BAŞKENT UNIVERSITY JOURNAL OF EDUCATION

2014, 1(1), 81-92

Mathematics for Young Children: A Review of the Literature with Implications for Children with Disabilities

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Abstract

This paper reviews the research literature in mathematics for young children, with a focus on those with disabilities. Highlights on the importance of mathematics for young children, characteristics of young children with math difficulties or disabilities, math interventions for young children, math instruction in early childhood, and recommendations and implications for practice are presented. 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, particularly utilizing evidence based interventions. Evidence supports the benefits of focusing on mathematics instruction in the preschool years for children with disabilities. Implications for personnel preparation for those working with young children in mathematics are presented.

Keywords: Early Numeracy, Disabilities, Preschool, Mathematics

1. Introduction

Young children have the capability and potential to learn complex and sophisticated mathematical concepts (Baroody, 2004; Sarama & Clements, 2009). Early math achievement not only predicts elementary school math success (Claessens, Duncan, & Engel, 2009), but also high school math (NMAP, 2008; NRC, 2009), and total academic achievement (Claessens et al., 2009). This paper reviews the research literature in mathematics for young children, preschool through early primary school-aged, with a focus on those with disabilities.

Highlights on the importance of mathematics for young children, the characteristics of young children with math difficulties or disabilities, math interventions for young children, math instruction in early childhood education (ECE), and recommendations and implications for practice are presented. 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 mathematics, particularly utilizing evidence based interventions. This is especially important for young children from rural areas who may be less proficient in educational measures, such as literacy and math (Grace et al., 2006).

Several factors have influenced teaching ECE mathematics including programs such as Head Start for children from disadvantaged backgrounds in the U.S. and elsewhere, as well as the increased understanding of the influence of ECE on later academic achievement (Balfanz, 1999). With an increase in research on mathematics, in 2000, the U. S. National Council of Teachers of Mathematics (NCTM) published the *Principles and Standards of School Mathematics*, with a focus on teaching mathematics within context, integrated across other content areas (Moomaw & Davis, 2010; NCTM, 2000). In the U. S., Science, Technology, Engineering, and Mathematics (STEM) Education has been a recent effort to encourage a focus on mathematics and science in education curricula across all grade levels, including ECE.

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Similar to reading difficulties, difficulty with learning mathematics is associated with serious lifelong challenges, as math skills are critical for later school success and future career opportunities, particularly in science and technology (Clark, 1988). The prevalence of mathematics difficulties is high in the U. S., with estimates of between 5 and 9% of school aged children having academic challenges in math (e.g., Geary, Hoard, Nugent, & Bailey, 2012). Unfortunately, challenges in mathematics in the early years may persist throughout schooling. For example, Morgan, Farkas, and Wu (2009) found that within a representative sample of elementary-aged students, students who demonstrated mathematical performance in the lowest 10^{th} percentile at both the beginning and end of kindergarten, had a 70% chance of remaining in the lowest 10^{th} percentile in the fifth grade.

Knowledge of mathematics is an important tool that helps facilitate a person's daily living (Arias de Sanchez, 2010). Introducing math early may be beneficial to the neurological development of children as the brain undergoes significant developmental changes in the early years that are best stimulated with complex and engaging activities. Further, research shows that if children are actively engaged in meaningful and enjoyable math activities, they will likely continue to engage in math in later years (Van de Walle & Lovin, 2006).

Young children typically learn math from informal learning opportunities through play and exploration of their environment (Baroody, Lai, & Mix, 2006; Clements & Sarama, 2007a). 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 and exhibit competence in mathematics (Seo & Ginsburg, 2004). Yet, there is often a gap between children's informal mathematical knowledge and formal schooling opportunities (Griffin & Case, 1997). There is also great variability in the rate at which young children develop and understand early math knowledge and concepts (Bowman, Donovan, & Burns, 2001). This variability is due to several factors, including interactions and relationships with significant adults in or outside the home (Aubrey, Bottle, & Godfrey, 2003). Other factors linked with math achievement include birth weight, socioeconomic status, mother's education level, gender, home learning environment (Anders et al., 2012; Melhuish et al., 2008), and early math knowledge (Stevenson& Newman, 1986), suggesting that children from disadvantaged backgrounds are at risk for lower mathematics achievement. Fortunately, effective preschool and primary school experiences can positively influence children's mathematical performance (Melhuish et al., 2008). Further, high-quality preschool education can improve math and literacy competences of all children (Bridges, Fuller, Rumberger, & Tran, 2004), with the greatest gain if children enter preschool at ages two or three (Loeb, Bridges, Bassok, Fuller, & Rumberger, 2007).

2. Method

All literature on early numeracy published in English, from 1984 to 2013 was reviewed. Literature was accumulated for this review from several sources in a progressive format. First, a search was conducted through the EBSCO database using the terms *early numeracy, early mathematics, number sense, preschool,* and *disability*. Manuscripts were retrieved if the respective studies were published in a peer-reviewed journal, investigated early numeracy with children ages three to eight, and included participants with disabilities. Six articles met the criteria, and ancestral searches were conducted. Due to the paucity of published manuscripts investigating mathematics for young children with disabilities, a second search included children who were typically developing and those at risk. Thus, the final search criteria were studies published in a peer-reviewed journal that investigated early numeracy with children ages three to eight, and included participants with or without disabilities. Thirty-one articles were selected for final review (25 U.S. and 6 international).

3. Findings

3.1. 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 35th percentile on standardized tests (Clements & Sarama, 2009), whereas children with a mathematics learning disability (MLD) have memory or cognitive deficits that interfere with their learning of concepts or procedures in one or more domains of mathematics (Geary, 2004). Children with MLD tend to have persistent math achievement scores at or below the 10^{th} national percentile (Geary et al., 2012). Geary, Hoard, Nugent, and Bailey (2012) suggest that approximately seven percent of children will have MLD, while ten percent of children will exhibit persistent MD. In contrast to typically developing peers, children with MD or MLD are characterized as having difficulty in number sense tasks (e.g., counting or connecting numbers in the real world), representation and retrieval of arithmetic facts, symbolic or visual representations or coding numerical information for storage in working memory, sorting and the logical organization of objects; and have a poor memory for numbers, inadequate strategies for solving math tasks, high frequency of procedural errors, and deficits in generalization and transfer of new knowledge (Geary et al., 2012; NCLD, 2006).

Although generally children with disabilities experience lower math achievement and slower growth than typically developing peers, math difficulties manifest differently within specific disability groups and with great variability between children (Wei, Lenz, & Blackorby, 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 ages three to 10, Carlson, Jenkins, Bitterman, and Keller (2011) found that on standardized math measures, 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. While all students experienced growth, the rate of change in mathematics slowed down as the children got older. Another example of the variability among disability groups is students with attention deficit hyperactivity disorder (ADHD). Children with ADHD may have difficulty rehearsing mathematics facts and strategies and attending to auditory processes (Clements & Sarama, 2009). These students may exhibit challenges with multistep and/or complex problems (Shaw, Grayson, & Lewis, 2005).

Mazzocco (2001) found that girls with Turner or Fragile X syndrome exhibited indicators of MLD, with a larger effect size for those with Turner syndrome. Additionally, many children with Fetal Alcohol Spectrum Disorders (FASD) appear to have math challenges associated with executive functioning and working memory. Rasmussen and Bisanz (2011) studied the performance of four-to-six-year-old children with FASD on applied problems and quantitative concepts, and three components of working memory. Children with FASD showed deficits with both types of math problems and experienced particular difficulty with phonological as well as central executive working memory compared to typically developing peers.

In summary, math difficulties in young children manifest differently within disability groups. The characteristics of young children who experience MD include difficulties with number sense, retrieving math facts, and symbolic representations; high frequency of procedural errors; and deficits in central executive functioning, generalization, and transfer of knowledge and strategies (Geary et al., 2012). Children who have been diagnosed with MLD experience memory or cognitive deficits that interfere with acquiring mathematical concepts or procedures (Geary, 2004), and will likely continue with persistent challenges in mathematics.

3.2. Math Interventions for Young Children with and without Disabilities

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

The large majority of interventions for children ages three to five with MD were designed for children at-risk for academic challenges, rather than for children with disabilities (Dowker, 2004). Math interventions with young typically developing children or children at risk have consisted of integrating mathematics within activities throughout the day (Arnold, Fisher, Doctoroff, & Dobbs, 2002), as well as teaching mathematics through games (Burton, 2010); in the context of play (Hanline, Milton, & Phelps, 2010; Vandermaas-Peeler, Nelson, &Bumpass, 2007); peer tutoring (Fuchs, Fuchs, & Karns, 2001); computer assisted instruction(Baroody, Eiland, & Thompson, 2009; Fuchs et al., 2006); children's literature (Hong, 1996; Skoumpourdi & Mpakopoulou, 2011); family and home environment (Anderson, 1997; Vandermaas-Peeler et al., 2007), and through developed programs and curricula (Ginsburg, Greenes, & Balfanz, 2003; Klein, Starkey, Clements, Sarama, & Iyer, 2008). There are fewer research interventions on mathematics interventions specific to young children with disabilities. Research in mathematics instruction and characteristics of young children with math disabilities documents that high-quality, explicit mathematics instruction may prevent future learning difficulties and promote mathematical outcomes (Agondi & Harris, 2010). Mathematics interventions that included preschoolers with disabilities utilized constant time delay (Daughtery, Grisham-Brown, & Hemmeter, 2001) or self-instruction (Murphy, Bates, & Anderson, 1984). Each of these areas are highlighted below.

Arnold et al. (2002) evaluated a six week math intervention in Head Start settings with 112 at-risk children in eight classrooms. The teachers were trained to *incorporate mathematics throughout the regular classroom routine* through a variety of activities such as books, music, or games, with the targeted skills of counting, recognizing and writing numbers, one-to-one correspondence, comparison, change operations, and understanding numbers and quantities. Emergent math abilities improved for children in the intervention group and increased interest in math for students and teachers.

Several authors have studied the *use of games* to improve children's math competencies and motivation. Games can provide a meaningful and natural context to work on fundamental math skills such as counting (Burton, 2010; Cutler, Gilkerson, Parrott, & Brown, 2003), encourage children to understand the element of chance, and allow children opportunities to communicate mathematically with their peers (Burton, 2010) through skills such as one to one correspondence, counting dots on the dice, or using spinners for number recognition.

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 of play* (Vandermaas-Peeler et al., 2007). Block play is often associated with later mathematics skills; however, in a study of 51 preschoolers (22 with disabilities), Hanline, Milton, and Phelps (2010) did not find a predictive relationship between block play and mathematical abilities. Other researchers did not find a predictive relationship between preschool construction play and mathematics until children were of middle and high school age (e.g., Wolfgang, Stannard, & Jones, 2001), suggesting that the influence of block play on mathematical achievement is not evident until children perform higher level abstract mathematics, such as geometry, trigonometry, or calculus (Hanline et al., 2010).

The use of *peer tutoring instruction or peer-assisted learning strategies* (PALS) for improving math skills has been evaluated with children with and without disabilities. 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). 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, Fuchs, and Karns (2001) found that teacher-led implementation of PALS twice weekly for 15 weeks was effective in improving whole-number sense for kindergarten students with and without disabilities.

Although the large majority of research on *Computer Assisted Instruction (CAI)* is with older elementary students (Fuchs et al., 2006), researchers have also utilized CAI to assist young children in learning mathematics, and have found positive effects and benefits, including improved motivation of academic work, as well as creative mathematical thinking (Clements& Sarama, 2003). Baroody, Eiland, and Thompson (2009) evaluated discovery-learning CAI within the *Everyday Mathematics* curriculum with preschoolers in a Head Start setting and found they made significant gains on number sense given intensive, targeted small group and individual tutoring. A classroom benefit of the use of CAI includes the ability of children to adapt and manipulate virtual manipulatives (Clements & Sarama, 2009). Further, while 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 have also found benefits to *integrating mathematics within children's literature,* including increased interest and improved knowledge in measurement (Van den Heuvel-Panhuizen, & Iliada, 2011), geometry (Casey, Erkut, Ceder, & Young, 2008; Skoumpourdi & Mpakopoulou, 2011), estimation (Whitin, 1994), math vocabulary (Jennings, Jennings, Richey, Dixon-Krauss, 1992), and classification and number combinations (Hong, 1996). Skoumpourdi and Mpakopoulou (2011) provided typically developing kindergartners a shared storybook reading with a researcher-made picture book and related activities. The authors found that the intervention assisted typically developing kindergarteners with their abilities to identify solid shapes and provide examples of plane figures. Similarly, Hong (1996) analyzed the effectiveness of using children's literature with complementary mathematics activities during free play with

57 typically developing kindergarteners and found that children in the experimental group spent more time in the math corner and chose to play with mathematics materials during free play more than did children in the control group. The experimental group also experienced higher qualitative results in classification, number combination, and shape tasks.

For young children, there is some research examining children's exposure to *pre numeracy 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; Melhuish et al., 2008), and the way children engage in mathematical experiences (Aubrey et al, 2003). Home interventions include play-based (Vandermaas-Peeler et al., 2007), and literature-based math interventions (e.g., Anderson, 1997; Anderson, Anderson, & Shapiro, 2004, 2005; Vandermaas-Peeler et al., 2007). Vandermaas-Peeler, Nelson, & Bumpass (2007), for instance, observed videotaped sessions of twenty-six mothers who read a story to their 4-year-old children and then completed a play activity related to a post office. Results suggested that numeracy related parent-child interactions supported procedural understanding of numeracy; however, much of the play was literacy-related.

Integrating literacy and mathematics is an intervention that families can use to promote mathematical knowledge with their children through shared storybook readings (Anderson et al., 2004, 2005). The mathematical concepts elicited through the integration of mathematics and literature in the home environment included counting, and naming shapes and numbers (Anderson, 1997), as well as size, subitizing, and counting (Anderson et al., 2004). Starkey and Klein (2000) noted that educators should foster parental support to assist in achieving school readiness for young children at risk.

Several *programs and curricula* have been developed specifically for mathematics for young children with positive effects. Curricula specific for preschool mathematics in the U. S. include *Pre-K Mathematics Curriculum* (Klein & Starkey, 2002), *Building Blocks* (Clements &Sarama, 2007b), *Big Math for Little Kids* (BMLK; Balfanz, Ginsburg, & Greenes, 2003; Ginsburg et al., 2003), *'Round the Rug Math* (Casey, 2004), the Measurement-based approach (Sophian, 2004), *Number Worlds* (Griffin, 2007), and the *Berkeley Math 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, as well as activities that focus on shape, measurement, algebra (patterning), and data analysis.

In the U. S., 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 prekindergarten teachers, and are comprehensive including multiple domains in mathematics (e.g., number and operation, geometry, measurement, patterning). However, these curricula differ from each other too. For example, *Pre K Math* and *Building Blocks* include computer software, while *BMLK* does not. A published evaluation of these curricula used different math assessments as the outcome variable (Ginsburg, Lewis, & Clements, 2008). *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* and *Pre K Math* resulting in the highest effects, followed by *BMLK*(see, Ginsburg, Lewis, &Clements, 2008).

The *'Round the Rug* curriculum (Casey, 2004), funded by the U. S. 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 effectiveness in the mathematical domain of geometry, and 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 a focus on measurement. When used with two- to four-year-old children in Head Start centers, the curriculum had small positive effects. 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).

Daughtery, Grisham-Brown, and Hemmeter (2001) found positive results for preschool aged children with speech and language delays when embedding *constant time delay (CTD)* within classroom activities and routines to teach the targeted skill of counting. 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 placed in front of the child. The number missed and the alternate numbers became the target numbers, with instruction occurring across the day. The intervention was effective in teaching the target numbers to all three participants.

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. Using 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.

In summary, 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 CAI, peer tutoring strategies, or through commercialized classroom curricula and programs. Interventions for young children with disabilities based their instruction on explicit and direct instruction, such as with constant time delay and self-instruction training. 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 can become more competent in mathematics.

3.3. Early Childhood Mathematics Instruction

Although it is well-documented that preschoolers enter school with some mathematical knowledge (Baroody et al., 2006; Clements & Sarama, 2007), there is a substantial variability in the levels of children's mathematical knowledge and understanding in the preschool years (e.g., Young-Loveridge, 1991). Furthermore, 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 math increases over time (e.g., Fogelman, 1983). The quality of preschool math instruction is thus of great importance to future student achievement. A recent longitudinal study on preschool quality showed strong positive impacts of preschool classroom quality on math achievement at the age of 11; these effects are even stronger than literacy outcomes (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2011). The children who attended classrooms of low quality had non-significant mathematical outcomes at the age of 11, similar to the group of children who stayed home during the 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 math development.

Current research has documented the importance of math achievement on future academic and economic success, yet researchers have found that preschoolers spend much less classroom time engaging in mathematical than in literacy activities (Phillips & Meloy, 2012). In homes and family child care centers, math 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). Likewise, special education mathematics instruction has been limited, often focusing on computation and instruction through repeated practice of math facts, with limited opportunity for children to communicate their reasoning and receive teacher feedback (Gersten & Chard, 1999).

While traditional methods of teaching mathematics such as drills or worksheets may assist in developing procedural knowledge, they do not help children acquire conceptual understanding or connect conceptual knowledge to procedural knowledge (NCTM, 1990). Unfortunately, many educators continue to use traditional instructional methods with very young children to teach early mathematical skills (Arias de Sanchez, 2010) and the permanent product may reflect no real understanding of the knowledge of numbers, even if the child is able to accurately complete the task (Van de Walle, 2001). These methods 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). 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, & Boyd, 2008), with little encouragement of conceptual counting, estimation, or use of proper mathematical terminology (Frede, Jung, Barnett, Lamy, & Figueras, 2007). 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 et al., 1992).

4. Conclusion

4.1 Recommendations on Math Instruction

There are key foundational skills that young children should master before understanding more complex mathematical skills. The National Association for the Education of Young Children in the U.S. (NAEYC) and NCTM (2002) suggest 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 geometry (NCTM, 2006), and an emphasis on the communication of math ideas. Early mathematical concepts that specifically relate to later math achievement are included in the Number and Operations area, particularly including the mastery of number sense (Jordan et al., 2007; Vukovic, 2012).

Ginsburg, Lee, and Boyd (2008) suggested six important components that should be involved in math instruction for all young children. 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 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 to elicit the math skills of measurement, representation, or spatial concepts. Fifth, teachers should plan and organize for deliberate, intentional teaching of mathematics. Finally, an organized, research based curriculum is an essential key component to guide all activities and projects (Ginsburg, Lee, et al., 2008).

While NAEYC(2009) encourages the use of naturalistic, constructivist approaches when teaching young children, some children, particularly those with disabilities, may also need explicit and direct instruction(Lane, Carter, Pierson, & Glaeser 2006). NCTM (2000) suggested that teachers focus on conceptual understanding, rather than procedural knowledge alone. This has implications for special education teachers who traditionally have spent more time on procedural strategies and computation rather than higher order thinking skills and conceptual knowledge (Cawley, Parmar, Yan, & Miller, 1998). Children with MD and MLD typically lack the conceptual understanding of mathematics. As such, procedural and conceptual knowledge should be integrated within math instruction, especially for students with disabilities (Baroody, 2003), as one may influence the other and therefore promote math proficiencies (Doabler et al., 2012). Further, the generalization and transfer of newly learned knowledge may not occur until numerical knowledge becomes meaningful to the child (Kaufmann, Handl, & Thöny, 2003). A "hybrid" notion combining behaviorist, constructivist, and social constructivist viewpoints for children with disabilities allows for skill instruction within meaningful contexts (Goldman & Hasselbring, 1997).

Overall, with a current focus on mathematics for school-aged children comes an increased awareness of the importance of early learning opportunities and environments for our youngest children, particularly those with disabilities. It is important that children be given opportunities to develop mathematical concepts. This literature review show many promising, affordable, and effective math interventions that can result in positive effects for children with and without disabilities, many of which can easily be implemented within the school day.

4.2 Implications for Personnel Preparation

The current review reveals great implication for personnel preparation for pre-service and in-service teachers in early mathematics. Studies have shown that many teachers of young children are not comfortable with teaching math (Arias de Sanchez, 2010). Further, many ECE educators rank math as less important than other content areas such as literacy or social development (Blevins-Knabe et al., 2000; Phillips & Meloy, 2012). Faculty in personnel preparation must understand why early numeracy is of great importance; what concepts to teach in early numeracy (i.e., Number and Operation, Geometry, Algebra, Measurement, Data Analysis and Probability); and how to teach early numeracy (e.g., setting up the classroom for learning, naturalistic teaching strategies, differentiating instruction for various learners' abilities) in order to prepare the highest quality teachers for all young children.

Teachers must also be aware of the need for early numeracy evidence-based practices and interventions, particularly for children with disabilities. Mandated by two educational policies, No Child Left Behind (NCLB, 2001) and Individuals with Disabilities Education Improvement Act (IDEIA, 2004), teachers in the U.S. are required to teach and instruct using scientific evidence-based practices. Researchers agree that a research-to-practice gap exists and that children are not all receiving instructional practices based on best research evidence (Spencer, Detrich, & Slocom, 2012). Although there is debate regarding the exact criteria of evidence-based practices (Cook & Odom, 2013), there is progress in determining which are research-based (e.g., What Works Clearinghouse).

More research in early numeracy should lead to even more research based practices. Although research in mathematics is increasing, there is more to learn regarding how to teach young children mathematics. For example, there are very few studies focusing on children with disabilities, particularly in inclusive environments. Although we know how to identify children that may have later mathematical difficulties, we are lacking research on preventing later math challenges through intervening early. Further, with an increasing desire to integrate content areas in learning environments (e.g., U. S. common core standards), researchers should also explore content-integrated mathematics instruction, even with the youngest learners.

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