort, E., Leonard, P., & Stone, G. (1993). Report of an implementation of a remodeling unit in a class of learning disabled students. In R. Borasi & C. F. Smith (Eds.), *Remodeling: Experiencing mathematics within a real-life context –*

Detailed reports of three classroom implementations (pp. 138-166) (Interim Report, Supporting middle school learning disabled students in the mainstream mathematics classroom, Project No. TPE-9153812). Arlington, VA: National Science Foundation.

Borasi, R., Sheedy, J. R., & Siegel, M. (1990). The powers of stories in learning mathematics. *Language Arts, 67*, 174-188.

Boulton-Lewis, G. M., Wilss, L. A., & Mutch, S. L. (1996). An analysis of young children's strategies and use of devices of length measurement. *Journal of Mathematical Behavior, 15,* 329-347.

Bowman, B. T., Donovan, M. S., & Burns, M. S. (2001). *Eager to learn: Educating our preschoolers*. Washington, DC: National Academy Press.

Braddon, K. L., Hall, N. J., & Taylor, D. (1993). *Math through children's literature: Making the NCTM standards come alive*. Englewood, CO: Teacher Ideas Press.

Branley, F. M. (2002). *Mission to mars.* Harper Collins.

Bredekamp, S., & Rosegrant, T. (Eds.). (1992). *Reaching potentials: Appropriate curriculum and assessment for young children.* Washington, DC: NAEYC.

Bridges, M., Fuller, B. C., Rumberger, R., & Tran, L. (2004). *Preschool for California's children: Promising benefits, unequal access.* PACE Policy Brief, 04-3, Berkeley, CA: Policy Analysis for California Education (PACE).

Brinkley, V.M. & Watson, J.A. (1987-88a) Effects of Microworld Training Experience on Sorting Tasks by Young Children, *Journal of Educational Technology Systems, 16,* 349-364.

Brinkley, V.M. & Watson, J.A. (1987-88b) Logo and Young Children: are quadrant effects part of initial Logo mastery? *Journal of Educational Technology Systems, 19,* 75-86.

Browder, D. M., Lee, A., & Mims, P. (2011). Using shared stories and individual response modes to promote comprehension and engagement in literacy for students for multiple, severe disabilities. *Education and training in autism and developmental disabilities, 46,* 339-351.

Bruce, R. A., & Threlfall, J. (2004). One, two, three, and counting. *Educational Studies in Mathematics, 55*, 3-26.

Brush, L. R. (1978), Preschool children's knowledge of addition and subtraction, *Journal for Research in Mathematics Education 9*, 44-54.

Bryant, D. P., Bryant, B. R., Gersten, R., Scammacca, N., & Chavez, M. M. (2008). Mathematics intervention with first- and second-grade students with mathematics difficulties: The effects of Tier 2 intervention delivered as booster lessons. *Remedial and Special Education, 29,* 20-32.

Bryant, D. P., Bryant, B. R., Gersten, R., Scammacca, N., Funk, C., Winter, A., . . . Pool, C. (2008). The effects of Tier 2 intervention on first-grade mathematics performance of first-grade students who are at risk for mathematics difficulties. *Learning Disability Quarterly, 31,* 47-63.

Bryant, D. P., Bryant, B. R., Roberts, G., Vaughn, S., Pfannenstiel, K. H., Porterfield, J., & Gersten, R. (2011). Early numeracy intervention program for first-grade students with mathematics difficulties. *Exceptional Children, 78,* 7-23.

Bryant, P. E., MacLean, M., Bradley, L. L., & Crossland, J. (1990). Rhyme and alliteration, phoneme detection, and learning to read. *Developmental Psychology, 26,* 429–438.

Bull, R., Espy, K. A., & Wiebe, S. A. (2008). Short-term memory, working memory, and executive functioning in preschoolers: Longitudinal predictors of mathematical achievement at age 7 years. *Developmental Neuropsychology, 33*, 205-228.

Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematical ability: Inhibition, switching, and working memory. *Developmental Neuropsychology, 19*, 273-293.

Bullock, J. K., Pierce, S., & McClelland, L. (1989). *Touch Math*. Colorado Springs, CO: Innovative Learning Concepts, Inc.

Burns, M. K., Kanive, R., & DeGrande, M. (2012). Effect of a computer-delivered math fact intervention as a supplemental intervention for math in third and fourth grades. *Remedial and Special Education, 33,* 184-191. doi: 10.1177/0741932510381652

Burton, M. (2010). Five strategies for creating meaningful mathematics experiences in the primary years. *Young Children, 65,* 92-96.

Butler, F. M., Miller, S. P., Lee, K., & Pierce, T. (2001). Teaching mathematics to students with mild-to-moderate mental retardation: A review of the literature. *Mental Retardation, 39,* 20–31.

Butterworth, B. (1999). *What counts – how every brain is hard wired for math*. New York: The Free Press.

Caffrey, E., & Fuchs, D. (2007). Differences in performance between students with learning disabilities and mild mental retardation: Implications for categorical instruction. *Learning Disabilities Research & Practices, 22,* 119-128. doi: 10.111/j.1540-5826.2007.00236.x

Caine, R. N., & Caine, G. (1991). *Making connections: Teaching and the human brain.* Alexandra, VA: Association for Supervision and Curriculum Development.

Calik, N. C., & Kargin, T. (2010). Effectiveness of the Touch Math technique in teaching addition skills to students with intellectual disabilities. *International Journal of Special Education, 25,* 195-204.

Campisi, L., Serbin, L. A., Stack, D. M., Schwartzman, A. E., & Ledingham, J. E. (2009). Precursors of language ability and academic performance: An inter-generational, longitudinal study of at-risk children. *Infant and Child Development, 18*, 377-403.

Carle, E. (1987). *The very hungry caterpillar* ([Rev.].) New York: Philomel Books.

Carlson, E., Jenkins, F., Bitterman, A., & Keller, B. (2011). *A Longitudinal View of Receptive Vocabulary and Math Achievement of Young Children with Disabilities*, (NCSER 2011-3006). U.S. Department of Education. Washington, DC: National Center for Special Education Research.

Carnine, D. (1997). Instructional design in mathematics for students with learning disabilities. *Journal of Learning Disabilities, 30*, 130-141.

Carnine, D., Jones, E., & Dixon, R. (1994). Mathematics: Educational tools for diverse learners. *School Psychology Review, 23*, 406-427.

Carnine, D. W., Silbert, J., Kame'enui, E. J., & Tarver, S. G. (2004). *Direct instruction reading* (4th ed.). Upper Saddle River, NJ: Pearson.

Carpenter, T. P., Franke, M. L., & Levi, L. (2003). *Thinking mathematically: Integrating arithmetic and algebra in elementary school.* Portsmouth, NH: Heinemann.

Case, R. (1998, April). *A psychological model of number sense and its development.* Paper presented at the annual meeting of the American Education Research Association, San Diego.

Case, R., & Griffin, S. (1990). Child cognitive development: The role of central conceptual structures in the development of scientific and social thoughts. In C. A. Haurt (Ed.). *Advances in psychology – developmental psychology: Cognitive, perception-motor and neurological perspectives.* Amsterdam: North Holland.

Case, R., Griffin, S., & Kelly, W. M. (1999). Socioeconomic gradients in mathematical ability and their responsiveness to intervention during early childhood. In D. P. Keating & C. Hertzman (Eds.), *Developmental health and the wealth of nations* (pp. 125-149). New York: Guilford.

Case, R., & Okamoto, Y. (1996). The role of central conceptual structures in the development of children's thought. *Monographs of the Society for Research in Child Development, 61* (Serial No. 246, Nos 1-2).

Casey, B. (2004). Mathematics problem-solving adventures: A language-arts-based supplementary series for early childhood that focuses on spatial sense. In D. H. Clements, J. Sarama, & A. –M. DiBiase (Eds.), *Engaging young children in mathematics: Standards for early childhood mathematics education* (pp. 377-389). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Casey, B., Erkut, S., Ceder, I., & Young, J. M. (2008). Use of a storytelling context to improve girls' and boys' geometry skills in kindergarten. *Journal of Applied Developmental Psychology, 29*, 29–48.

Casey, B., Kersh, J. E., & Young, J. M. (2004). Storytelling sagas: an effective medium for teaching early childhood mathematics. *Early Childhood Research Quarterly, 19*, 167-172. doi: 10.1016.ercesq.2004.01.001

Caspi, A., Elder, G. H., & Bem, D. J. (1987). Moving against the world: Life-course patterns of explosive children. *Developmental Psychology, 23,* 308-313.

Chard, D., Baker, S. K., Clarke, B., Jungiohann, K., Davis, K. L. S., & Smolkowski, K. (2008). Preventing early mathematics difficulties: The feasibility of a rigorous kindergarten mathematics curriculum. *Learning Disability Quarterly, 31,* 11-20.

Chard, D. J., & Kame'enui, E. J. (1995). Mathematics instruction for students with diverse learning needs: Heeding the message of the Cheshire cat. *Focus on Learning Problems in Mathematics, 17,* 24-38.

Charles, R., Crown, W., Fennell, F. S., Caldwell, J. H., Cavanaugh, M., Chancellor, D., . . . Van de Walle (2005). *Scott Foresman–Addison Wesley Mathematics. Grade 1*. Glenview, IL: Pearson Scott Foresman.

Claessens, A., Duncan, G., & Engel, M. (2009). Kindergarten skills and fifth-grade achievement: Evidence from the ECLS-K. *Economics of Education Review, 28*, 415-427.

Clark, C. A., Pritchard, V. E., & Woodward, L. J. (2010). Preschool executive functioning abilities predict early mathematics achievement. *Developmental Psychology, 46*, 1176-1191.

Clark, K. E. (1988). The importance of developing leadership potential of youth with talent in mathematics and science. In J. Dreyden, S. A. Gallagher, G. E. Stanley, & R. N. Sawyer (Eds.), *Report to the National Science Foundation: Talent Identification Program/National Science Foundation Conference on Academic Talent* (pp. 95-104). Durham, NC: National Science Foundation.

Clarke, B. A., Clarke, D. M., & Cheeseman, J. (2006). The mathematical knowledge and understanding young children bring to school. *Mathematics Education Research Journal, 11*, 110-127.

Clarke, B., Smolkowski, K., Baker, S., Fien, H., Doabler, C., & Chard, D. (2011). The impact of a comprehensive tier 1 core kindergarten program on the achievement of students at-risk for mathematics. *Elementary School Journal, 111,* 561-584. http://dx.doi.org/10.1086/659033

Clement, R. (1991). *Counting on Frank* (North American ed.). Milwaukee, WI: G. Stevens.

Clements, D. H. (1984). Training effects on the development and generalization of Piagetian logical operations and knowledge of number. *Journal of Educational Psychology, 76,* 766-776.

Clements, D. H. (1986). Effects of Logo and CAI environments on cognition and creativity. *Journal of Educational Psychology, 78,* 309-318.

Clements, D. H. (1995). Teaching creativity with computers. *Educational Psychology Review, 7,* 141-161.

Clements, D. H. (1999a). Geometric and spatial thinking in young children. In J. V. Copley (Ed.), *Mathematics in the early years* (pp. 66-79). Reston, VA: National Council of Teachers of Mathematics.

Clements, D. H. (1999b). Subitizing: What is it and why teach it? *Teaching Children Mathematics,* 400-405.

Clements, D. H. (2001). Mathematics in the preschool. *Teaching Children Mathematics, 7,* 270-278.

Clements, D. H., & Nastasi, B. K. (1993). Electronic media and early childhood education. In B. Spodek (Ed.), *Handbook of research on the education of young children* (pp. 251-275). New York: Macmillan.

Clements, D. H., & Sarama, J. (1997). Research on Logo: A decade of progress. *Computers in the Schools, 14,* 9-46.

Clements, D. H., & Sarama, J. (2003). Strip mining for gold: Research and policy in educational technology – A response to "Fool's Gold". *Educational Technology Review, 11,* 7-69.

Clements, D. H., & Sarama, J. (2007a). *Building Blocks – SRA Real Math, Grade PreK*. Columbus, OH: SRA/McGraw-Hill.

Clements, D. H., & Sarama, J. (2007b). Effects of a preschool mathematics curriculum: Summative research on the Building Blocks project. *Journal of Research in Mathematics Education, 38,* 136-163.

Clements, D. H., & Sarama, J. (2008). Experimental Evaluation of the Effects of a Research-Based Preschool Mathematics Curriculum. *American Educational Research Journal, 45*, 443-494.

Clements, D. H., & Sarama, J. (2009). *Learning and teaching early math: The learning trajectories approach.* New York: Routledge.

Clements, D. H., & Sarama, J. (2011). Mathematics knowledge of young children entering preschoolers in the US. *Far East Journal of Mathematics Education, 6,* 41-63.

Clements, D. H., & Swaminathan, S. (1995). Technology and School Change New Lamps for Old? *Childhood Education, 71,* 275-281. Doi: 10.1080/00094056.1995.10522619

Clements, D. H., Swaminathan, S., Hannibal, M. A. Z., & Sarama, J. (1999). Young children's concepts of shape. *Journal for Research in Mathematics Education, 30*, 192-212.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher, 23,* 13-20.

Cobb, P. (1995). Continuing the conversation: A response to Smith. *Educational Researcher, 24,* 25-26.

Conaway, B., & Midkiff, R. B. (1994). Connecting literature, language, and fractions. *Arithmetic Teacher, 41,* 430-434.

Copley, J. V. (1999). *Mathematics in the early years.* Reston, VA: National Council of Teachers of Mathematics; and Washington, DC: NAEYC.

Copley, J. V. (2010). *The young child and mathematics, 2nd edition.* National Association for the Education of Young Children, National Council of Teachers of Mathematics.

Crain-Thoreson, C., & Dale, P. S. (1992). Do early talkers become early readers? Linguistic precocity, preschool language, and emergent literacy. *Developmental Psychology, 28,* 421-429.

Cunningham, C. E., McHolm, A., Boyle, M. H., & Patel, S. (2004). Behavioral and emotional adjustment, family functioning, academic performance, and social relationships in children with selective mutism. *Journal of Child Psychology and Psychiatry, 45*, 1363–1372.

Curtis, R., Okamoto, Y., & Weckbacher, L. M. (2009). Preschoolers' use of count information to judge relative quantity. *Early Childhood Research Quarterly, 24,* 325-336.

Cutler, K. M., Gilkerson, D., Parrott, S., & Bowne, M. T. (2003). Developing math games based on children's literature. *Young Children*, *January,* 22-27.

Daughtery, S., Grisham-Brown, J., & Hemmeter, M. L. (2001). The effects of embedded skill instruction on the acquisition of target and nontarget skills in preschoolers with developmental delays. *Topics in Early Childhood Special Education, 21,* 213-221.

Dehaene, S., Spelke, E., Pinel, P., Stanescu, R., & Tsivkin, S. (1999). Sources of mathematical thinking: Behavioral and brain-imaging evidence. *Science, 284,* 970-974. doi: 10.1126/science.284.5416.970

Denton, K., & West, J. (2002). Children's reading and mathematics achievement in kindergarten and first grade. *Education Statistics Quarterly, 4,* 19-26.

Dirks, E., Spyer, G., van Lieshout, C. D. M., & de Sonneville, L. (2008). Prevalence of combined reading and arithmetic disabilities. *Journal of Learning Disabilities, 41,* 460-473.

Doabler, C. T., Cary, M. S., Jungjoham, K., Clarke, B., Fien, H., Baker, S., . . . Chard, D. (2012). Enhancing core mathematics instruction for students at risk for mathematics disabilities. *Teaching Exceptional Children, 44,* 48-57.

Donaldson, M. (1978). *Children's minds*. New York: Norton.

Dowker, A. D. (2004). What works for children with mathematical difficulties. *Department for Education and Skills: Research Report RR554.*

Ducolon, C. K. (2000). Quality literature as a springboard to problem solving. *Teaching Children Mathematics, 6,* 442-447.

Duncan, G. J., Dowsett, A., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., . . . Duckworth, K. (2007). School readiness and later achievement. *Developmental Psychology, 43,* 1428-1446.

Eccles, J. (1997). User-friendly science and mathematics: Can it interest girls and minorities in breaking through the middle school wall? In D. Johnson et al. (Eds.), *Minorities and girls in school: Effects on achievement and performance,* Vol. 1, pp. 65-104. Thousand Oaks, CA: Sage.

Elia, I., van den Heuvel-Panhuizen, M., & Georgiou, A. (2010). The role of picture books on children's cognitive engagement with mathematics. *European Early Childhood Education Research Journal, 18,* 125-147.

Elkin, B. (1968). *Six Foolish Fishermen.* Children's Press.

English, L. H., Barnes, M. A., Taylor, H. B., & Landry, S. H. (2009). Mathematical development in Spina Bifida. *Developmental Disabilities Research Reviews, 15*, 28-34.

Erkut, S. (2003, April). *Multicultural adventure stories as medium for teaching math in the early elementary grades: An evaluation*. Paper presented at Wellesley Centers for Women Board of Overseers meeting. Wellesley, MA.

Ernest, P. (1986). Games: A rationale for their use in the teaching of mathematics in school. *Mathematics in School, 15,* 2-5.

Feldman, S. S., & Wentzel, K. R. (1990). Relations among family interaction patterns, classroom self-restraint, and academic achievement in preadolescent boys. *Journal of Educational Psychology, 82,* 813-819.

Floyd, R. G., Hojnoski, R. L., & Key, J. (2006). Preliminary evidence of technical adequacy of the Preschool Numeracy Indicators. *School Psychology Review*, 35, 627-644.

Fogelberg, E., Skalinder, C., Satz, P., Hiller, B., Bernstein, L., & Vitantonio, S. (2008). *Integrating literacy and math: Strategies for K-6 teachers.* New York: Guilford.

Fogelman, K. (Ed.). (1983). *Growing up in Great Britain: Papers from the national child development study.* London: Macmillan.

Ford, M. J., Poe, V., & Cox, J. (1993). Attending behaviors of ADHD children in math and reading using various types of software. *Journal of Computing in Childhood Education, 4,* 183-196.

Frede, E., Jung, K., Barnett, W. S., Lamy, C. E., & Figueras, A. (2007). *The Abbott preschool program longitudinal effects study (APPLES*). Rutgers, NJ: National Institute for Early Education Research.

Fuchs, L. S., Compton, D. L., Fuchs, D., Paulsen, K., Bryant, J. D., & Hamlett, C. L. (2005). The prevention, identification, and cognitive determinants of math difficulty. *Journal of Educational Psychology, 97,* 493-513.

Fuchs, L. S., Fuchs, D., & Compton, D. L. (2012). The early prevention of mathematics difficulty: Its power and limitations. *Journal of Learning Disabilities, 45,* 257-269. doi: 10.1177/0022219412442167.

Fuchs, L. S., Fuchs, D., Finelli, R., Courey, S. J., Hamlett, C. L., Sones, E. M., & Hope, S. K. (2006) Teaching third-graders about real-life mathematical problem solving: A randomized controlled study. *The Elementary School Journal*, *106*, 293–311.

Fuchs, L. S., Fuchs, D., Hamlett, C. L., Phillips, N. B., Karns, K., & Dutka, S. (1997). Enhancing students' helping behavior during peer-mediation instruction with conceptual mathematical explanations. *The Elementary School Journal, 97,* 223-249.

Fuchs, L. S., Fuchs, D., Hamlett, C. L., Powell, S. R., Capizzi, A. M., & Seethaler, P. M. (2006). The effects of computer-assisted instruction on number combination skills in at-risk first graders. *Journal of Learning Disabilities, 39,* 467-475.

Fuchs, L. S., Fuchs, D., & Karns, K. (2001). Enhancing kindergartners' mathematical development: Effects of peer-assisted learning strategies. *The Elementary School Journal, 101,* 495-510.

Fuchs, L. S., Fuchs, D., Yazdian, L., & Powell, S. R. (2002). Enhancing first-grade children's mathematical development with peer-assisted learning strategies. *School Psychology Review, 31,* 569-583.

Fuchs, L. S., Powell, S. R., Seethaler, P. M., Fuchs, D., Hamlett, C. L., Cirino, P. T., & Fletcher, J. M. (2010). A framework for remediating number combination deficits. *Exceptional Children, 76,* 135-156.

Fuchs, L. S., & Vaughn, S. (2012). Responsiveness-to-intervention: A decade later. *Journal of Learning Disabilities, 45,* 195-203. doi: 10.1177/0022219412442150.

Fuson, K. (1988). *Children's Counting and Concepts of Number.* New York: Springer-Verlag.

Fuson, K. C. (2004). Pre-K to grade 2 goals and standards: Achieving 21st century mastery for all. In D. H. Clements, J. Sarama, & A.-M. DiBiase (Eds.), *Engaging young children in mathematics: Standards for early childhood mathematics education.* (pp. 105-148). Mahwah, NJ: Lawrence Erlbaum Associates.

Fuson, K. C. (2006). *Math expressions. Grade 1.* Boston: Houghton Mifflin.

Fuson, K. C., & Murray, C. (1978). The haptic-visual perception, construction, and drawing of geometric shapes by children aged two to five: A Piagetian extension. In R. Lesh & D. Mierkiewicz (Eds.), *Concerning the development of spatial and geometric concepts*. (pp. 49-83). Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education.

Gailey, S. K. (1993). The mathematics-children's-literature connection. *Arithmetic Teacher, 40*, 258-261.

Geary, D. C. (1993). Mathematical disabilities: Cognitive, neuropsychological, and genetic components. *Psychological Bulletin, 114,* 345-362. doi: 10.1037/0033-2909.114.2.345

Geary, D. C. (1994). *Children's mathematical development: Research and practical applications.* Washington, DC: American Psychological Association.

Geary, D. C. (1996). International differences in mathematical achievement: Their nature, causes, and consequences. *Current Directions in Psychological Science, 5,* 133-137.

Geary, D. C. (2004). Mathematics and Learning Disabilities. *Journal of Learning Disabilities, 37*, 4-15.

Geary, D. C., Bow-Thomas, C. C., & Yao, Y. (1992). Counting knowledge and skill in cognitive addition: A comparison of normal and mathematically disabled children. *Journal of Experimental Child Psychology, 54*, 372-391.

Geary, D. C., Brown, S. C, & Samaranayake, V. A. (1991). Cognitive addition: A short longitudinal study of strategy choice and speed-of-processing differences in normal and mathematically disabled children. *Developmental Psychology, 27,* 787–797.

Geary, D. C., Hamson, C. O., & Hoard, M. K. (2000). Numerical and arithmetical cognition: A longitudinal study of process and concept deficits in children with learning disability. *Journal of Experimental Child Psychology, 77,* 236-263.

Geary, D. C., Hoard, M. K., Byrd-Craven, J., & DeSoto, M. C. (2004). Strategy choice in simple and complex addition: Contributions of working memory and counting knowledge for children with mathematical disability. *Journal of Experimental Child Psychology, 88,* 121-151. doi: 10.1016/j.jecp.2004.03.002

Geary, D. C., Hoard, M. K., Byrd-Craven, J., Nugent, L., & Numtee, C. (2007). Cognitive mechanisms underlying achievement deficits in children with mathematical learning disability. *Child Development, 78*, 1343-1359.

Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2012). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five-year prospective study. *Journal of Educational Psychology*. Advance online publication. Doi: 10.1037/a0025398

Geist, E. A. (2000). Lessons for the TIMMS videotape study. *Teaching Children Mathematics, 7,* 180-185.

Gelman, R. (1980). What young children know about numbers. *Educational Psychologist, 15,* 54-68.

Gelman, R., & Brenneman, K. (1994). First principles can support both universal and culture-specific learning about number and music. In L. A. Hirschfeld, & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture.* (pp. 369-390). Cambridge, MA: University Press.

Gelman, R., & Gallistel, C. R. (1986). *The child's understanding of number*. Cambridge, MA: Harvard University Press.

Georgia Department of Education (2012). SDD rules and regulations. Retrieved from http://www.doe.k12.ga.us/Curriculum-Instruction-and-Assessment/Special-Education-Services/Pages/Significant-Developmental-Delay.aspx

Gerdes, P. (2001). Exploring the game of "Julirde": A mathematical-educational game played by Fulbe children in Cameroon. *Teaching Children Mathematics, 7,* 321-327.

Gersten, R., & Chard, D. (1999). Number sense: Rethinking arithmetic instruction for students with mathematical disabilities. *The Journal of Special Education, 33,* 18-28.

Gersten, R., Chard, D., Jayanthi, M., Baker, S., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research, 79,* 1202-1242.

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities, 38*, 293-304.

Gerardi, K., Goette, L., & Meier, S. (2010). *Financial literacy and subprime mortgage delinquency: Evidence from a survey matched to administrative data*. Atlanta, GA: Federal Reserve Bank of Atlanta Working Paper 2010-10.

Gettinger, M., & Stoiber, K. (2007). Applying a response-to-intervention model for early literacy development in low-income children. *Special Topics in Early Childhood Education, 27*, 198 – 213.

Gilbert, S. J., & Burgess, P. W. (2008). Executive functioning. *Current Biology, 18*, 110-114.

Ginsburg, H. P. (1989). *Children's arithmetic: How they learn it and how you teach it (2nd ed.).* Austin, TX: Pro Ed.

Ginsburg, H. P. (1997). Mathematics learning disabilities: A view from developmental psychology. *Journal of Learning Disabilities, 30*, 20-33.

Ginsburg, H.P., & Baroody, A.J. (1983). *Test of early mathematical ability.* Austin, TX: PRO-ED, Inc.

Ginsburg, H. P., & Baroody, A. J. (1990). *Test of Early Mathematics Ability* (Second Edition). Austin, TX: Pro-Ed.

Ginsburg, H. P., & Baroody, A. J. (2003). *Test of Early Mathematics Ability* (Third Edition). Austin, TX: Pro-Ed.

Ginsburg, H. P., Cannon, J., Eisenband, J. G., & Pappas, S. (2006). Mathematical thinking and learning. In K. McCartney & D. Phillips (Eds.), *Handbook of Early Child Development* (pp. 208-229). Oxford, England: Blackwell.

Ginsburg, H. P., Greenes, C., & Balfanz, R. (2003). *Big math for little kids.* Parsippany, NJ: Dale Seymour Publications.

Ginsburg, H. P., Klein, A., & Starkey, P. (1998). The development of children's mathematical thinking: Connecting research with practice. In I. E. Sigel & K. A. Renninger (Eds.), *Handbook of child psychology. Child Psychology in Practice* (Vol. 4, 5th ed., pp. 401-476). New York: John Wiley & Sons.

Ginsburg, H. P., Lee, J. S., & Boyd, J. S. (2008). Mathematics education for young children: What it is and how to promote it. *Social Policy Report, 22*, 3-22.

Ginsburg, H. P., Lewis, A., & Clements, M. (2008). *School readiness and early childhood education: What we can learn from federal investments in research on mathematics programs?* A working paper prepared for a working meeting on recent school readiness research: Guiding the synthesis of early childhood research. Washington, DC: October 21-22, 2008. http://aspe.hhs.gov/hsp/10/SchoolReadiness/apb3.pdf

Ginsburg, H. P., & Russell, R. L. (1981). Social class and racial influence on early mathematical thinking. In *Monograph of the Society for Research in Child Development* (Vol. 46, Serial No 193).

Ginsburg, H. P., & Seo, K. H. (1999). Mathematics in children's thinking. *Mathematical Thinking and Learning, 1,* 113-129.

Ginsburg-Block, M. D., Rohrbeck, C. A., & Fantuzzo, J. W. (2006). A meta-analytic review of social, self-concept, and behavioral outcomes or peer-assisted learning. *Journal of Educational Psychology, 98,* 732-749. doi: 10.1037/0022-0663.98.4.732

Goldman, S. R. (1989). Strategy instruction in mathematics. *Learning Disability Quarterly, 12,* 43-55.

Goldman, S. R., & Hasselbring, T. S. (1997). Achieving meaningful mathematics literacy for students with learning disabilities. *Journal of Learning Disabilities, 30,* 198-208.

Graham, T. A., Nash, C., & Paul, K. (1997). Young children's exposure to mathematics: The child care context. *Early Childhood Education Journal, 25*, 31-38.

Greenes, C. (1999). Ready to learn: Developing young children's mathematical powers. In J. Copley (Ed.), *Mathematics in the early years* (pp. 39-47). Reston, VA: National Council of Teachers in Mathematics.

Gresham, F. M., MacMillan, D. L., & Bocian, K. M. (1996). Learning disabilities, low achievement, and mild mental retardation: More alike or different? *Journal of Learning Disabilities, 29,* 570-581. doi: 10.1177/002221949602900601

Griffin, S. A. (1998). *Fostering the development of whole number sense.* Paper presented at the annual meeting of the American Educational Research Association, San Diego.

Griffin, S. (2003). The development of math competence in the preschool and early school years: Cognitive foundations and instructional strategies. In J. M. Royer (Ed.), *Mathematical cognition* (pp. 1-32). Greenwich, CT: Information Age Publishing.

Griffin, S. (2007). *Number Worlds: A mathematics intervention program for grades prek-6.* Columbus, OH: SRA/McGraw-Hill.

Griffin, S., & Case, R. (1997). Rethinking the primary school math curriculum: An approach based on cognitive science. *Issues in Education, 3,* 1-49.

Griffin, S., Case, R., & Capodilupo, A. (1995). Teaching for understanding: The importance of central conceptual structures in the elementary mathematics curriculum. In A. McKeough, I. Lupert, and A. Marini (Eds.), *Teaching for transfer: Fostering generalization in learning* (pp. 121-151). Hillsdale, NJ: Erlbaum.

Griffin, S. A., Case, R., & Siegler, R. S. (1994). Rightstart: Providing the central conceptual prerequisites for first formal learning of arithmetic to students at risk for school failure. In K. McGilly (Ed.). *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 25-49). Cambridge, MA: MIT Press.

Griffiths, R., & Clyne, M. (1991). *Books you can count on; Linking mathematics and literature*. Melbourne: Nelson.

Groffman, S. (2009). Subitizing: Vision therapy for math deficits. *Journal of Optometric Vision Development, 40,* 229-238.

Guha, S. (2002). Integrating mathematics for young children through play. *Young Children, May,* 90-93.

Hanich, L. B., Jordan, N. C., Kaplan, D., & Dick, J. (2001). Performance across different areas of mathematical cognition in children with learning difficulties. *Journal of Educational Psychology, 93*, 615-626.

Hanline, M. F., Milton, S., & Phelps, P. C. (2010). The relationship between preschool block play and reading and maths ability in early elementary school: a longitudinal study of children with and without disabilities. *Early Child Development and Care, 180*, 1005-1017.

Hannula, M. M., Rasanen, P., & Lehtinen, E. (2007). Development of counting skills: Role of spontaneous focusing on numerosity and subitizing-based enumeration. *Mathematical Thinking & Learning: An International Journal, 9,* 51-57.

Hanushek, E. A., Peterson, P. E., & Woessmann, L. (2010). U.S. math performance in global perspective: How well does each state do at producing high-achieving students? Retrieved from: http://www.hks.harvard.edu.pepg

Harland, K. (1990). Starting multiplying. *Mathematics Teaching, 131*, 43-7.

Hasselbring, T. S., Goin, L. I., & Bransford, J. (1988). Developing math automaticity in learning handicapped children: The role of computerized drill and practice. *Focus on Exceptional Children, 20,* 1-7.

Haury, D. (2001). *Literature-based mathematics in elementary school*. ERIC Digest. Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education (ED No. 464807).

Hecht, S. A., Torgeson, J. K., Wagner, R. K., & Rashotte, C. A. (2001). The relations between phonological processing abilities and emerging individual differences in mathematical computation skills: A longitudinal study from second to third grades. *Journal of Experimental Child Psychology, 79*, 192-227. doi: 10.1006/jecp.2000.2586

Hellwig, S. J., Monroe, E. E., & Jacobs, J. S. (2000). Making informed choices: Selecting children's trade books for mathematics instruction. *Teaching Children Mathematics, 7,* 138-143.

Heddens, J. W., & Speer, W. R. (1992). *Today's mathematics: Concepts and methods in elementary school mathematics.* New York: Macmillan.

Hiebert, J. C., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (Vol. 1, pp. 371–404). New York: Information Age.

Hiebert, J., & Lindquist, M. M. (1990). Developing mathematical knowledge in the young child. In J. J. Payne (Ed.), *Mathematics for the young child.* Reston, VA: National Council of Teachers of Mathematics.

Hill, H. C. & Ball, D. L. (2004). Learning mathematics for teaching: Results from California's mathematics professional development institutes. *Journal for Research in Mathematics Education, 35,* 330-351.

Hinshaw, S. P. (1992). Externalizing behavior problems and academic underachievement in childhood and adolescence: Causal relationships and underlying mechanisms. *Psychological Bulletin, 111,* 127-155.

Hoffman, E. S. (2002). Making connections, making sense: Rationale and methods for integrating children's literature into mathematics instruction. *The Dragon Lode: The Journal of Children's Literature and Reading Special Interest Group, 21*(1).

Hohmann, M., & Weikart, D. P. (1998). *Educating young children.* Ypsilanti, MI: High/Scope Press.

Hohmann, M., & Weikart, D. P. (2002). *Educating young children: Active learning practices for preschool and child care* (2nd ed.). Ypsilanti, MI: High/Scope Press.

Hong, H. (1996). Effects of mathematics learning through children's literature on math achievement and dispositional outcomes. *Early Childhood Research Quarterly, 11*, 477-494.

Hooper, S. R., Roberts, J., Sideris, J., Burchinal, M., & Zeisel, S. (2010). Longitudinal predictors of reading and math trajectories through middle school for African American versus Caucasian students across two samples. *Developmental Psychology, 46,* 1018-1029. doi: 10.1037/a0018877

Hopkins, K. B., McGillicuddy-De Lisi, A. V., & De Lisi, R. (1997) Student gender and teaching methods as sources of variability in children's computational arithmetic performance. *Journal of Genetic Psychology*, *158*, 333–345.

Howell, S. C., & Kemp, C. R. (2010). Assessing preschool number sense: skills demonstrated by children prior to school entry. *Educational Psychology, 30,* 411-429.

Hudson, P., & Miller, S. P. (2006). *Designing and implementing mathematics instruction for students with diverse learning needs.* Boston, MA: Pearson.

Hughes, M. (1981). Can preschool children add and subtract? *Educational Psychology, 1,* 207-219.

Hughes, M. (1986). *Children and number. Difficulties in learning mathematics.* New York: Basil Blackwell.

Hungate, H. (1982) Computers in the kindergarten, *The Computing Teacher, 9*, 15-18.

Huntley-Fenner, G. (2001). Why count stuff?: Young preschoolers do not use number for measurement in continuous dimensions. *Developmental Science, 4,* 456-462.

Huntley-Fenner, G., & Cannon, E. (2000). Preschooler's magnitude comparisons are mediated by a preverbal analog mechanism. *Psychological Science, 11,* 147-152.

Hutchins, P. (1968). *Rosie's walk.* New York: Macmillan.

Huttonlocher, J., Jordan, N. C., & Levine, S. C. (1994). A mental model for early arithmetic. *Journal of Experimental Psychology: General, 123*, 284-296.

Irwin, K., & Burgham, D. (1992). Big numbers and small children. *The New Zealand Mathematics Magazine, 29,* 9-19.

Jacobs, A., & Rak, S. (1997). Mathematics and literature – A winning combination. *Teaching children mathematics, 4*, 156-157.

Jennings, C. M., Jennings, J. E., Richey, J., & Dixon-Krauss, L. (1992). Increasing interest and achievement in mathematics through children's literature. *Early Childhood Research Quarterly, 7*, 263-276.

Jordan, N. C., & Hanich, L. (2000). Mathematical thinking in second-grade children with different forms of LD. *Journal of Learning Disabilities, 33*, 567-578.

Jordan, N. C., Hanich. L. B., & Kaplan, D. (2003). A longitudinal study of mathematical competencies of children with specific mathematics difficulties versus children with comorbid mathematics and reading difficulties. *Child Development, 74,* 834-850. doi: 10.1111/1467-8624.00571

Jordan, N. C., Kaplan, D., & Hanich, L. B. (2002). Achievement growth in children with learning difficulties in mathematics: Findings of a two-year longitudinal study. *Journal of Educational Psychology, 94,* 587-597. doi: 10.1037/0022-0663.94.3.586

Jordan, N. C., Kaplan, D., Locuniak, M. N., & Ramineni, C. (2007). Predicting first grade math achievement from developmental number sense trajectories. *Learning Disabilities Research and Practice, 22,* 36-46.

Jordan, N. C., & Montani, T. O. (1997). Cognitive arithmetic and problem solving: A comparison of children with specific and general mathematics difficulties. *Journal of Learning Disabilities, 30,* 624-634.

Joyce, B., Weil, M., & Calhoon, E. (2000). *Models of teaching* (6th ed.). Boston: Allyn & Bacon.

Juel, C. (1988). Learning to read and write: A longitudinal study of 54 children from first through fourth grades. *Journal of Educational Psychology, 80*, 437–447.

Katz, L. G., & Chard, S. C. (1989). *Engaging children's minds: the project approach.* Norwood, NJ: Ablex.

Kaufmann, L., Handl, P., & Th□ny, B. (2003). Evaluation of a numeracy intervention program focusing on basic numerical knowledge and conceptual knowledge: A pilot study. *Journal of Learning Disabilities, 36,* 564-573.

Kazdin, A. E. (1985). *Treatment of antisocial behavior in children and adolescents.* Homewood, IL: Dorsey Press.

Keats, J. E. (1962). *The snowy day.* New York: Viking Press.

Klahr, D., & Wallace, J. G. (1973). The role of quantification operators in the development of conservation of quantity. *Cognitive Psychology, 4,* 301-327.

Kleemans, T., Peeters, M., Segers, E., & Verhoeven, L. (2012). Child and home predictors of early numeracy skills in kindergarten. *Early Childhood Research Quarterly*. doi:10.1016/j.ecresq.2011.12.004

Klein, A., & Starkey, P. (2002). *Pre-K mathematics curriculum*. Glenview, IL: Scott Foresman.

Klein, A., Starkey, P., Clements, D. H., & Iyer, R. (2008). Effects of a pre-kindergarten mathematics intervention: A randomized experiment. *Journal of Research Education Effectiveness, 1,* 155-178.

Klibanoff, R. S., Levine, S. C., Huttenlocher, J., Vasilyeva, M., & Hedges, L. V. (2006). Preschool children's mathematical knowledge: The effect of teacher "math talk." *Developmental Psychology, 42*, 59-69.

Kolstad, R., & Briggs, L. D. (1996). Incorporating language arts into the mathematics curriculum: A literature survey. *Education, 116,* 423-427.

Kostelnik, M. J., Soderman, A. K., & Whiren, A. P. (2007). *Developmentally Appropriate Curriculum.* (Fourth Edition). Upper Saddle River, NJ: Pearson.

Kouba, V. L., Brown, C. A., Carpenter, T. P., Lindquist, M. M., Silver, E. A., & Swafford, J. O. (1988a). Results of the fourth NAEP assessment of mathematics:

Measurement, geometry, data interpretation, attitudes, and other topics. *Arithmetic Teacher, 35*, 10-16.

Kouba, V. L., Brown, C. A., Carpenter, T. P., Lindquist, M. M., Silver, E. A., & Swafford, J. O. (1988b). Results of the fourth NAEP assessment of mathematics: Numbers, operations, and word problems. *Arithmetic Teacher, 35*, 14-19.

Kouba, V. L., Carpenter, T. P., & Swafford, J. O. (1989). Numbers and operations. In M. M. Lindquist (Ed.), *Results of the fourth mathematics assessment of the National assessment of educational progress* (pp. 64-93). Reston, VA: National Council of Teachers of Mathematics.

Krajewski, K. (2008). Prevention der Rechenschwache. [The early prevention of math problems]. In W. Schneider, & M. Hasselhorn (Eds.), *Handbuch der Padagogischen Psychologie* (pp. 360-370). Goettingen, Germany: Hogrefe. (see Krajewski & Scheider, 2009).

Krajewski, K., & Schneider, W. (2009). Early development of quantity to number-word linkage as a precursor of mathematical school achievement and mathematical difficulties: Findings from a four-year longitudinal study. *Learning and Instruction, 19,* 513-526.

Kraner, R. E. (1977). The acquisition age of quantitative concepts of children from 3 to 6 years old. *Journal of Experimental Education, 46*, 52-59.

Kraus, W.H. (1981) Using a computer game to reinforce skills in addition basic facts in second grade, *Journal fofr Research in Mathematics Education, 12*, 152-155.

Kristensen, H. (2000). Selective mutism and comorbidity with developmental disorder / delay, anxiety disorder, and elimination disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*, 249–256.

Kroesbergen, E. H., & Van Luit, J. E. H. (2003). Mathematics interventions for children with special educational needs: A Meta-Analysis. *Remedial and Special Education, 24*, 97-114.

Kunsch, C. A., Jitendra, A. K., & Sood, S. (2007). The effects of peer-mediated instruction in mathematics for students with learning problems: A research synthesis. *Learning Disabilities Research and Practice, 22,* 1-12.

Lane, K. L., Carter, E. W. Pierson, M. R., & Glaeser, B. C. (2006). Academic, social, and behavioral characteristics of high school students with emotional disturbances and learning disabilities. *Journal of Emotional and Behavioral Disorders, 14*, 108–117.

Larson, N. (2004). *Saxon Math 1*. Austin, TX: Harcourt Achieve.

Layzer, J., Goodson, B. D., & Moss, M. (1993). *Life in preschool: Volume one of an observational study of early childhood programs for disadvantaged four-year-olds*. Cambridge, MA: Abt Associates Inc.

Le Corre, M., Van de Walle, Brannon, E. M., & Carey, S. (2006). Re-visiting the competence/performance debate in the acquisition of the counting principles. *Cognitive Psychology, 52,* 130-169.

Lee, K., Ng, E. L., & Ng., S. F. (2009). The contributions of working memory and executive functioning to problem representation and solution generation in algebraic word problems. *Journal of Educational Psychology, 101,* 373-387.

LeSieg, T. (1961). *Ten apples on top.* Beginner's Books.

Levin, H. M., Glass, G. V., & Meister, G. R. (1987). Cost-effectiveness of computer-assisted instruction. *Evaluation Review, 11,* 50-72.

Lewis, B. A., Long, R., & Mackay, M (1993). Fostering communication in mathematics using children's literature. *Arithmetic Teacher, 40,* 470-473.

Linder, S. M., Powers-Costello, D., & Stegelin, D. A. (2011). Mathematics in early childhood: Research-based rationale and practical strategies. *Journal of Early Childhood Education, 39,* 29-37.

Linnell, M., & Fluck, M. (2001). The effect of maternal support for counting and the cardinal understanding in pre-school children. *Social Development, 2,* 202-220.

Lionni, L. (1963). *Swimmy.* New York: Pantheon.

Lionni, L. (1992). *Mr. McMouse.* New York: Knopf.

Lipton, J. S., & Spelke, E. S. (2003). Origins of number sense: large-number discrimination in human infants. *Psychological Science, 14,* 396-401.

Lock, R. H. (1996). Adapting mathematics instruction in the general education classroom for students with mathematics disabilities. *LD Forum, 21*, 19-23.

Loeb, A., Bridges, M., Bassok, D., Fuller, B., & Rumberger, R. W. (2007). How much is too much? The influence of preschool centers on children's social and cognitive development. *Economics of Education Review, 26*, 52-66.

Lonigan, C. J., Farver, J. M., Phillips, B. M., & Clancy-Menchetti, J. (2011). Promoting the development of preschool children's emergent literacy skills: a randomized evaluation of a literacy-focused curriculum and two professional development models. *Reading and Writing, 24.* 305–337. doi: 10.1007/s11145-009-9214-6

Ma, L. (1999). *Knowing and teaching elementary mathematics.* Mahwah, NJ: Lawrence Erlbaum Associates.

Manning, M. M., & Manning, G. L. (1984). Early readers and nonreaders from low socioeconomic environments: What their parents report. *The Reading Teacher, 38,* 32-34.

Mason, J. (2008). Making use of children's powers to produce algebraic thinking. In J. J. Kaput, D. W. Carraher, & M. L. Blanton. *Algebra in the early grades.* New York: Routledge.

Mazzocco, M. M. M. (2001). Math learning disability and math LD subtypes: Evidence from studies of Turner syndrome, Fragile X syndrome, and Neurofibromatosis Type 1. *Journal of Learning Disabilities, 34,* 520-533.

McClelland, M. M., Cameron, C. E., Connor, C. M., Farris, C. L., Jewkes, A. M., & Morrison, F. J. (2007). Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. *Developmental Psychology, 43*, 947–959.

McGivern, R. F., Hilliard, V. R., Anderson, J., Reilly, J. S., Rodriguez, A., Fielding, B., & Shapiro, L. (2007). Improving preliteracy and premath skills of Head Start children with classroom computer games. *Early Childhood Services, 1,* 71-81.

McMaster, K. L., Fuchs, D., & Fuchs, L. S. (2007). Promises and limitations of peer-assisted learning strategies in reading. *Learning Disabilities: A Contemporary Journal, 5,* 97-112.

Melhuish, E. C., Sylva, K., Sammons, P., Sirah-Blatchford, I., Taggert, B., Phan, M. B., & Malin, A. (2008). Preschool influences on mathematics achievement. *Science, 321*, 1161-1162.

Melser, N., & Leitze, A. (1999). Connecting language arts and mathematical problem solving in the middle grades. *Middle School Journal, 31*, 48-54.

Mercer, C. D. (1997). *Students with learning disabilities.* Upper Saddle River, NJ: Merrill Prentice Hall.

Miller, K. F., & Parades, D. R. (1996). On the shoulders of giants: Cultural tools and mathematical development. In R. J. Sternberg & T. Ben-Zeev (Eds.), *The nature of mathematical thinking* (pp. 83-117). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100.

Morgan, P. L., Farkas, G., & Wu, Q. (2009). Five-year growth trajectories of kindergarten children with learning difficulties in mathematics. *Journal of Learning Disabilities, 42,* 306-321. Doi: 10.1177/0022219408331037

Moseley, B. (2005). Pre-service early childhood educators' perceptions of math-mediated language. *Early Education & Development, 16*, 385-396.

Murphy, J., Bates, P., & Anderson, J. (1984). The effect of self-instruction training of counting skills by pre-school handicapped students. *Education and Treatment of Children, 7,* 247-257.

Murphy, M. M., Mazzocco, M. M. M., Hanich, L. B., & Early, M. C. (2007). Cognitive characteristics of children with mathematics learning disability (MLD) vary as a function of the cutoff criterion used to define MLD. *Journal of Learning Disabilities, 40*, 458-478.

Murphy, S. J. (2000). Children's books about math: Trade books that teach. *New Advocate, 13,* 365-374.

Muthukrishna, N., & Borkowski, J. G. (1995). How learning contexts facilitate strategy transfer. *Applied Cognitive Psychology*, *9*, 425–446.

National Association for the Education of Young Children (2009*). Developmentally appropriate practice in early childhood programs serving children from birth through age 8*. National Association for the Education of Young Children.

National Association for the Education of Young Children & National Council of Teachers of Mathematics (2002). *Early childhood mathematics: Promoting good beginnings. A joint position statement of NAEYC and NCTM.* Retrieved from http://www.naeyc.org/files/naeyc/file/positions/psmath.pdf

National Center for Learning Disabilities. (2006). *Dyscalculia.* Retrieved from http://www.ldonline.org/article/dyscalculia?theme=print

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. (1990). *Mathematics for the young child*. Reston, VA: Author.

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

National Council of Teachers of Mathematics. (2006). *Curriculum focal points for prekindergarten through Grade 8 mathematics: A quest for coherence*. Reston, VA: Author.

National Joint Committee on Learning Disabilities (2006). *Learning disabilities and young children: Identification and intervention*. Retrieved from http://www.ncld.org/ld-basics/njcld-position-papers/index-and-summaries-of-njcld-reports

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel.* Washington, DC: U. S. Department of Education. Retrieved from http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

National Research Council. (2001). Adding it up: Helping children learn mathematics. Washington, DC: National Academy Press.

National Research Council. (2009). *Mathematics in early childhood: Learning paths toward excellence and equity* (C. T. Cross, T. A. Woods, H. Schweingruber, Eds.). National Academy Press, Washington, DC, 2009.

Nowakowski, M. E., Cunningham, C. C., McHolm, A. E., Evans, M. A., Edison, S., St. Pierre, J., . . . Schmidt, L. A. (2009). Language and academic abilities in children with selective mutism. *Infant and Child Development, 18,* 271-290.

Organisation for Economic and Co-operation and Development. (2010). PISA 2009 Results: *What students know and can do – student performance in reading, mathematics, and science* (Volume 1). doi: 10.1787/9789264091450.

Odom, S. L., & Wolery, M. (2003). A unified theory of practice in early intervention/early childhood special education: Evidence-based practices. *The Journal of Special Education, 37,* 164-173.

Ojose, B. (2008). Applying Piaget's theory of cognitive development to math instruction. *The Mathematics Educator, 18*, 26-30.

Ostad, S. A. (1997). Developmental differences in addition strategies: A comparison of mathematically disabled and mathematically normal children. *British Journal of Educational Psychology, 67,* 345–357.

Owen, R. L., & Fuchs, L. S. (2002). Mathematical problem-solving strategy instruction for third-grade students with learning disabilities. *Remedial and Special Education, 23,* 268–278.

Padula, J. (2004). The role of mathematical fiction in the learning of mathematics in primary school. *Australian Primary Mathematics Classroom, 9,* 8-14.

Padula, J., & Stacey, K. (1990). Learning basic concepts for early mathematics. *Australian Journal of Early Childhood, 15,* 34-37.

Parmar, R. S., Cawley, J. F., & Miller, J. H. (1994). Differences in mathematics performance between students with learning disabilities and students with mild mental retardation. *Educational Children, 60,* 549-563.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas,* New York: Basic Books.

Pasnak, R., Greene, M. S., Ferguson, E. O., & Levit, K. (2006). Applying principles of development to help at-risk preschoolers develop numeracy. *The Journal of Psychology, 140,* 155-173.

Peisner-Feinberg, E. S., Burchinal, M. R., Clifford, R. M., Culkin, M. L., Howes, C., Kagan, S. L., & Yazejian, N. (2001). The relation of preschool child-care quality to children's cognitive and social development trajectories through second grade. *Child Development, 72,* 1534-1553.

Pennington, B. F. (1991). *Diagnosing learning disorders: a neuropsychological framework*. New York: Guilford Press, 1991.

Pentimonti, J. M., Zucker, T. A., & Justice, L. M. (2011). What are preschool teachers reading in their classrooms? *Reading Psychology, 32,* 197-236.

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

Phillips, E., & Anderson, A. (1993). Developing mathematical power: A case study. *Early Child Development and Care, 96,* 135-146.

Phillips, D. & Croswell, N. A. (Eds.). (1994). *Cultural diversity and early education: Report of a workshop*. Washington, DC: National Academy Press.

Phillips, D. A., & Meloy, M. E. (2012). High-quality school-based pre-k can boost early learning for children with special needs. *Exceptional Children, 78,* 471-490.

Piaget, J. (1964). Development and learning. In R. E. Ripple & V. N. Rockcastle (Eds.). *Piaget Undiscovered.* (pp. 7-20).

Piaget, J. (1977). Comments on mathematical education. In H. E. Gruber & J. J. Voneche (Eds.), *The essential Piaget* (pp. 726-732). New York: Basic Books.

Porter, J. (1999). Learning to count: A difficult task? *Down Syndrome Research and Practice, 6,* 85-94.

Portney, L. G., & Watkins, M. P. (2009). *Foundations of Clinical Research: Application to Practice, 3rd edition.* Prentice-Hall: Upper Saddle River, NJ.

Provasnik, S., Kastberg, D., Ferraro, D., Lemanski, N., Roey, S., & Jenkins, F. (2012). *Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context* (NCES 2013-009 Revised). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Purpura, D. J., Hume, L. E., Sims, D. M., & Lonigan, C. J. (2011). Early literacy and early numeracy: The value of including early literacy skills in the prediction of numeracy development. *Journal of Experimental Child Psychology, 110,* 647-658.

Ramani, G. B., & Siegler, R. S. (2008). Promoting broad and stable improvements in low-income children's numerical knowledge through playing number board games. *Child Development, 79,* 375-394.

Rasmussen, C., & Bisanz, J. (2011). The relation between mathematics and working memory in young children with fetal alcohol spectrum disorders. *The Journal of Special Education, 45,* 184-191. doi: 10.1177/0022466909356110

Richards, J., & von Glasersfeld, E. (1980). Jean Piaget, psychologist of epistemology: A discussion of Rotman's Jean Piaget: Psychologist of the real. *Journal for Research in Mathematics Education, 11,* 29-36.

Rittle-Johnson, B. (2006) Promoting transfer: Effects of self-explanation and direct instruction. *Child Development, 77*, 1–15.

Rittle-Johnson, B., & Alibali, M. W. (1999). Conceptual and procedural knowledge of mathematics: Does one lead to the other? *Journal of Educational Psychology, 91.* 175-189.

Rivera, D. P. (1997). Mathematics education and students with learning disabilities. Introduction to the special series. *Journal of Learning Disabilities, 30,* 2–19.

Rivera-Batiz, F. L. (1992). Quantitative literacy and the likelihood of employment among young adults in the United States. *Journal of Human Resources, 27*, 313-328.

Robinson, C. S., Menchetti, B. M., & Torgesen, J. K. (2002). Toward a two-factor theory of one type of mathematics disability. *Learning Disabilities Research, 17,* 81-89.

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. Oxford, England: Oxford University Press.

Rohrbeck, C. A., Ginsburg-Block, M. D., Fantuzzo, J. W., & Miller, T. R. (2003). Peer-assisted learning interventions with elementary school students: A meta-analytic review. *Journal of Educational Psychology, 95,* 240-257.

Rolfhus, E., Gersten, R., Clarke, B., Decker, L., Wilkins, C., & Dimino, J. (2012). *An evaluation of Number Rockets: A Tier 2 intervention for grade 1 students at risk for difficulties in mathematics.* (NCEE 2012-4007). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Romberg, T. A., & Kaput, J. J. (1999). Mathematics worth teaching, mathematics worth understanding. In E. Fennema & T. A. Romberg (Eds.), *Mathematics classrooms that promote understanding* (pp. 3-17). Mahwah, NJ: Erlbaum.

Rosen, D., & Hoffman, J. (2009). Integrating concrete and virtual manipulatives in early childhood mathematics. *Young Children, 64*, 26-33.

Sarama, J., & Clements, D. H. (2008). Mathematics in early childhood. In O. Saracho, & B. Spodak (Eds.), *Contemporary perspectives on mathematics in early childhood education,* (pp. 253-276). Charlotte, NC: Information Age Publishing.

Samara, J., & Clements, D. H. (2009). *Early childhood mathematics education research: Learning trajectories for young children*. New York: Routledge.

Satariano, P. (1994). *Storytime mathtime: Math explorations in children's literature.* Palo Alto, CA: Dale Seymour.

Saxe, G. B., Guberman, S. R., & Gearhart, M. (1987). Social processes in early number development. *Monographs of the Society for Research in Child Development,* 52 (2, Serial No. 216).

Scarborough, H. S., Dobrich, W., & Hager, M. (1991). Preschool literacy experience and later reading achievement. *Journal of Learning Disabilities, 24,* 508-511.

Schiro, M. S. (1997). *Integrating children's literature and mathematics in the classroom: Children as meaning makers, problem solvers, and literary critics*. New York: Teachers College Press.

Scott, K. S. (1993). Multisensory mathematics for children with mild disabilities. *Exceptionality, 4,* 97-111.

Scieszka, J., & Smith, L. (1995). *Math Curse.* New York: Viking.

Seefeldt, C., & Galper, A. (2008). *Active experiences for active children: Mathematics* (2nd ed.). Upper Saddle River, NJ: Pearson.

Seo, Y. J., & Bryant, D. (2012). Multimedia CAI program for students with mathematics difficulties. *Remedial and Special Education, 33,* 217-225.

Seo, K. H., & Ginsburg, H. P. (2004). What is developmentally appropriate in early childhood mathematics education? Lessons from new research. In D. H. Clements, J. Sarama, & A. M. DiBaiase (Eds.), *Engaging young children in mathematics: Standards for early childhood mathematics education* (pp.91-104). Hillsdale, NJ: Erlbaum.

Sfard, A., Nesher, P., Streefland, L., Cobb, P., & Mason, J. (1998). Learning mathematics through conversation: Is it as good as they say? *For the Learning of Mathematics, 18*, 41-51.

Shalev, R. S., Auerbach, J., Manor, O., & Gross-Tsur, V. (2000). Developmental dyscalculia: Prevalence and prognosis. *European Child and Adolescent Psychology, 9*, 58-64.

Shaw, R., Grayson, A., & Lewis, V. (2005). Inhibition, ADHD, and computer games: The inhibitory performance of children with ADHD on computerized tasks and games. *Journal of Attention Disorders, 8,* 160-168.

Sherer, M., Pierce, K. L., Paredes, S., Kisacky, K. L., Ingersoll, B., & Schreibman, L. (2001). Enhancing conversation skills in children with autism via video technology: Which is better, "self" or "other" as a model? *Behavior Modification, 25,* 140-158, doi: 10.1177/0145445501251008

Shipley, E. F., & Shepperson, B. (1990). Countable entities: Developmental changes. *Cognition, 34,* 109-136.

Shrager, J. & Siegler, R.S. (1998). SCADS: A model of children's strategy choices and strategy discoveries. *Psychological Science*, *9*, 405–410.

Siegler, R. (1988). Individual differences in strategy choices: Good students, not-so-good students, and perfectionists. *Child Development, 59, 833-851.*

Siegler, R. S., & Ramani, G. B. (2008). Playing linear numerical board games promotes low-income children's numerical development. *Developmental Science, 11,* 655-661. doi: 10.1111/j.1467-7687.2008.00714.x

Siegler, R. S., & Ramani, G. B. (2009). Playing linear number board games – but not circular ones – improves low-income preschoolers' numerical understanding. *Journal of Educational Psychology, 101,* 545-560.

Simmons, F. R., & Singleton, C. (2008). Do weak phonological representations impact on arithmetic development? A review of research into arithmetic and dyslexia. *Dyslexia, 14*, 77-94.

Simon, R., & Hanrahan, J. (2004). An evaluation of the Touch Math method for teaching addition to students with learning disabilities in mathematics. *European Journal of Special Needs Education, 19,* 191-209.

Sipe, L. R. (1998). How picture books work: A semiotically framed theory of text-picture relationships. *Children's Literature in Education, 29,* 97-108.

Skoumpourdi, C., & Mpakopoulou, I. (2011). The prints: A picture book for pre-formal geometry. *Journal of Early Childhood Education, 39*, 197-206.

Sophian, C. (2002). Learning about what fits: Preschool children's reasoning about effects of object size. *Journal for Research in Mathematics Education, 33,* 290-302.

Sophian, C. (2004). Mathematics for the future: Developing a Head Start curriculum to support mathematics learning. *Early Childhood Research Quarterly, 19*, 59-81. doi: 10.1016/j.ecresq.2004.01.015

Sophian, C., & Kailihiwa, C. (1998). Units of counting: Developmental changes. *Cognitive Development, 13*, 561-585.

Stannard, L. L., Wolfgang, C. H., Jones, I., & Phelps, C. (2001). A longitudinal study of the predictive relations among construction play and mathematical achievement. *Early Child Development and Care, 167,* 115-125.

Starkey, P., & Cooper, R. G. (1980). Perception of numbers by human infants. *Science, 210*, 1033-1035.

Starkey, P., & Klein, A. (2000). Fostering parental support for children's mathematical development: an intervention with Head Start. *Early Education and Development, 11,* 659-680.

Starkey, P., Klein, A., Chang, I., Qi, D., Lijuan, P., & Yang, Z. (1999). *Environmental supports for young children's mathematical development in China and the United States.* Paper presented at the Society for Research in Child Development, Albuquerque, NM.

Starkey, P., Klein, A., & Wakeley, A. (2004). Enhancing young children's mathematical knowledge through a pre-kindergarten mathematics intervention. *Early Childhood Research Quarterly, 19,* 99-120. doi: 10.1016/j.ecresq.2004.01.002

Steffe, L. P., Kieran, T. (1994). Radical constructivism and mathematics education. *Journal for Research in Mathematics Education, 25,* 711-733.

Steinhausen, H. C., & Juzi, C. (1996). Elective mutism: An analysis of 100 cases. *Journal of the American Academy of Child and Adolescent Psychiatry, 35*, 606–614.

Stevenson, H. W., & Newman, R. S. (1986). Long-term prediction of achievement and attitudes in mathematics and reading. *Child development, 57,* 646-659.

Stewig, J. W. (1992). Reading pictures, reading text: Some similarities. *New Advocate 5*, no. 1: 11-22.

Stigler, J. W., Lee, S. Y., & Stevenson, H. W. (1990). *Mathematical knowledge of Japanese, Chinese, and American elementary school children*. Reston, VA: National Council of Teaching of Mathematics.

Stipek, D. J., & Ryan, R. H. (1997). Economically disadvantaged preschoolers: Ready to learn but further to go. *Developmental Psychology, 33,* 711-723.

Swanson, H. L., Carson, C., & Lee, C. M. (1996). A selective synthesis of intervention research for students with learning disabilities. *School Psychology Review, 25,* 370–392.

Swanson, H. L., & Hoskyn, M. (1998). Experimental intervention research on students with learning disabilities: A meta-analysis of treatment outcomes. *Review of Educational Research, 68,* 277–321.

Sylva, K., Melhuish, E., Sammons, P., Siraj-Blatchford, I., & Taggart, B. (2011). Pre-school quality and educational outcomes at age 11: Low quality has little benefit. *Journal of Early Childhood Research, 9,* 102-124.

Taylor-Cox, J. (2003). Algebra in the early years? Yes! *Young Children, 58,* 14-22.

Temple, C. M. (1991). Procedural dyscalculia and number fact dyscalculia: Double dissociation in developmental dyscalculia. *Cognitive Neuropsychology, 8*, 155-176.

Thomas, B. (1984). Early toy preferences of four-year-old readers and nonreaders. *Child Development, 15,* 424-430.

Thrailkill, C. (1994). Math and literature: A perfect match. *Teaching K-8, 24*, 64-65.

Toll, S. W. M., Van der Ven, S. H. G., Kroesbergen, E. H., & Van Luit, J. E. H. (2011). Executive functions as predictors of math learning disabilities. *Journal of Learning Disabilities, 44,* 521-532.

Topping, K. J. (2005). Trends in peer learning. *Educational Psychology, 25,* 631-645.

Tremblay, R. E., Masse, B., Perron, D. LaBlanc, M., Schwartzman, A. E., & Ledingham, J. E. (1992). Early disruptive behavior, poor school achievement, delinquent behavior, and delinquent personality: Longitudinal analyses. *Journal of Consulting and Clinical Psychology, 60,* 64-72.

U. S. Department of Education, N. C. E. S. (2000). *The condition of education 2000*. Washington, DC: U.S. Government Printing Office.

Usnick, V., & McCarthy, J. (1998). Turning adolescents onto mathematics through literature. *Middle School Journal, 29*, 50-54.

Van den Heuvel-Panhuizen, M., & Iliada, E. (2011). Kindergartener's performance in length measurement and the effect of picture book reading. *ZDM Mathematics Education, 43*, 621-635.

Van den Heuvel-Panhuizen, M., & Ven den Boogaard, S. (2008). Picture books as an impetus for kindergartners' mathematical thinking. *Mathematical Thinking and Learning, 10*, 341-373.

Van de Walle, J., & Lovin, L. (2006). Teaching student-centered mathematics: Grades K-3. Boston: Pearson Education.

Vandermaas-Peeler, M., Nelson, J., & Bumpass, C. (2007). Quarters are what you put into the bubble gum machine: Numeracy interactions during parent-child play. *Early Childhood Research and Practice, 9.* Retrieved from http://ecrp.uiuc.edu/v9n1/vandermaas.html

Van der Sluis, S., De Jong, P. F., & Van der Leij, A. (2007). Executive functioning in children, and its relations with reasoning, reading, and arithmetic. *Intelligence, 35,* 427-449.

Van Luit, J. E. H., & Schopman, E. A. M. (2000). Improving early numeracy of young children with special educational needs. *Remedial and Special Education, 21,* 27-40.

Van Luit, J. E. H., Van de Rijt, B. A. M., & Pennings, A. H. (1994). *Utrechtse Getalbegrip Toets* [Utrecht Test of Number Sense]. Doetinchem, The Netherlands: Graviant.

Vivas, J. (1985). *The grandma poss cookbook.* Adelaide, S. A., Omnibus Books.

Von Glasersfeld, E. (1981). An attentional model for the conceptual construction of units and number. *Journal for Research in Mathematics Education, 12*, 83-94.

Von Glasersfeld, E. (1982). Subitizing: The role of figural patterns in the development of numerical concepts. *Archives de Psychologie, 50*, 191-218.

Vu, J. A., Babikian, T., & Asarnow, R. F. (2011). Academic and language outcomes in children after traumatic brain injury: A meta-analysis. *Exceptional Children, 77,* 263-281.

Vukovic, R. K. (2012). Mathematics difficulty with and without reading difficulty: Findings and implications from a four-year longitudinal study. *Exceptional Children, 78,* 280-300.

Vygotsky, L. (1978). *Interaction between learning and development*. From: Mind and Society (pp. 79-91). Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1987). *Collected works* (Volume 1). New York: Plenum. In Library.

Wei, X., Lenz, K. B., & Blackorby, J. (2012). Math growth trajectories of students with disabilities: Disability category, gender, racial, and socioeconomic status differences from ages 7 to 17. *Remedial and Special Education.* Advance online publication. doi: 10.1177/0741932512448253

Welchman-Tischler, R. (1992). *How to use children's literature to teach mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Wells, G. (1985). Preschool literacy-related activities and success in school. In R. Olson & A. Hildyard (Eds.), *Literacy, language, and learning* (pp. 229-255). Cambridge, England: Cambridge University Press.

Welsh, J. A., Nix, R. L., Blair, C., Bierman, K. L., & Nelson, K. E. (2010). The development of cognitive skills and gains in academic school readiness for children from low-income families. *Journal of Educational Psychology, 102*, 43–53.

West, J., Denton, K., & Germino-Hausken, E. (2000). *America's kindergartners (*Publication *NCES 2000-070).*Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Whitin, D. J. (1994). *Exploring estimation through children's literature*. Arithmetic Teacher, 41, 436-441.

Whitin, D. J. (2002). The potentials and pitfalls of integrating literature into the mathematics program. *Teaching Children Mathematics, 8*, 503-504.

Whitin, D. J., & Gary, C. C. (1994). Promoting mathematical explorations through children's literature. *Arithmetic Teacher, 41,* 394-399.

Whitin, D. J., & Whitin, P. (2004). *New visions for linking literature and mathematics.* Reston, VA: National Council of Teachers of Mathematics.

Whitin, D., & Wilde, S. (1992). *Read any good math lately? Children's books for mathematical learning, K-6.* Portsmouth, NH: Heinemann.

Wilburne, J. M., Keat, J. B., & Napoli, M. (2011). *Cowboys count, monkeys measure, and princesses problem solve: Building early math skills through storybooks.* Baltimore, MD: Brookes Publishing.

Williams, M. (1986). The place of games in primary mathematics. *Mathematics in School, 15,* 19.

Wise, J. C., Pae, H. K., Wolfe, C. B., Sevcik, R. A., Morris, R. D., Lovett, M., & Wolf, M. (2008). Phonological awareness and rapid naming skills of children with reading disabilities and children with reading disabilities who are at risk for mathematics difficulties. *Learning Disabilities Research and Practice, 23*, 125-136.

Wolery, M., & Hemmeter, M. L. (2011). Classroom instruction: Background, assumptions, and challenges. *Journal of Early Intervention, 33*, 371-380.

Wolery, M., Ault, M. J., Gast, D., Doyle, P. M., & Mills (1990). The use of choral and individual attentional responses with constant time delay when teaching sight word reading. *Remedial and Special Education, 11,* 47-58.

Wolfgang, C. H., Stannard, L. L., & Jones, I. (2001). Block play performance among preschoolers as a predictor of later school achievement in mathematics. *Journal of Research in Childhood Education, 15,* 173-180.

Woodward, J. (2006). Developing automaticity in multiplication facts: Integrating strategy instruction with timed practice drills. *Learning Disability Quarterly, 29*, 269–289.

Woodward, J., & Howard, L. (1994). The misconceptions of youth: Errors and their mathematical meaning. *Exceptional Children, 61,* 126-136.

Wynn, K. (1992). Addition and subtraction by human infants. *Nature, 358*, 749-750.

Xin, Y. P., Jitendra, A. K., & Deatline-Buchman, A. (2005). Effects of mathematical word problem-solving instruction on middle school students with learning problems. *Journal of Special Education, 39*, 181–192.

Xu, F., & Spelke, E. S. (2000). Large number discrimination in 6-month-old infants. *Cognition, 74,* B1-B11.

Xu, F., Spelke, E. S., & Goddard, S. (2005). Number sense in human infants. *Developmental Science, 8,* 88-101.

Young-Loveridge, J. M. (1989). The relationship between children's home experiences and their mathematical skills on entry to school. *Early Child Development and Care, 43,* 43-59.

Young-Loveridge, J. M. (1991). The development of resources to improve children's number concepts using games and books. In A. Begg, B. Bell, F. Biddulph, M. Carr, M. Carr, J. McChesney, & J. Young Loveridge (Eds.), *SAMEpapers 1991 (pp. 64-78).* Hamilton, Australia: Longman Paul.

Young-Loveridge, J. M. (2004). Effects on early numeracy of a program using number books and games. *Early Childhood Research Quarterly, 19*, 82-98. doi: 10.1016/j.ecresq.2004.01.001

Yuzawa, M., Bart, W. M., Kinne, L. J., Sukemune, S., & Kataoka, M. (1999). The effects of "origami" practice on size comparison strategy among young Japanese and American children. *Journal of Research in Childhood Education, 13*, 133-143.

Zamarian, L., Visani, P., Delzaer, M., Seppi, K., Mair, K. J., Diem, A., . . . Benke, T. (2006). Parkinson's disease and arithmetic: The role of executive functions. *Journal of the Neurological Sciences, 248*, 124-130.

Zazkis, R., & Liljedahl, P. (2009). *Teaching mathematics as storytelling*. The Netherlands, Rotterdam: Sense Publishers.

APPENDIXES

APPENDIX A

Appendix A. *Specific Components of Integrating Mathematics within Children's Literature*

This is a 6-day sequence of integrating mathematics within children's literature. Each day will consist of a daily reading of the same storybook with small group activities to follow. Each activity will focus on the instructor using explicit and direct instruction of (1) teacher modeling, (2) student guided instruction, and (3) student independent practice. The activities may vary slightly based on the nature of the chosen storybook and the target concepts. Each lesson will always begin building rapport with the students and conclude with a review of the concepts learned.

Explicit Instruction Keys:

1. I do (Teacher model using self-talk throughout)
2. We do (Student guided Instruction with appropriate scaffolding)
3. You do (Student independent practice)

Day One:

Picture Walk through Book (~3 minutes)

- Predictions
- Discuss illustrations

First reading of the storybook (~7 minutes)

- Focus on characters, plot, and setting
- Comprehension/recall questions
- Focus on the "big picture" math concepts

- Focus on student questions and interests

Math Activity: Felt Board Math Re-Tell (~10 minutes)

The purpose of this activity is to begin to (1) highlight and introduce the math concepts in the book, (2) encourage active engagement of students, (3) encourage comprehension of both the story and the target math concepts.

- Using the felt board and felt board objects/characters, briefly highlight the target concepts through re-telling at least part of story. Invite children to fully participate by adding pieces to the board and through responding to questions and discussion.

Closure: Review the target skills learned and two comprehension questions from the storybook.

Day Two:

Review: Review of target math concepts from prior lesson (~3 minutes)

Storybook Reading with Math Elaborations (~5 minutes)

Math Activity: Storybook Reading with Felt Board (~10 minutes)

The purpose of this activity is to (1) highlight the math concepts in the book, (2) encourage active engagement of students, (3) encourage comprehension of both the story and the target math concepts.

- Use the felt board to tell the entire story while elaborating on the mathematics within the book.
- While using the felt board, ask a minimum of three math questions throughout the story and a minimum of two math questions at the end of the story.

Closure: Review the target skills learned, two comprehension questions from the storybook.

Day Three:

Review: Review of target math concepts from prior lesson (~3 minutes)

Storybook Reading with Brief Math Elaborations (~5 minutes)

Math Activity: Create Your Own Book (~12 minutes)

The purpose of this activity is to (1) encourage comprehension of the book, (2) focus on targeting math concepts through explicit activities, (3) encourage reading of the book outside the small group element.

- Create a book or poster that illustrates the plot and mathematics within the story. When each child has completed his or her work, ask him/her to read his or her book to you. Suggestion: for children who are non-verbal, read the book to the child, but ask the child to participate in pointing to the pictures, gesturing, and turning the pages.
- Direct instruction: model the making of the book/board first, breaking down the tasks to one page at a time. Suggestion: This activity allows children to work towards math, fine motor, and literacy skills. To spend more time focusing on the math, rather than on the fine motor skills of cutting and coloring, have children color and cut out book pieces in advance.

Closure: Review the target skills learned, including a minimum of two comprehension and two math concept questions from the book.

Day Four:

Review: Review of target math concepts from prior lesson (~3 minutes)

Storybook Reading with Math Manipulatives (~10 minutes)

- While reading, use manipulatives to elaborate the mathematics

- Greater focus on mathematics
- Ask a minimum of 5 math questions throughout the story and at least 3 math questions at the end of the story.

Math Activity: Manipulative Play (~10 minutes)

The purpose of this activity is to (1) incorporate the use of manipulatives within the learning of the early math concepts, and (2) encourage conceptual learning of mathematics through opportunities for informal discussion and questioning.

- This activity can be introduced and extended in many different ways. One way to introduce the manipulatives (the mystery box activity) is highlighted below.
- Example activity: Mystery Box. The instructor places all manipulatives in a mystery box. Acting as a character in the story, the children take turns pulling the manipulatives from the box (e.g., The Very Hungry Caterpillar: the children pretend to be the caterpillar by wearing a green sock on their hand. The children pull fruit out of the box as if they were the caterpillar eating through the fruit). Once all the manipulatives are chosen, the instructor discusses the target math concepts with the children. Direct instruction: The instructor should model answering each question first, and scaffold the children's responses as needed. Next, the instructor can extend the activity, such as graphing, sorting, patterning, adding or subtracting the manipulatives.
    - For example, Teacher: "How many pears do you have? I have one, two, three pears. What about you?" Child incorrectly responds with: "I have two pears." Teacher scaffolds, "count the pears again, and touch each one as you count." Child: "one, two, three, four. I have four pears!" Teacher:

"That's right, you have four pears! Great work touching each pear as you counted! Can you find the number 4? You found the number 4! Do you have more pears or apples?"

- Suggestion for children who are non-verbal: Ask the children to respond by showing you the correct answers with the manipulatives, rather than verbalizing the responses.
- Example Discussion Points:
  - How many do ___ you have?
  - What do you have more/fewer of?
  - Who has 1 apple, who has 2 apples?

Closure: Review the target skills learned, including a minimum of one comprehension and four math concept questions from the book.

Day Five:

Review: Review of target math concepts from prior lesson (~3 minutes)

Storybook Reading Focused on Math Concepts and Elaboration (~6 minutes)

Storybook Reading with the Child Reenactment (~10 minutes)

The purpose of this activity is to (1) encourage active engagement of students, (2) encourage comprehension of both the story and the target math concepts.

- While reading, encourage the children to reenact the story by using puppets, manipulatives, or felt board characters.
- Focus on target math concepts

Closure: Review the target skills learned, including a minimum of one comprehension and four math concept questions from the book.

Day Six:

Review: Review of target math concepts from prior lessons (~3 minutes)

Storybook Reading focused on Math Concepts and Elaboration (~6 minutes)

Math Activity: Math Games (~11 minutes)

The purpose of this activity is to explicitly focus on the target math concepts.

- Instructor will introduce a simple math game to students related to the storybook. The game should explicitly focus on the target math concepts.
- Direct instruction: Provide a model of how to play the game. On students' first turn, provide student-guided assistance. For students' subsequent turns encourage independent practice and provide immediate corrective feedback. Provide any level of scaffolding the student may require.

Closure: Review the target skills learned, including a minimum of one comprehension and four math concept questions from the book.

APPENDIX B

Appendix B. *Child Demographic Form*

Participant #		**Classroom #** **Treatment/Control**	
Date of Birth		**Race/Ethnicity**	
Gender		**Special Education Eligibility**	
Medical Diagnoses		**Special Education Services and Hours per Week/Month** (Please circle and provide specifics when needed)	Speech and Language Occupational Therapy Physical Therapy Other _______________
IEP Goals (Please circle and provide specifics where noted)	Cognition Social/Emotional Adaptive Communication Motor	**Notes**	

APPENDIX C

Appendix C. *Teacher Demographic Form*

Teacher #		**Classroom # Treatment/Control**	
Date of Birth		**Gender**	
College Degree(s)		**Teaching Certification Area(s)**	
Total Number of Years Teaching Experience		**Number of Years Teaching Experience in Preschool Special Needs**	
Current Classroom Curriculum		**Additional or Supplemental Curricula**	

APPENDIX D

Appendix D. *Preschool Numeracy Indicators*

One-to-One Correspondence Counting Fluency (30 Seconds)

Sample

Present sheet with 4 circles (3 across, 1 down). **I'm going to count these circles as fast as I can. Watch what I do.** Count the 4 circles, and point to each circle as you count it. **When I say, "Count," count these circles out loud as fast as you can. Put your finger on each one as you count.** Point to circle at child's top left corner. **Start here. Ready? Count.**
If all 4 circles counted correctly without prompting, proceed to Task.

If child. . .	Examiner Response
Does not respond within 3 seconds	Point to the first circle, say, **One,** and drop your voice to indicate that another number should follow it. Then, point to the second circle and say, **Keep counting.** If the child does not continue counting, say, **Keep counting.** If the child still does not count, discontinue the sample, do not administer the task, and score 0 for One-to-One Correspondence Counting Fluency.
Pauses for 3 seconds after beginning task	Repeat the last number stated in the sequence, drop your voice to indicate that another number should follow it, and say, **Keep counting.** Repeat as necessary. Proceed to Task.
Responds incorrectly	Repeat Sample. Proceed to Task.
Counts without pointing to circles, provides last number, or points to circles without counting aloud	Stop the task and say, **Put your finger on each one as you count.** Point to the first 3 circles. **Put your finger here.** Point to circle at child's top left corner, and say, **Ready? Count.**

Task

Present the sheet with 20 circles, and say, **Let's do another one. When I say "Count," count these circles out loud as fast as you can. Put your finger on each one as you count.** Point to each of the first 3 circles. **Put your finger here.** Point to circle at child's top left corner. **Start here. Ready? Count.** Start timing, time for 30 seconds, and say **Stop.**

If child. . .	Examiner Response
Does not respond within 3 seconds	Point to the first circle, say, **One,** and drop your voice to indicate that another number should follow it. Then, point to the second circle and say, **Keep counting.** If the child does not continue counting, say, **Keep counting.** If the child still does not count, discontinue and score 0 for One-to-One Correspondence Counting Fluency.
Pauses for 3 seconds after beginning task OR Stops before counting all circles	Repeat the last number stated in the sequence, drop your voice to indicate that another number should follow it, and say, **Keep counting.** Repeat prompt as necessary. If the child still does not respond after prompt, discontinue, record 30 seconds for the time, and record the last number stated in sequence from 1 in One-to-One Correspondence Counting.
Responds incorrectly	Stop timing and say, **Put your finger on each one as you count.** Point to the first 3 circles. **Put your finger here.** Point to circle at child's top left corner, and say, **Ready? Count.** Re-start timing. If the child continues not to point to the circles, discontinue and score 0 for One-to-One Correspondence Counting Fluency.
Counts the circles in a random sequence using one-to-one correspondence	Give full credit for all circles counted with one-to-one correspondence, even though the child did not go row by row or column by column.
Counts a circle twice OR Counts without one-to-one correspondence after beginning task	Discontinue, record 30 seconds for the time, and record the last number stated with One to One correspondence in sequence from 1 in One-to-One Correspondence Counting.
Counts all circles in less than 30 seconds	Record exact time of completion in Time in Seconds.

(Floyd & Hojnoski, 2005)

Quantity Comparison Fluency (1 minute)

Demonstration

Present the page with 6 circles on one side and 2 circles on the other side.
Look here and here. Point to both sides. **I will show you which box has more circles** Point to the side with more circles. **This one has more.**

Sample 1

Present next page. **Your turn. Which box has more?**

If child. . .	Examiner Response
Is correct	Say, **Good.** Proceed to Sample 2.
Does not respond within 3 seconds OR Is incorrect	Point to the correct side, and say, ***This* has more** Proceed to Sample Trial 2.
Counts circles.	Say, **Don't count the circles. Just look and show me which box has more.** Allow child to finish item.
Does not point clearly (Ex: points to center of page)	Say, **Which box has more?** Repeat as necessary.

Sample 2

Present the page with 4 circles on one side and 5 circles on the other side.
Let's do another one. Which box has more? Go as fast as you can.

If child. . .	Examiner Response
Is correct	Say, **Good.** Proceed to Perceptual Task.
Does not respond within 3 seconds OR Is incorrect	Point to the correct side, and say, ***This* box has more**
Counts circles	Say, **Don't count the circles. Just look and show me which box has more.** Allow child to finish item.
Does not point clearly (Ex: points to center of page)	Say, **Which box has more?** Repeat as necessary.

If child responds correctly to <u>either</u> sample, proceed to task.
If child responds incorrectly to <u>both</u> samples, discontinue and score 0 for Quantity Comparison Fluency.

Perceptual Task (1 minute)

Present the first page, and say, **Let's do some other ones. For each page, show me which box has more. Go as fast as you can. Ready? Go.** Start timing, time for 1 minute, and say, **Stop**. Turn pages as quickly as necessary.

If child. . .	Examiner Response
Does not respond within 3 seconds	Score item as incorrect, turn the page, and say, **Try this one. Show me which box has *more*.**
Appears to count circles	Say, **Don't count the circles. Just look and show me which box has more.** Turn page, and say, **Try this one.** Repeat as necessary.
Does not point clearly (Ex: points to center of page)	Say, **Which box has more?** Repeat as necessary.

(Floyd & Hojnoski, 2005)

Number Naming Fluency (1 minute)

Sample

Present the pages with the numbers 3, 1, & 12.

I'm going to look at some numbers and name them as fast as I can. Watch what I do. Turn the pages, point to the numbers, and say, **3, 1, 12.** After stating 12, point to it and say, **Look at this. If you see two numbers together, say the whole number. This is the number 12.**

Now, you name the numbers as fast as you can. Say, **Good** for each number named correctly. Administer the Task no matter how child performs on the Sample.

If child. . .	Examiner Response
Does not respond within 3 seconds OR Responds incorrectly	Say, **This number is (name the number). What is this number?** If response is correct, say, **Good. Keep going** and present the next page. If response is incorrect, repeat prompt as necessary.
Provides individual digits for the number 12	Say, **This number is 12. What is this number?** If response is correct, say, **Good. If you see two numbers together, say the whole number.** If response is incorrect, say, **If you see two numbers together, say the whole number** and repeat prompt as necessary.
Responds orally in a language other than English	Say **In English, this is also called a (name the number in English). Tell me the name in English.** If the child continues to respond in a different language on subsequent items, say, **Tell me the name in English.**

Task

Present blank page at beginning of first set of numbers.

Now, I am going to show you some more numbers. Name each number as fast as you can. Ready? Present first page, and start timing. Time for 1 minute, and turn pages as quickly as necessary.

If child. . .	Examiner Response
Does not respond within 3 seconds	Score number as incorrect, turn the page, and say, **Try this one.**
Does not correctly name any numbers in the first row	Discontinue and score 0 for Number Naming Fluency.
Responds in a different language	The first time, prompt child to **Tell me the name in English**, and score as correct if child provides correct English response. Subsequent responses in a different language should be scored as incorrect.
Provides individual digits for multi-digit numbers	Score number as incorrect.
Finishes in less than 1 minute	Record exact time of completion in Time in Seconds.
Says the letter "o" for number zero	Score as correct.

(Hojnoski & Floyd, 2005)

APPENDIX E

Appendix E. *Intervention Procedures Fidelity Checklist*

Math and Literacy Intervention
Fidelity Checklist

Researcher / Research Assistant: ___________________ Date: _____________

	Did not observe (0)	Observed some of the time - inconsistent (1)	Observed most of the time – consistent (2)	N/A
Introduction				
Researcher began session by inviting the participants to the small group activities.				
The attending children willingly joined the researcher for the story and activities.				
The researcher called the participants by their names and spent a short time building rapport.				
The researcher wrote down initials of the participants in attendance on the daily lesson plan/fidelity checklist.				
The researcher reviewed concepts from the prior lessons.				
***Storybook Reading* – If this is an observed session of the first session of a new book (Skip if it is the 2nd-6th session of the week).**				
The researcher took a picture walk with the children and discussed predictions and the illustrations.				
The researcher read the prescribed book to the children, focusing on the characters, plot, and setting.				
The researcher asked at least three open-ended “wh” comprehension questions during the story and two questions at the end of the story.				
The researcher asked at least 3 math				

questions throughout the story and two questions at the end of story.				
The researcher encouraged a small discussion at the end of the first reading.				
The researcher attended to student interests within the storybook reading.				
Researcher used least to most prompting strategies				
***Storybook Reading* – if observed session is the 2nd – 6th storybook reading.**				
The researcher read the storybook attending to mathematical concepts.				
The researcher attended to the number of objects on the pages and their attributes.				
The researcher asked at least 3 – 5 math questions during the story, and at least 2 math questions at the end of the story.				
The researcher asked at least 2 – 3 comprehension questions during the story and at the end of the story.				
The researcher attended to the illustrations and print in the story focusing on mathematical concepts.				
The researcher provided immediate corrective feedback when needed.				
Researcher used least to most prompting strategies				
Activity				
The researcher presented the children with the daily activity.				
The researcher followed the directions of the activity, making slight accommodations (e.g., using slant boards, adaptive scissors, communication devices, etc.) as needed.				
The researcher discussed targeted skills				

of one-to-one correspondence, quantity comparison, and numeral identification.				
The researcher provided immediate feedback on the performance of the activity.				
The researcher used the "I do, We do, You do" direct instruction model.				
Researcher used least to most prompting strategies				
***Assessment* – If this is the last storybook session of the 2 weeks.**				
The researcher individually assessed the children utilizing the PNI at the end of the last storybook session. Occurs on the 6th, 12th, and 18th sessions.				
Conclusion				
The researcher summarized the lesson and the targeted mathematical concepts of 1:1 correspondence, quantity comparison, and numeral identification.				
The researcher praised the children and thanked them for participating.				
The researcher allowed for the children to choose a sticker or stamp if the child desired.				
The session lasted approximately 20 minutes				
The researcher tracked fidelity on the daily lesson plan/fidelity checklist.				

Total Points Earned________/Total Points Possible_________=_________*100=__________

Observer ___________________________

IOA: Yes No 2nd Observer: ____________________________

Smallest # of Observed Steps_______/Largest # of Observed Steps______=______*100=_____