Exploring Early Mathematics Curriculum and Instructional Strategies: A Three Article Dissertation

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Abstract

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Exploring Early Mathematics Curriculum and Instructional Strategies: A Three Article Dissertation

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Mathematics concepts in early childhood education are often predictors later outcomes for student success, because mathematics is a foundational area of academics. The purpose of the research is to engage educators in conversations regarding experiential learning opportunities in early mathematics through curriculum planning and instructional practices that benefit young children in general and special education contexts. The three manuscripts presented explore topics of play-based instructional strategies that foster growth mindsets, utilizing differentiation strategies in mathematics, and comparing mathematics intervention strategies for children with speech or language impairments.

Each manuscript brings unique opportunities for educators through underlying connections including foundational mathematics concepts, special factors that contribute to learning difficulties in mathematics, play-based learning, and instructional strategies. Throughout the research foundational early mathematics concepts and developmental trajectories are examined, specifically in the number sense domain, which is essential for constructing later mathematical concepts including logical thinking and arithmetic processes. Curriculum planning and instructional practices such as play-based experiential learning strategies, explicit instruction, differentiation, and repeated practice

opportunities are imperative to creating engaging and meaningful learning experiences in an early childhood classroom.

The major outcome of the research has been opening a discussion with educators, administrators, and other stakeholders regarding the importance of mathematics curriculum in early childhood educations. Implications for the field include aspects of teacher preparation courses, bolstering mathematics curriculum, incorporating a variety of research based instructional practices, and considering a diverse range of special factors when designing mathematics interventions. Through the research educators are able to make curricular choices that inform practices regarding mathematics in early childhood, which aid in alleviating the opportunity gap before children enter formalized education in elementary school.

Dedication

This work is dedicated to my husband who pushes me and makes me a better person, my family and friends who have supported and encouraged me throughout this journey. My grandparents who have always believed in me, especially Grandma Pat who is greatly missed.

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Chapter 1: Connecting Themes Between Articles

Introduction

Various research in early childhood mathematics and play-based instructional practices reveal a great deal of benefits that educators can provide for young children. Utilizing early intervention strategies, such as those discussed later in the chapter, educators attempt to decrease the opportunity gap in mathematics before formal schooling begins. The research delves into the importance of experiential learning opportunities presented across various contexts regarding mathematics and the impacts of such experiences for young children.

Within this dissertation, early mathematics concepts, play-based activities, special factors related to education, and various instructional strategies will be discussed. The first chapter will discuss the connections between the three manuscripts of Chapter 3 titled *Incorporating a growth mindset into play-based education: Teaching strategies for early childhood educators,* Chapter 4 titled *Learning mathematics through everyday play activities: Enhancing exposure and mastery,* and Chapter 5 titled *Comparing mathematical interventions for children with speech or language impairments in preschool.* Throughout the rest of this chapter, these manuscripts will be referred to by their chapter association.

This dissertation discusses the importance of early mathematics concepts, play based learning opportunities within early childhood education, instructional strategies, and special factors including speech or language impairments, related to the difficulties of learning mathematics. The three manuscripts that constitute this dissertation serve to further the discussion of early mathematics concepts in the perspective field of educational research. This chapter will begin by introducing the problem statement, then the purpose of research, followed by an overview of the connecting concepts which include the following: foundational mathematics concepts, special factors that contribute to learning difficulties, play-based learning, and instructional strategies. After a brief overview of the connecting concepts between manuscripts an exploration of early mathematics development, specific to number sense, provides a foundation for the three manuscripts that discuss various aspects of mathematics education will be conducted. This section will begin by discussing the cultural context within mathematics and moving to developmental trajectories in early childhood.

The special factors in education section will explore many themes connecting the three manuscripts, such as: educator perceptions of mathematics; mathematics anxiety; atypical play and barriers to play-based learning; planning for differentiation; difficulties with mathematics language specifically the connection to speech or language impairments; working memory; and socio-economic status. These factors all contribute to difficulties within mathematics beginning at an early age and may compound over time. The next section will discuss play-based learning; specifically the benefits of learning through play, experiential learning, and planning for play. This will be followed by a section that highlights the importance of using varied instructional strategies, and a final conclusion before introducing Chapter 2 of the dissertation: Discussion and implications of research.

Problem Statement

Early mathematics concepts are foundational for success throughout the school years and later during adult life (Bregant, 2016; Lee et al., 2016; Mainela-Arnold et al., 2011; Opfer et al., 2018; Toll & Van Luit, 2012; Watts et al., 2018). Educators face several problems in designing curriculum, implementing appropriate instructional strategies, and monitoring interventions in an early childhood classroom where children are at various and often differing ends of a spectrum of mathematical abilities (Anders & Rossbach, 2015; Geist, 2015; Oppermann et al., 2016). Often, these difficulties are compounded by the educator's perception of their own mathematical abilities and lack of confidence teaching such concepts (Celik, 2017; Dunekacke, et al., 2015; Platas, 2014; Thiel, 2010). While research has been increasing in the area of instructional and intervention strategies in mathematics for elementary educators over the past two to three decades (Beilock et al., 2010; Fuson et al., 2015; Sayers, 2013), more research into the early or preschool years might yield a higher impact on the closing of the opportunity gap (Carter et al., 2013) and offer earlier intervention opportunities (Hachey, 2015; Lee & Ginsburg, 2007; Lee & Md-Yunus, 2015). The three manuscripts that comprise this dissertation describe early mathematical concepts, discuss special factors that can compound the learning of such mathematical concepts, and communicate the impact that play-based instructional strategies can have in a classroom or intervention setting while attempting to close the opportunity gap.

Purpose of Research

The purpose of this research and the three manuscripts included in this dissertation is the exploration and discussion of experiential learning opportunities which build relevant mathematics skills for preschool students. Therefore, the manuscripts serve to engage educators in a conversation about the importance and value of teaching early mathematics concepts, which are enfolded in play-based instructional strategies that fostering the development of foundational mathematics skills for later success in school and life. The three manuscripts within this dissertation describe important early mathematics concepts, explore special factors such as difficulties with early language development that make learning mathematics difficult, and identify effective play-based instructional strategies to help remediate special factors during learning. The research presented in the three manuscripts adds to the research base in the field of early childhood education and mathematics instruction. The following section introduces the overarching themes that connect the manuscripts which comprise the dissertation.

Overview of Connecting Concepts

Concept 1: Foundational Mathematics Concepts

The first underlying connection for this research is the concept that foundational mathematical competencies developed during early childhood are important for later achievement. Children require a foundational understanding of numbers, often referred to as number sense, which is essential for constructing later mathematical concepts (Andrews & Sayers, 2014; Doabler et al., 2019; Powell & Fuchs, 2012). A plethora of research indicates that early mathematics concepts, including logical thinking processes, are crucial for later success in school and beyond (Lee et al., 2016; Mainela-Arnold et al., 2011; Toll & Van Luit, 2012; Watts et al., 2017). Cultural values in mathematics mirror various problem-solving experiences and linguistic skills children encounter between home, such as parents introducing counting and numbers through toys, songs, finger plays, games, etc. (Worthington & Van Oers, 2016), and school environments during formal experiences (Doabler et al., 2019; Kleemans et al., 2013; Okamoto, 2018). Mathematics concepts can be thought of as being built like a house of cards: if careful attention is not paid to the foundation and mastery of skills, the whole house will fold and crumble. In a sense, if essential skills are missed or poorly developed early on then later mathematics concepts could have major flaws, possibly resulting in major skill deficits (Andrews & Sayers, 2014; McGrath, 2021; Van Luit & Toll, 2015).

These concepts are discussed in terms of examples of play-based activities within the manuscript that comprises Chapter 3. The benefits of using manipulatives (Carbonneau & Marley, 2015; Uribe-Florez & Wilkins, 2016) are discussed in association with play and mathematics concepts within this manuscript specifically, such as various types of dice and spinners during game play to build foundational number sense concepts (Colliver & Veraksa, 2019; Good & Ottley, 2019; Laski & Siegler, 2014). Within the manuscript that comprises Chapter 4, specific principles are discussed, including: one-to-one correspondence, abstraction, and order-irrelevance. Additionally, concepts such as quantification, cardinality, stable order counting, and subitizing are discussed. The final manuscript comprising Chapter 5 discusses the following mathematical concepts in detail: enumeration, stable order counting, one-to-one correspondence, cardinality, subitizing, comparing quantities or magnitudes, and symbol comprehension.

Concept 2: Special Factors that Contribute to Learning Difficulties in Mathematics

The second underlying connection between the three manuscripts, is that special factors contribute to the difficulties reported in the learning of early mathematics skills during the early childhood years. Mathematical or numerical abilities and success in this area of learning are frequently considered to be dependent on one's ability to comprehend and express language (Cross et al., 2019; Donlan, 2003; Kleemans et al., 2012). In combination with language, working memory can play a huge part in early mathematics (Archibald & Griebeling, 2015; Gathercole & Alloway, 2007; McLeod, 2012). The ability to recall numbers for manipulation, as in that needed to solve simple equations, falls within the umbrella of working memory.

Other special factors that contribute to learning difficulties include atypical play behaviors (i.e. perseverance on objects, unusual social interactions, or limited play skills) and barriers to play-based learning which include attitudinal (i.e. educators' personal values regarding play), structural (i.e. time, materials, etc.), and functional barriers within the context or environment (lack of professional development training for teachers) (Baron et al., 2016). At times, planning for differentiated instruction is also a barrier for teachers (Cash, 2011; Ensign, 2012; Kobelin, 2009; Tomlinson, 2014) due to time contraints, availiblity of materials, and space within the classroom, among other factors. Lower socio-economic status also plays a role in opportunities for success with mathematics according to a plethora of research (Geist, 2015; Hachey, 2013; Harvey &

Miller, 2016; Jordan, 2007; Lee et al., 2016), stating that children within this population are four times more likely to have fewer opportunities to engage with quality mathematical experiences compared to peers in the middle to upper socio-economic status.

Within Chapter 3, special factors are discussed through the lens of atypical play and the barriers to play-based learning. Play is diverse and can look different for children depending on culture, age, developmental level, and exceptional needs (Brown & Vaughan, 2009; Christakis, 2017; Okamoto, 2018). Barriers for assessing play (Baron et al., 2016), how play is understood developmentally, and what a typical trajectory looks like for various age ranges can also provide many complications for educators. Chapter 4 includes discussion of special factors in terms of differentiation of instructional strategies, including how an educator might use a distinctive material for varied developmental levels of the students within a group (Cohrssen et al., 2014; Ensign, 2012; Tomlinson, 2014). One student may require a specific type of manipulative (e.g., dice, spinner, card) to play a game, while the student playing with them may require a more or less advanced version of the same manipulative in order to participate in game play. Chapter 5 looks specifically at speech or language impairments as a special factor when working with young children, with the study that forms the basis of the research presented in this manuscript focusing especially on how a child may be affected by speech or language impairments when engaged with early mathematics concepts within the number sense domain (Gillam et al., 2016; Mononen et al., 2014; Vukovic & Lesaux, 2013). The connection between language and mathematics runs deep and is discussed in-depth within this manuscript.

Concept 3: Play-based Learning

The third underlying connection between the three manuscripts, is that play-based learning is beneficial for preschool children in constructing foundational mathematics knowledge (Lee & Ginsburg, 2007; Moomaw, 2015; McGrath, 2021; National Association for the Education of Young Children [NAEYC] & National Council of Teachers of Mathematics [NCTM], 2010). Learning through experiences, which is the foundation of play and the basis for early childhood education (Biel & Peske, 2009; Elkind, 2007; Morrison, 2015; Simms & Schum, 2000; Vermeulen, 2012), is immersive for children and builds skills in the areas of social-emotional, cognition including literacy and mathematics, and language development (Shin & Partyka, 2017). Play-based learning opportunities afford children the contexts for engaging with mathematical concepts and relationships while constructing foundational mathematical knowledge (Good & Ottley, 2019; Moomaw et al, 2010). Children learn through participating in experiences based in their cultures (Ginsburg, 2006; Okamoto, 2018; Worthington & Van Oers, 2016); through these actions their background knowledge grows, and they can apply what they have learned to related academic concepts when in a school setting (Worthington & Van Oers, 2016). The concept of play-based learning and its benefits connect the child's experiences, described as imaginative scenarios which reconfigure ideas acquired from reality (Casper & Theilheimer; 2009; Colliver & Versaksa, 2019;

Fleer, 2011; Vogt et al., 2018; Vygotsky, 1967), with new information to be assimilated and provides a safe space to explore concepts (Colliver & Veraksa, 2019).

Chapter 3 is situated as the first manuscript in this dissertation because it includes a discussion of the importance of play-based learning activities at length, which is then the basis for the other two manuscripts included as Chapters 4 and 5. Chapter 3 lays the groundwork for using play-based learning as an integral part of instructional strategies throughout the other two manuscripts. Chapter 4 uses play-based learning as an experiential way of reinforcing mathematics concepts (Ginsburg, 2006; Okamoto, 2018; Vogt et al., 2018;). This can be seen throughout the instructional strategies section when various game play, including grid games, short and long path games, roll and spin graph games, card games, concept games, and dominoes, is discussed and illustrated within vignettes. The manuscript that comprises Chapter 5 uses play-based experiential learning within the design of the various lesson activities and game play (Colliver & Versaksa, 2019; Good & Ottley, 2019; Moomaw et al., 2010; Vogt et al., 2018). This again is used to reinforce various mathematics concepts and provide engagement and motivation for repeated practice opportunities (Ardoin et al., 2018; Rosenshine, 2012; Ryoo et al., 2018).

Concept 4: Instructional Strategies

The fourth underlying connection between the manuscripts are instructional strategies. Such important instructional strategies include explicit instruction, repeated practice, modeling, intentional teaching, and game-based instruction. These practices may be implemented within whole group, small group, or individual lessons (Cash, 2011;

Tomlinson, 2014) or as a foundation for interventions for student that have been identified as at risk or having a disability (Mainela-Arnold et. al., 2011). Using various and blended strategies is an important aspect of curriculum planning in order to reach all children at their learning levels and preferences. This enables learning to become meaningful and have personal real-life connections for children in order to generalize learned skills and abilities (DEC, 2014). Powell and Fuchs (2012) remind educators that instruction should be explicit and designed in meaningful ways that engages children and extends their conceptual and procedural knowledge of mathematics.

Chapter 3 discusses the following instructional strategies as they relate to play-based learning: engagement, motivation, praise, intentional or purposeful play, sociodramatic play, project approaches, assessment and progress monitoring as part of planning for play opportunities. Chapter 4 discusses instructional strategies geared towards differentiation which include: structuring small groups, graphic organizers, teacher created materials and games, questioning with varied levels of difficulty, providing wait time, and offering choices within activities. In the original article one section that did not make it to publication discussed the blending of various combinations of the mentioned instructional strategies which will be included in the current manuscript of Chapter 4. In Chapter 5 there are three instructional strategies of note which are discussed in-depth and include explicit instruction, repeated practice and modeling. How these are used to design the various intervention modules that are being compared within the study is of importance within this manuscript. The use of manipulatives as an instructional strategy (Carbonneau & Marley, 2015; Uribe-Florez & Wilkins, 2016) is also mentioned throughout the article and how they support the understanding of abstract concepts using concrete objects.

In summary, each of these underlying concepts will be discussed more in-depth throughout the remainder of this chapter. In addition, any underlying factors that connect the concepts will be discussed as well. The discussion will begin with the development of early mathematics concepts focusing on number sense. Followed by special factors which contribute to learning difficulties of mathematics that begin during the early childhood years and can follow children throughout their development into adults. Moving to play-based activities and curriculum and the importance of instructional strategies. The first discussion will encompass early childhood mathematics concepts and developmental trajectories.

Early Mathematics Development

This section will focus on the number sense domain of early mathematics, cultural context of mathematics, and developmental trajectories that are identified throughout this dissertation. This is also a reflection of the recommendations from NAEYC & NCTM (2010) regarding early mathematics concepts, and NAEYC (2020) developmentally appropriate practices.

Gallistel and Gelman (2005) define mathematics as, “a system for representing and reasoning about quantities, with arithmetic as its foundation” (p. 559). This corresponds to the positional statements made by various professional organizations (e.g., NAEYC, NCTM, and DEC) that number sense should be a priority during the early childhood years. Another way to think of number sense is the ability to manipulate numbers and quantities flexibly through simple processes (Andrews & Sayers, 2014). Chigeza and Sorin (2016) define mathematical literacy in terms of instruction, comprehension, and experiences in which mathematics is used within everyday life. Without a strong foundation in early concepts and processes children may not achieve mathematics literacy; however, these concepts are not a guarantee that mastery of mathematics will occur. Constant use of early concepts and processes aid in building competency within mathematics (Ardoin et al., 2018; Kleemans et al., 2012; Rosenshine, 2012; Toll & Van Luit, 2012) and is impacted by cultural contexts.

Mathematics Recommendations

The National Research Council report recommends that mathematics education in early childhood focus on foundational and attainable content in number sense (e.g., representing numbers, relating or comparing numbers, and numerical operations), geometry, spatial relations, measurement, and data. Evidence of this can be seen in Ohio's Early Learning Content Standards, with more time devoted to number sense than other topics (Ohio Department of Education, 2020).

The joint statement by the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM) in 2010 states:

> High-quality, challenging, and accessible mathematics education for 3- to 6-year-old children is a vital foundation for future mathematics learning. In every early childhood setting, children should experience effective, research-based curriculum and teaching practices. Such high-quality classroom practice requires

> policies, organizational supports, and adequate resources that enable teachers to do this challenging and important work. (p. 1)

This statement reflects the importance of early mathematics experiences for preschool children. It is the responsibility of teachers, parents, and communities (Karatas et al., 2017; McCray & Chen, 2012) working together to sculpt these experiences for children and build their confidence through positive experiences (Bjorklund, 2012; Ginsburg et al., 2008; Hughes et al., 2016; Sayers, 2013) with mathematics concepts as they grow. Cultural contexts plays a vital role in the construction of foundational mathematics for young children as illustrated in the following section.

Cultural Context within Mathematics

Across all cultures, children are developing in environments which contain a plethora of objects and circumstances that support mathematics learning in their everyday lives (Ginsburg, 2006; Okamoto, 2018; Worthington & Van Oers, 2016). Agar (1996) states, "Language fills the spaces between us with sound; culture forges the human connection through them. Culture is in language, and language is loaded with culture" (p. 28). Mathematics itself can be thought of as a culture given its own dual language meanings and precise use of terminology. One major example of this includes the use of the '-teen' numbers. When counting in English, we add the numerical suffix -teen onto our counting sequence. In several other languages, the counting sequence continues as ten-one, ten-two and so on; this tends to be easier for children to learn as it continues the base ten concepts (Okamoto, 2018). Another example of differences between cultures related to mathematics includes the time spent in teacher-directed activities versus nonteacher-directed activities which is expected to lead to greater gains in early concepts (Opfer et al., 2018). Eastern cultures spend more time in school, therefore leading to more opportunities to engage in mathematics activities versus students within Western cultures; by the time a child reaches sixth grade, this could be a one to two year difference in experiences (Okamoto, 2018; Opfer et al., 2018).

Cultural practices that impart meaning to mathematical thinking for young children develop through pretend play activities where communication is a large part (Worthington & Van Oers, 2016). Child-initiated pretend play with mathematical underpinnings tends to reinforce mathematical concepts linked to everyday life by highlighting the importance of the concepts themselves. Vygotskian approaches to cultural contexts explain how meaning is associated with concepts throughout learning and development (Radford & Roth, 2017). One example could be when a child is presented with a nickel and given the name for the concept as well. Once the adult has used the term nickel functionally (e.g. telling the child they are going to use a nickel to pay for a piece of candy worth 5 cents), the child then has the opportunity to assimilate the information and connect meaning to the object (nickel), the term, and how it is used within the culture. Once these connections have been made the child is able to reinforce them throughout pretend play scenarios (Worthington & Van Oers, 2016). Through various scenarios like the one just described, children learn to observe and follow cultural contexts for mathematics and build a vast mathematical vocabulary that will allow them to master concepts throughout school and continue to be successful (Okamoto, 2018).

Cultural contexts are an important factor when considering the developmental trajectories for mathematics detailed throughout the following section.

Developmental Trajectories

Early mathematics developmental activities come in many forms, such as dividing treats equally between a group, determining that adding a toy or two in a group results in a larger group or more objects, and counting with parents while completing a task or activity (Ginsburg, 2006; Greenes, 2009). During typical development of mathematics, bidirectional mapping of mental magnitudes – which includes concepts of subitizing, enumerating, comparing quantities, etc. – and symbolic representations (i.e. number words, numerals, etc.) of numerosity occur (Gallistel & Gelman, 2005). The foundation on which mathematical calculations are built include the awareness of magnitudes and their comparisons (Holloway & Ansari, 2009).

The seminal work by Gallistel and Gelman (1978) regarding the counting principles demonstrates early learning foundational concepts upon which arithmetic operations function later on. Such concepts include one-to-one correspondence, stable order counting, order irrelevance, and cardinality (Fuson et al., 2015; Gelman & Gallistel, 1978; Gunderson & Levine, 2011; Kamawar et al., 2010; Moomaw et al., 2010; Sarama & Clements, 2009). It can take a long time to develop these skills, especially if list learning is the mode of instruction (Gallistel & Gelman, 2005). By providing children with manipulatives and engaging materials or environments to practice (McGuire et al., 2012; McWilliams & Casey, 2008; Uribe-Florez & Wilkins, 2016), it lessens the load for learning such skills. Andrews and Sayers (2014) note that there are seven interrelated concepts for number sense (p. 3-5):

1. Number recognition (often to 20) and the corresponding quantity
2. Stable order counting (forwards and backwards)
3. Relationship between number and quantity (one-to-one correspondence and cardinality)
4. Magnitude and comparisons (greater than, less than, equal)
5. Estimation (a rough calculation of a set of objects)
6. Simple operations (addition and subtraction)
7. Awareness of number patterns (i.e. skip counting, identifying missing numerals)

These seven concepts can be seen throughout various research and works including early learning standards used by educators (Common Core State Standards Initiative, 2020; Ohio Department of Education, 2020). Such concepts provide some context for how numbers can be manipulated and when combined with cultural context highlight why mathematics is important in everyday life (Okamoto, 2018; Opfer et al., 2018; Radford & Roth, 2017).

Table 1 outlines the development of the number sense domain and the verbal or non-verbal components for each concept or principle. However, some non-verbal components will require a verbal component for the concept after enough foundational knowledge has been developed. Preverbal or non-verbal components are often differing magnitudes that allow for comparisons (Cross et al., 2019; Gallistel & Gelman, 1992; Kleemans et al., 2011; Vukovic & Lesaux, 2013). An example of this could be providing a set of two objects and a set of ten objects and asking the child to indicate, generally by pointing, an answer to a comparison question. It could also be to indicate the answer to a quantity question, such as “show me which group has two objects?”

Table 1

Development of the Number Sense Domain

Number Sense

Approximate Age Range	**Verbal / Non-verbal**	**Concept or Principle**	**Characteristics**
2 – 4 years old	Non-verbal moving to verbal.	One-to-one correspondence	One and only one object at a time is tagged (often pointing or touching objects as each one is tagged).
3 – 5 years old	Verbal	Cardinality	The last number used when counting a set of objects.
3 – 5 years old	Verbal	Subitizing	Ability to recognize or name a quantity without counting or one-to-one correspondence (usually within 5 objects).
3 – 6 years old	Verbal	Stable order counting or enumeration	Sequential counting from zero to twenty.
3 – 6 years old	Non-verbal moving to verbal.	Comparisons	Ability to indicate similarities or differences, when comparing quantities stating more, less, equal.
3 – 7 years old	Non-verbal moving to verbal	Operations (simple addition and subtraction)	Ability to solve simple problems involving counting on and taking away.
3 – 8 years old	Non-verbal	Abstraction principle	Counting can be applied to any set of physical or abstract objects.
4 – 6 years old	Verbal	Numeral recognition	Ability to name a numeral that represents a specified quantity.
4 – 6 years old	Non-verbal moving to verbal	Symbol recognition	Ability to identify or apply symbols during mathematics activities (simple word problems and equations).
4 – 8 years old	Nonverbal-moving to verbal	Estimation	A rough evaluation of a quantity.
4 – 11 years old	Non-verbal	Order irrelevance principle	The order in which objects are tagged is irrelevant to the count itself.

Note: Table information obtained from Andrews & Sayers, 2014, Gelman & Gallistel, 1978, Kamawar et al., 2010; Merkley & Ansari, 2016; Pixner et al., 2018, Sayers et al., 2016, Sarma & Clements, 2009, Siegler & Booth, 2004, Yuan et al., 2019.

The development of the number sense domain is complex and has several interrelated concepts that build on each other, which takes several years to develop and master throughout the early childhood years (Gelman & Gallistel, 1978; Merkley & Ansari, 2016; Sarma & Clements, 2009; Yuan et al., 2019,). Early mathematics incorporates the identification of mathematics within everyday environments and situations (Chigeza & Sorin, 2016; Ginsburg, 2006; Okamoto, 2018; Ramani et al., 2015), then making use of these contexts as learning opportunities, which highlights the relevance of such mathematics concepts to everyday life (Carbonneau & Marley, 2015; McCrone & Dossey, 2007; McGrath, 2010; Toll & Van Luit, 2014). Early mathematics is important foundational knowledge upon which curriculum and interventions are built to aid young children in being successful throughout their lives. There are several special factors that can confound the learning of mathematics during the early childhood years, which will be explored throughout the next section of this chapter.

Special Factors in Education

This section will focus on special factors that contribute to learning difficulties that have been identified throughout this dissertation, which includes: educator perceptions of mathematics, mathematics anxiety, atypical play and barriers to play-based learning, planning for differentiation, difficulties with mathematics language, working memory, and lower socio-economic status. The nuances of these special factors will be discussed within the context of early childhood education as it relates to the work included in this dissertation.

Mathematical disabilities within education, including dyscalculia, are estimated to represent approximately 6-10% of the population (Evans & Ullman, 2016; Jordan, 2007; Mazzocco et al., 2011) and research indicates that a lack of mastery in the number sense domain may be at the heart of such difficulties (Clements & Sarama, 2011; Lee et al., 2016). The opportunity gap for mathematic may be attributed in part by difficulties experienced with mathematical language (Cross et al., 2019; Ginsburg et al., 2008; Hughes et al., 2016; Okamoto, 2018). With a variety of special factors that may contribute to difficulties with mathematics, Powell and Fuchs (2012) found that children often struggle with comparing numbers or quantities which falls within the number sense domain and is foundational for other mathematics skills. Early identification of at-risk students and implementing interventions is key to closing opportunity gaps during early childhood education, especially since mathematics is a concept that builds on previous concepts as children move through their educational careers (Mainela-Arnold et. al., 2011). The first special factor that will be addressed are educator perceptions of mathematics and how it originates from mathematics anxiety.

Educator Perceptions of Mathematics

The beliefs held by educators regarding mathematics and efficacy of instruction can be related to the importance with which they assign to the subject. Some educators express negative feelings towards mathematics, especially in the elementary years, which may be shaped by negative personal experiences (Benz, 2012; Sayers, 2013; Vogt et al, 2018). This is problematic because children need adults to model confidence in their skills in order for students to feel confident in their own mathematics skills.

The research of Beilock et al. (2010) indicates that children who observe their teachers having difficulty with mathematical concepts or find these concepts unimportant are at risk of developing identical attitudes towards mathematics. A variety of research implies that many early childhood educators have a fear or anxiety of teaching mathematics concepts because they are not often clear on how or what they should be teaching, nor are they aware of the importance of their students' mastering these concepts during the early childhood years to ensure future success (Beilock et al., 2010; Chen et al., 2014; Geist, 2015; Vogt et al., 2018).

In light of research stating the importance of early math skills for later student achievement, the emphasis on mathematics in university teacher education programs should hold the same weight given to literacy. Parks and Wager (2015) stated,

> There is no consensus on how mathematics should be taught to young children. This lack of shared understanding may result in a lack of agreement about how to teach it or how much time to devote to early mathematics in a course with a broader focus. (p. 126)

The researchers also allude to the possibility that during these mathematics methods classes, the concepts of how to teach, and what to teach, are geared towards upper elementary grade levels. Chen et al. (2014) identified through their research that many colleges and universities throughout the United States lack sufficient mathematics requirements for those majoring in early childhood education programs. While preservice and even veteran educators may shy away from teaching mathematics there is a plethora of research that indicates mathematics anxiety plays a large part in this reluctance. Next a discussion of mathematics anxiety, where it may stem from, and how it can affect young students.

Mathematics Anxiety

Anxiety related to the concept of mathematics is not just detrimental for children, it can also have widespread consequences for educators who are expected to provide instruction in the subject (Anders & Rossbach, 2015; Dunekacke et al., 2016; Geist, 2015). Research indicates that mathematics anxiety and ability first show a relationship as early as kindergarten and spanning to the third grade with roughly 20% of the general population suffers from mathematics-related anxiety (Geist, 2015). Mathematics anxiety may be described as feelings of fear and other powerful emotions regarding the prospect of mathematical processes and application in an educational environment and everyday activities (Bates et al., 2013; Beilock et al., 2010; Celik, 2017). Emotions that may be included in the spectrum of mathematics anxiety include dread, faintness, helplessness, frustration, panic, and fear, and may be evidenced by avoidance of mathematics tasks via a multitude of behaviors, all resulting in poor academic performance (Bates et al., 2013; Celik, 2017; Richardson et al., 2001). Radford and Roth (2017) describe subjective alienation, which is a person's sense of being uncomfortable while learning mathematics, and objective alienation, which is when a person is forced into engaging with mathematics extrinsically instead of through intrinsic motivation such as personal growth. This is further explored in Chapter 3 while discussing a growth mindset. Such factors as the two types of alienation described previously play a role in mathematics anxiety and how it can be perpetuated.

The anxiety that some educators experience associated with mathematics can influence, usually unconsciously, children within the educational environment (Bates et al., 2013; Beilock et al., 2010; Geist, 2015). Children may exhibit behaviors described previously as a result of anxiety due to emulating the adults they are exposed to on a regular basis and, often time, at a higher percentage if they are of the same gender (Beilock et al., 2010). Many educators affected by such anxiety often continue such cycles through the choices they make regarding teaching and playing with mathematical concepts in their classrooms (Chen et al., 2014; Karatas et al., 2017; Sayers, 2013). A lack of confidence in mathematics abilities can be detrimental to educators; therefore, the children within these learning environments unless the anxiety associated with mathematics is remediated. Atypical play and barriers to play-based teaching can further compound how mathematics is learned and explored within an early childhood environment, which will be explored further in the following section.

Atypical Play and Barriers to Play-based Learning

Atypical play development is a special factor when discussing play-based learning as an instructional strategy. According to the National Center for Learning Disabilities (2020), typical development generally follows a predictable pattern referred to as developmental milestones, while atypical development falls outside of the general norms or milestones. Such behaviors and delayed skills or abilities should be noted so that proper interventions can be implored, analysing whether the atypical development is a delayed or disordered skill or ability is key for implementation of interventions within the classroom (Biel & Peske, 2009; National Center of Learning Disabilities, 2020). Joint attention and symbolic play along with language and social competency all have important roles within the developmental trajectories of play (McCollow & Hoffman, 2019; Short et al., 2020; Wong & Kasari, 2012). Such special factors are discussed in further detail within Chapter 3 of the dissertation.

Baron et al. (2016) discuss structural barriers such as a lack of resources and materials for play, attitudinal barriers such as teacher's knowledge and administrative attitudes towards play in the classroom, and functional barriers such as time spent in play versus instructional time on academics (Kinkead-Clark, 2019). There are several barriers to play that fall within these three categories that are explored further in Chapter 3. Play-based barriers can be addressed through differentiation strategies and proper planning, which will be discussed in the following section.

Planning for Differentiation

The Division for Early Childhood (2014) has recommended that educators "plan for and provide the level of support, accommodations, and adaptations needed" (p.11) for all children to actively participate in classroom activities. Differentiation is a term commonly used to describe how educators make their curriculum developmentally and individually appropriate for all children. Differentiation encompasses educators utilizing a variety of instructional methods and adaptations to facilitate the learning of all children (Cash, 2011; McGrath, 2021; Tomlinson, 2014). Differentiation aligns with the NAEYC

Program Standards (2020) to utilize a variety of appropriate instructional practices and materials to engage children and positively impact their learning. There are multiple ways to differentiate learning based on children's readiness levels, interests, and learning styles. Unfortunately, many early childhood educators are not differentiating their instruction effectively for the wide range of students they encounter (Hachey, 2015; Wasik, 2008); this can span from children who are gifted and typically developing to children from diverse cultural and linguistic backgrounds and those who experience disabilities.

There are a variety of strategies that can be used in a preschool environment for differentiation. Cash (2011) reiterates, "Educators must be able to differentiate the learning environment so it is structured in ways that respect the learners' differing brain requirements, and it nurtures and supports the natural curiosity and creativity of our students" (p. 179). Differentiation helps bridge the gaps in opportunities for students of all developmental levels. It enables educators to blend the lines between a strictly general education setting and inclusive settings, which sets the precedence of belonging for all students in the learning environment. Multiple intelligence theorist Howard Gardner emphasizes that all people do not learn in exactly the same way; rather, children learn at their own pace and through a combination of intelligences. Using this information in conjunction with student interest will have a vast impact on student learning and attention to task. Constructivist theorists such as Piaget, Vygotsky, Bruner, and Dewey advocate for the opportunities of children to construct their own learning through play-based activities that are perfectly suited to the concept of differentiation. These concepts are discussed at length within Chapter 4 of the dissertation.

While differentiation can be an effective tool within the instructional toolbox, it does not directly address the limitations posed by difficulties with mathematics language as a special factor for learning. The following discussion will target language specifically related to receptive and expressive difficulties as it relates to learning mathematics during early childhood.

Difficulties with Mathematics Language

Mathematical language can be defined as a system of words and symbols to communicate mathematical ideas and processes, which may be abstract in nature (Kenney et al., 2005; Kharde, 2016; Leshem & Markovits, 2013). Often, such terminology is prevalent in everyday vocabulary and is not readily recognized as being specifically related to mathematics (Greenberg, 2012; Hughes et al., 2016; Lee & Ginsburg, 2009). It is important that educators use clear and precise mathematical terms that translate between concepts and grade levels to support students in understanding mathematical language and in generalizing skills and concepts (Hughes et al., 2016; Vukovic & Lesaux, 2013).

Formal instructional practices across many educational settings rely heavily on expressive and receptive language (Cross et al., 2019; Harrison et al., 2009; Hughes et al., 2016; Vukovic & Lesaux, 2013) skills such as, listening and following directions, answering questions either in written or verbal formats, etc., to indicate acquisition and comprehension of new skills (Donlan, 2018; Hughes et al., 2016). Educators use of questions about a child's reasoning related to the process of completing a mathematical process is essential in assessing if concepts or skills are missing and therefore informing instructional strategies (Lee & Md-Yunus, 2016). However, such questions may create more strain on the child's expressive language abilities (Cross et al., 2019; Harrison et al., 2009; Vukovic & Lesaux, 2013), thereby confounding observational data gained by the educator. Clear, concise, and consistent use of mathematical vocabulary that translates across multiple grade levels may help generalize concepts for children with language difficulties (Cross et al., 2019; Hughes et al., 2016; Van Luit & Toll, 2015).

Research indicates the existence of specialized language or vocabulary within mathematics that should be explicitly taught, often regarding abstract concepts or symbols and academic elements of language that aid in the mastery of content (Toll & Van Luit, 2014; Vukovic & Lesaux, 2013). Table 2 depicts three forms of mental representations of connecting abstract concepts that are common numerical tasks that young children who are beginning to understand mathematical language are asked to undertake.

Table 2

Three Forms of Numerical Mental Representations

Form	Examples	Definition
Numerical	0, 1, 2, 3, 4, etc.	Numbers are represented as Arabic numerals or digits.
Verbal	Zero, one, two, three, etc.	Numbers are represented in verbal or linguistic form
Quantity/Visual Array	* * * * * *	Numbers are represented as visual arrays (groups or sets), numerical magnitudes or quantities.

Note: Table information obtained from Cross et al., 2019.

Table 2 demonstrates tasks that educators ask young children to begin comprehending as early as preschool. Not only do children need to internalize this information, they are also expected to be able to generalize it to various mathematics activities (Kleemans et al., 2012; Toll & Van Luit, 2014; Watts et al., 2018) such as various games, counting materials, estimation, subitizing, and comparing magnitudes. There is a plethora of problems that may occur when applying these concepts without ample time for mastery during the early years, which may lead to later mathematical difficulties (Hachey, 2013; Hughes et al., 2016; Lee & Md-Yunus, 2016). Difficulties with mathematical language can be a large pitfall within education for young children especially if speech or language impairments are noted. When such factors are under consideration working memory should also be a focal point for exploration. The following section will discuss working memory as a special factor which is not discussed in any of the following chapters but does play an underlying part when discussing mathematical disabilities.

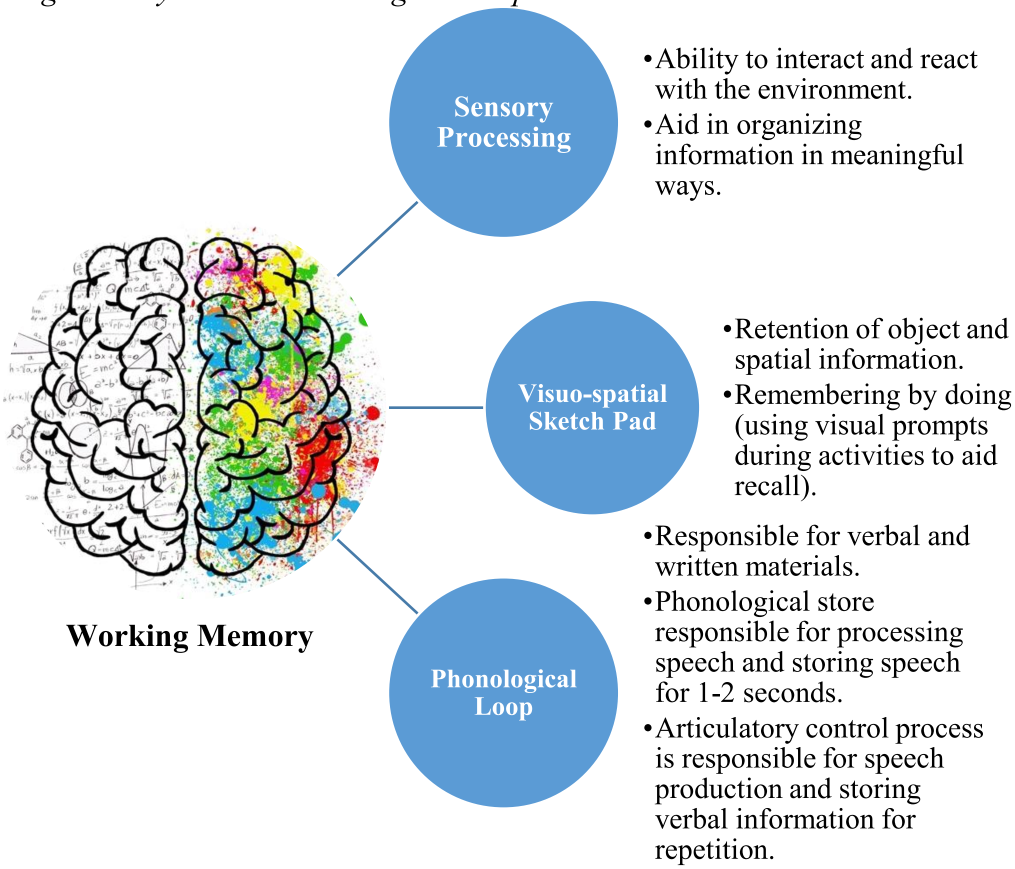
Working Memory

A specific area that can impact the use of specific mathematical concepts and language is working memory (Greenes, 2009). Working memory can be defined as part of short term memory that is in charge of perceptions and linguistic processing which includes, high-speed memory and recall, that may be responsible for automaticity and fluency of facts (Archibald & Griebeling, 2016; Gillam et al., 2016; Vukovic & Lesaux, 2013). Of particular interest within working memory is the phonological loop which is responsible for spoken and written materials. There are two parts to the phonological loop: the phonological store (i.e. inner ear), responsible for processing speech and storing spoken words for 1-2 seconds, and the articulatory control process (i.e. inner voice), which is responsible for rehearsing speech production and stores verbal information which allows us to repeat verbal information (McLeod, 2012; Mononen et al., 2014).

The phonological loop contributes to processes such as encoding and processing number words (e.g., sequence, computational processes, numerical retrieval) and the ability to use linguistic forms, such as those from Table 2 (numerical mental representations), from long-term memory (Gillam et al., 2016; Mononen et al., 2014). Figure 1 demonstrates the concepts of working memory, the phonological loop, and aspects that contribute to its effectiveness.

Figure 1

Working Memory and the Phonological Loop



Note: Information for this figure was obtained from Biel & Peske, 2009, Buchsbaum & D'Esposito, 2008; Gathercole, 2008, Mcleod, 2012, and Mononen et al., 2014.

The importance of working memory (Archibald & Griebeling, 2015; Buchsbaum & D'Esposito, 2008; Gathercole & Alloway, 2007; McLeod, 2012) can be seen throughout various mathematics activities. One example is playing a grid game to reinforce one-to-one correspondence where the child rolls a six-sided die and places the corresponding number of manipulatives on the grid. The child has to be able to hold the number in their working memory while counting the corresponding number of objects to apply to the game board. When there is a disconnect in the phonological loop, the child may not be able to hold the number for recall (Archibald & Griebeling, 2015; Mononen et al., 2014) for the duration of the task. This in turn makes various mathematical tasks difficult and involves constant recounting of objects, which will be explored in Chapter 5 of this dissertation. Reinforcing working memory with various instructional practices such as guided practice and repeated practice may bolster these skills and assist with improving mathematical competency (Carbonneau & Marley, 2015; Donlan, 2003; Jacobi-Vessels et al., 2014). Working memory is one factor that can compound the learning of mathematics during early childhood. However, lower socio-economic status can be a larger factor that may follow children throughout their school careers. The following section will explore how lower socio-economic status impacts early mathematics learning.

Socioeconomic Disadvantages and the Opportunity Gap

A plethora of research discussed throughout this section indicates a large disparity in mathematics achievement of children from socioeconomically disadvantaged environments, which could be attributed to backgrounds (Harvey & Miller, 2016; Okamoto, 2018), language abilities (see Chapter 5), metacognition (Ginsburg et al., 2008), educator and parent attitudes, families with limited abilities to elaborate on mathematical ideas and processes (Clements & Sarama, 2011; Kleemans et al., 2012), educator preparation courses (Beilock et al., 2010; Lee & Ginsburg, 2007), and other various special factors. Children entering formal schooling with minimal linguistic and cultural diversity show lower mathematical, verbal, and social competency (Hachey, 2015; Harvey & Miller, 2016; Lee & Md-Yunus, 2016); thus, negatively impacting learning trajectories upon school entry. Research indicates that educators and parents in economically disadvantaged contexts tend to have negative attitudes towards engaging in mathematics related experiences in particular, which may be a result of mathematics related anxiety (Carter et al., 2013; Geist, 2015). Bachman et al. (2017) reports a 1.3 standard deviation lower on kindergarten mathematics assessments of children from socioeconomically disadvantaged homes than their middle to higher socioeconomically advantaged peers. Children with fewer opportunities in mathematics during the early childhood years, could translate to deficits later on and result in difficulties with employment during adult years (Bachman et al., 2017; Lee et al., 2016; McCrone & Dossey, 2007). Remediation of special factors such as socioeconomic disadvantages can assist in decreasing the opportunity gap through various instructional methods and chief among those in the early childhood setting is play-based learning. Next a discussion of play-based learning and the role it plays in early childhood education.

Play-based Learning

This section will focus on the benefits of play-based learning, specifically the role of experiential learning, and planning for play opportunities during early childhood education. The impact of play and experiential learning opportunities will be discussed in the context of early mathematics development. This is also a reflection of the recommendations from DEC (2014) and NAEYC (2020) developmentally appropriate practices.

It is generally understood in Western culture that play can be adult- or child-directed and that there are several varying definitions of play available (Fleer, 2011). Play can be defined by the presence of imaginary situations with rules assisting with its creation, providing it with an air of hypothetical contexts (Colliver & Versaksa, 2019). Another way to define play is as a set of activities that are fun, voluntary, flexible, engaging, intrinsically motivated, and have elements of make-believe for the child (Vogt et al., 2018). Child-initiated play is generally thought of as voluntary, spontaneous, and intrinsically motivating by what is on the child's mind at the time, which is very serious for the child (Worthington & Van Oers, 2016). The following section will explore the benefits of play-based learning to reinforce mathematics concepts within the early childhood environment.

Play-based Learning Recommendations

Chapter 3 specifically relates to the play-based learning recommendations in that it is developmentally appropriate practice for early childhood educators to incorporate play with intentional learning opportunities. The NAEYC (2020) position statement regarding developmentally appropriate practice reminds early childhood educators of the importance of play-based learning for curriculum planning. The incorporation of play activities for learning purposes serves to extend concepts within the curriculum, making them more accessible for all developmental levels. The Developmentally Appropriate Practice (DAP) position statement (NAEYC, 2020) notes six key factors in planning early childhood program curriculums:

1. Linguistically and culturally responsive goals for young children's development which are clearly articulated.
2. Program has a comprehensive curriculum that targets identified developmental goals.
3. Educators use curriculum framework when planning instruction to support the experiences of all children.
4. Educators prioritize meaningful experiences for every child.
5. Educators of previous and subsequent grade levels collaborate to help ensure continuity of concepts and development.
6. A planned and written curriculum is in place across all age/grade levels. (p. 25-27)

These key factors reflect the ideals that NAEYC promotes within its organization and the larger early childhood education community. Play within the context of learning fosters self-regulation and motor, language, mathematics, cognition, and social-emotional competencies essential for all children (Biel & Peske, 2009; Fleer, 2011; NAEYC, 2020; Piescor, 2017; Trawick-Smith et al., 2016). Play-based learning opportunities are a great way to incorporate mathematics and utilize various instructional planning strategies, which will be discussed in the next section.

Benefits of Play-based Learning

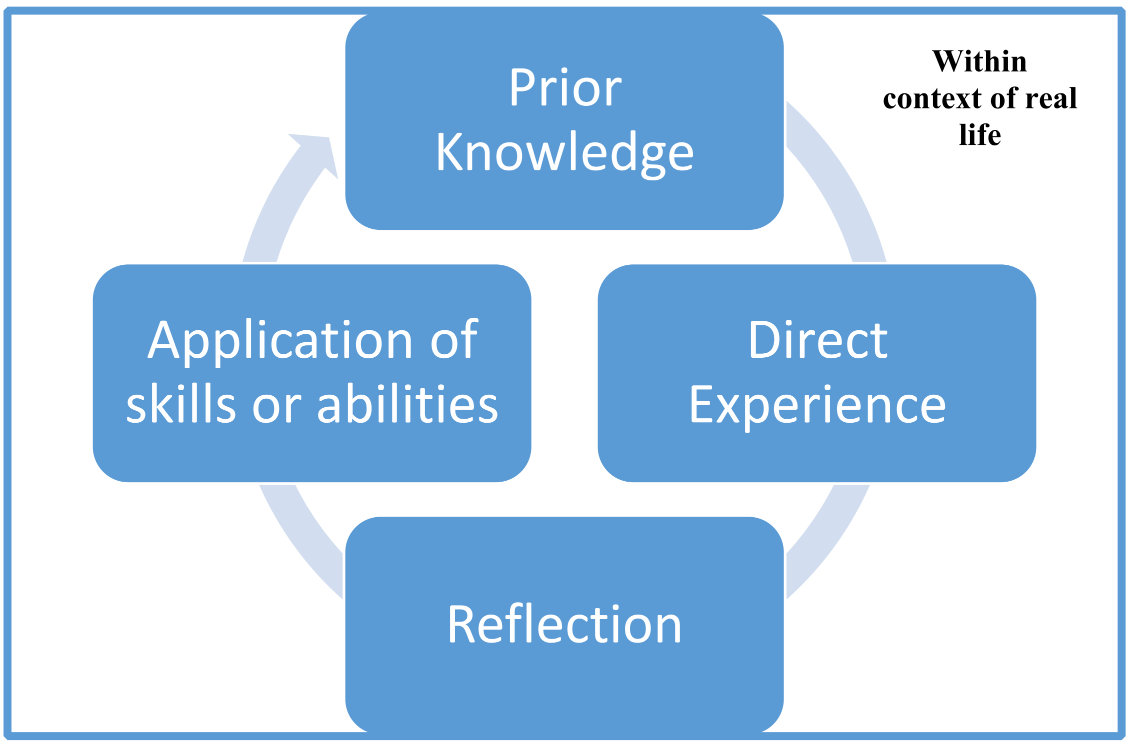
There is a plethora of benefits to incorporating play-based learning experiences within the early childhood curriculum (Hunter, 2019; Shin & Partyka, 2017; Vygotsky, 1967). Opportunities for play-based learning expand language and bolster social competence (Baron et al., 2016; McCollow & Hoffman, 2019; Short et al., 2020), as well as building joint attention skills and developing symbolic and pretend play (Thiemann-Bourque et al., 2011; Wong & Kasari, 2012; Worthington & Van Oers, 2016). Developing relationships among peers and with familiar adults fosters positive experiences and growth mindsets which in turn promotes engagement and intrinsic motivation for play opportunities within the context of education (Hunter, 2019).

Kinkead-Clark (2019) state, “Playful children display greater creativity and cognitive competence resulting in advanced verbal skills and the ability to engage in more complex critical thinking and problem solving skills” (p. 179). Thus, allowing for more abstract concepts to be explored such as those found within early mathematics. Young children benefit from mathematics experiences that are a result of exploration and play within their natural environments (Karatas et al., 2017), with the use of manipulatives to assist with making abstract concepts concrete in order to build on foundational skills (Ardoin et al., 2018; Donlan, 2003; Lee & Ginsburg, 2007). Such aspects of play-based learning will be discussed at length in Chapter 3. Experiential learning is an integral part of play-based instructional strategies, which will be discussed further in the following section.

Experiential Learning. Experiential learning theory developed by Kolb in 1984, begins by utilizing direct experiences, have time to reflect on the experience, and apply what was learned within the context of real life (Arends & Kilcher, 2010; Heinrich & Green, 2020; McPherson-Geyser et al., 2020). Multi-sensory experiences make such instructional learning more effective by personalizing the knowledge that is being gained through the experience (Arends & Kilcher, 2010; Biel & Peske, 2009). Figure 2 illustrates the cyclical nature of experiential learning situated within the context of real life situations to obtain the greatest benefit from the learning experience.

Figure 2

Cycle of Experiential Learning



Note: Information for this figure was obtained from Arends and Kilcher (2010) and McPherson-Geyser et al. (2020).

Play-based experiential learning is the cornerstone of early childhood instruction (Simoncini & Lasen, 2018), especially when discussing science, technology, engineering, and mathematics (STEM) areas of development. When educators implement experiential learning within the educational environment, they are not only planning experiences they set an atmosphere about the room which includes the space, arrangement of materials and furniture, and the energy of the lesson (McPherson-Geyser et al., 2020). Following will be a discussion of implementing such experiences includes planning for play when working with young children.

Planning for Play

Planning for play within a curriculum takes practice on the part of the educator. Understanding developmental trajectories of play, both typical and atypical discussed in Chapter 3, is key to choosing effective instructional strategies for play-based learning (Hassinger-Das et al., 2017; Short et al., 2020; Thiemann-Bourque et al., 2011). Play-based opportunities are considered best practices as established by NAEYC (2020) position statement on developmentally appropriate practices for early childhood education. Careful planning assists in diminishing barriers to play-based learning that were previously discussed.

With this in mind, Hunter (2019) outlines five key practices which support play-based learning within an educational environment that include:

1. Creating a classroom that meets the diverse needs and special interest areas of all children
2. Using knowledge of curriculum to identify learning opportunities within play experiences
3. Using and building prior knowledge that children bring to the classroom

4. Being a participant in purposeful conversations that broaden children's knowledge
5. Scaffolding interactions with children to support social-emotional development (p. 19)

Such practices are supported by the instructional strategies that are described in Chapter 3 including: engagement, motivation, praise, intentional or purposeful play, sociodramatic play, project approaches incorporating special interests, assessment and progress monitoring. Further instructional factors and strategies are highlighted in the following sections of this chapter.

Instructional Strategies

This section will focus on some of the foundational instructional strategies or practices identified throughout this dissertation, which includes: alignment of standards to instruction and the importance of using varied instructional strategies. This is also a reflection of the recommendations from DEC (2014) and NAEYC (2020) developmentally appropriate practices.

Instructional Planning Recommendations

Chapter 5 incorporates the instructional strategy recommendations as well as the early mathematics recommendations in the development of the study to compare mathematics interventions with preschool aged children with speech or language impairments. The Division for Early Childhood (DEC) of the Council for Exceptional Children (DEC, 2014) recommended practices state that instructional planning is the cornerstone of early intervention, which may be used to assist in the development of all domains for children who have been identified as at risk of or having developmental delays. DEC (2014) defines instructional practices as, “a subset of intervention activities conducted by practitioners and parents” (p. 12). The instructional practices of import for this dissertation include (DEC, 2014):

INS4. Practitioners plan for and provide the level of support, accommodations, and adaptations needed for the child to access, participate, and learn within and across activities and routines.

INS5. Practitioners embed instruction within and across routines, activities, and environments to provide contextually relevant learning opportunities.

INS6. Practitioners use systematic instructional strategies with fidelity to teach skills and to promote child engagement and learning.

INS7. Practitioners use explicit feedback and consequences to increase child engagement, play, and skills.

INS8. Practitioners use peer-mediated intervention to teach skills and to promote child engagement and learning. (p. 12)

The stated instructional practices coincide with the instructional strategies that will be discussed later in this chapter and in the later manuscripts within this dissertation. Such practices have been researched in various contexts (Ardoin et al., 2018; Cohrssen et al., 2014; Fuson et al., 2015; McDonald et al., 2015; Ryoo et al., 2018) and are developmentally appropriate to use with young children in a whole group, small group, or individual setting depending on the goal of instruction.

Recommendations from prominent organizations assist in guiding educators with various aspects of planning and learning for optimal effectiveness within thier classrooms. In conjunction with domain specific pedagogical knowledge, educators are better situated to set goals and provide opportunities for children to experience success within the learning environment. Developmental trajectories, domain specific standards, instructional strategies, analysis of assessment data, and planning of curriculum to meet the growth of all students should inform classroom decisions and goals during early childhood education (Chigeza & Sorin, 2016). It would benefit teacher candidates to engage in these processes during their undergraduate studies, with a large scope that is as strong in mathematics curriculum as is experienced with literacy curriculum (Chen et al., 2014; Parks & Wager, 2015). The first part of this section will highlight curriculum alignment to standards for early mathematics, especially during the preschool and kindergarten years.

Alignment of Standards to Instruction

Educators utilize standards along with pedagogical knowledge for planning of concepts and instruction for students within their classrooms (McCray & Chen, 2012; Opperman et al., 2016; Squires, 2012). Alignment to specified content standards within early childhood curriculums is a way to ensure concept coverage within the instructional and learning process (Squires, 2012). While it is widely acknowledged that standards are a broad type of coverage, curriculum is more specific, and going further instructional strategies are a fine tuning of how content is to be taught within the learning environment (McCray & Chen 2012; Squires, 2012; Tomlinson, 2014). Taking a look at the pressures of utilizing standards within education the next paragraph will share information pertaining to the often concerning aspect of ‘pushing down’ standards.

Parks and Wager (2015) indicate an increase in the pressure to ‘push down’ the curriculum so that preschool is the new Kindergarten. This is evidenced by many states making available documents aligning early learning standards (e.g., preschool, 3-6 year-olds) to common core (e.g. Kindergarten through third grade for early childhood) state standards (Common Core State Standards Initiative, 2020). Table 3 compares Ohio’s early learning standards with the Common Core State Standards for mathematics, focusing specifically on early childhood (birth through Kindergarten).

Table 3

Comparison of Early Learning Standards and Common Core State Standards

Number Sense

Elements	**Early Learning Standards**	**Common Core State Standards**
Strands included in Number Sense Domain	Number sense and counting, number relationships.	Counting and cardinality, operations and algebraic thinking, number and operations in base ten.
Age range	Birth to 5 years old (3 to 5 years old for preschool).	5 to 6 years old (e.g. Kindergarten).
Concepts included within the learning strands	• Count to 20 by ones • Identify and name numerals 1-9 • Subitizing up to 3 items • One-to-one correspondence up to 10 objects • Count to tell the number of objects or Cardinality • Greater than, less than, equal too up to 10 objects • Count to solve simple addition and subtraction problems up to 8 objects	• Count to 100 by ones and tens • Count forward beginning from a given number • Write numerals from 0 to 20. • Count to tell the number of objects or Cardinality • Count to answer how many questions up to 20 • Greater than, less than, equal too when comparing quantities • Compare two numbers between 1 and 10 • Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from up to 10 objects • Fluently add and subtract within 5 • Work with numbers 11-19 to gain foundations for place value

Note: Information for comparisons was obtained from the Common Core State Standards Initiative (2020) and Ohio Department of Education (2020) Early Learning Standards for birth through five years old.

Learning standards like those contained in Table 3 inform early childhood curriculum, activities, and instructional methods. Through such alignments, educators have a type of roadmap to guide instructional planning based on grade level or age if working with preschool standards (McCray & Chen 2012; Squires, 2012). The following section will explain the importance of using varied instructional strategies under the lens of developmentally appropriate practices such as engaging students, increasing motivation, promotion of social and communication development, and making learning of abstract concepts more concrete for young learners.

Importance of using Varied Instructional Strategies

How mathematics experiences during the early years are presented, especially amid formal instruction, can influence the engagement and motivation that children have towards the subject (Anders & Rossbach, 2015; Celik, 2017; Merkley & Ansari, 2016; Opperman et al., 2016). Early childhood educators have to work to present engaging opportunities for children to practice early concepts (Carbonneau & Marley, 2015; Jacobi-Vessels et al., 2014); often, this is done through everyday play-based activities and routines Through this instructional practice that reflects the DEC (2014) recommendations, educators can extend mathematics concepts identified within the curriculum during play.

Peer modeling and scaffolding are important practices in early childhood education that serve to demonstrate developmentally appropriate trajectories, sustained play resulting in more complex outcomes, greater cognitive flexibility, and instructional planning for further opportunities (Fuson et al., 2015; Trawick-Smith et al., 2016). The blending of peer modeling and the use of gameplay with manipulatives to support the practice of numeracy skills during early childhood is a fundamental place to begin instructional planning.

The use of games during instruction or for practice is not a new concept; however, it is a strong motivational reinforcement strategy for young learners (Carbonneau & Marley, 2015; McGrath, 2021; Laski & Siegler, 2014). A plethora of experiences with numerical concepts during games and play activities before formal schooling (i.e. the elementary years) begins, supports children's understanding of mathematical concepts and builds their foundation for more abstract and advanced mathematics (Laski & Siegler, 2014; Powell & Fuchs, 2012; Trawick-Smith et al., 2016). One particularly important instructional strategy within early mathematics is the use of manipulatives for reinforcing abstract concepts and making them more concrete for younger children. The following section highlights the importance of this strategy in more detail.

Use of Manipulatives for Instructional Purposes

The instructional strategy of repeated practice using manipulatives, whether it be through independent practice, cooperative games with peers, or simple tasks used for practice, strengthens the associations of targeted skills/concepts which increases automaticity and fluency (Ardoin et al., 2018; Donlan, 2003; Lee & Ginsburg, 2007).

Practice with mathematics concepts involves repeated experience with tangible objects that are meaningful and relevant to the child (Carbonneau & Marley, 2015; Uribe-Florez & Wilkins, 2016). Manipulatives serve to make learning engaging, as well as abstract concepts more concrete for young children (Carbonneau & Marley, 2015; Uribe-Florez & Wilkins, 2016). In this way, children can see how adding manipulatives or taking them away physically changes the total number of a set or group, making the numbers concrete. The concept of utilizing manipulatives while implementing play-based instructional methods is explored in detail throughout Chapters 4 and 5 of this dissertation.

Specific instructional strategies which include: engagement, motivation, praise, intentional or purposeful play, sociodramatic play, project approaches, assessment and progress monitoring, differentiation, small groups, graphic organizers, educator created materials and games, questioning with varied levels of difficulty, wait time, offering choices, explicit instruction, and repeated practice will be discussed at length in later chapters of this dissertation.

Conclusion

Throughout Chapter 1 four underlying themes which include: foundational mathematics concepts, special factors that contribute to learning difficulties, play-based learning, and instructional strategies, have been discussed including various connections which impact curricular decisions made by early childhood educators on a daily basis. Further reviews of the literature in the chapter, regarding the particular themes mentioned, demonstrate the importance of mathematics and instructional strategy considerations within early childhood education. The three manuscripts that make up chapter 3, 4, and 5 illustrate such important concepts within early childhood curriculum and instruction. Moving forward, Chapter 2 will discuss important outcomes of the dissertation and present implications for the field of early childhood education, as well as personal implications for practice.

Chapter 2: Discussion and Implications

Throughout the manuscripts presented in the dissertation, connections have been made amid play-based learning strategies, in conjunction with early mathematics concepts, to benefit curriculum and instructional planning in the field of early childhood general and special education. Chapter 1 provided the literature review and made important connections between the concepts discussed in each manuscript. Chapter 3 examines the importance of mindset and play-based learning opportunities during the early childhood years. Chapter 4 explains the benefits of differentiating instruction using play-based strategies while engaging in early mathematics concepts. Finally, Chapter 5 compares two intervention strategies for early mathematics concepts that can be used when working with children who are identified as having speech or language impairments.

With these aspects in mind, Chapter 2 considered the implications of the research presented in this dissertation for the field of early childhood general and special education. The prominence of mathematics curriculum in early childhood education is discussed and how the research presented makes a difference in the conversations educators are experiencing around early mathematics in early education. Especially, when considering how early mathematics curriculum is viewed by educators, administrators, and stakeholders in the context of early education during curricular planning and instructional practices. Following a discussion centered around planning for early childhood intervention specialists as it relates to constructing mathematics interventions for young children to decrease the opportunity gap moving forward. A major outcome from the research, which will be discussed further in the chapter, is an open discussion of mathematics curriculum and instructional practices in early childhood between educators, administrators, teacher candidates, and other stakeholders. An analysis of the implementation of play-based instructional strategies, while addressing the benefit of educators overcoming mathematics anxiety in order to yield better outcomes for the children in early childhood programs. A further inquiry into teacher preparation programs, regarding mathematics requirements to boost pedagogical content knowledge and fortify curriculum and instructional practices to the benefit of future educators.

During the final sections of Chapter 2, a presentation of how the research conducted in the dissertation affects my professional relationships and choices moving forward in my chosen career as an early childhood intervention specialist is explored. A large part of being an educator and growing in the profession requires time spent in reflection; by considering the personal implications from the research, I hope to make personal gains and show growth in my professional life. Personal implications will be explored regarding the implementation of interventions centered around mathematics, teacher candidate experiences and course work provided as an adjunct instructor, and professional collaborations as an intervention specialist and itinerant teacher. Lastly, a look at possible future research endeavors to explore other aspects of mathematics development including various special considerations, curriculum and instructional practices which may benefit the field of early childhood education. The initial discussion in this chapter will explore the prominence or lack of regarding mathematics curriculum in early childhood education and how research can inform and change perspectives in this area.

Implications for the Field of Early Childhood Education

There are many avenues research can take a person down and implications are just possibilities that can lead to wonderous results in various future circumstances. In conducting research and presenting findings through the final three chapters of this dissertation, a multitude of opportunities and connections have occurred in the area of mathematics. Collaborative relationships have been formed, professional practices have been impacted, and children have benefited from the implications gleaned through the dissertation journey. The first outcome to be discussed includes the prominence or lack of mathematics curriculum in early childhood.

Prominence of Mathematics Curriculum

Traditionally, the mathematics curriculum has not been afforded the same standing as literacy throughout the field of early childhood education (Ginsburg et al., 2008; Hachey, 2013; McCrone & Dossey 2007; Platas, 2014). However, a plethora of research indicates that mathematics, especially the number sense domain, is a good predictor or future achievement in education and subsequent success throughout adult life (Durkin et al., 2013; Lee et al., 2016; Mainela-Arnold et al., 2011; Opfer et al., 2018; Sayers et al., 2016; Toll & Van Luit, 2012; Watts et al., 2017). Educator attitudes and beliefs, specifically levels of anxiety related to mathematics, may dictate the planning and delivery of curriculum in an educational setting (Celik, 2017; Platas, 2014). This can directly translate into how early mathematics curriculum is perceived by the education community, the general population including parents, and other stakeholders.

How Early Mathematics Curriculum is Perceived

Many early childhood educators are reluctant to teach early mathematics concepts due to mathematics anxiety and having more confidence in other areas of academics, such as literacy (Beilock et al., 2010; Geist, 2015; McGrath, 2021). The mathematics curriculum in the United States, compared to various other European and Asian countries, is not valued in the same ways as literacy and language arts within educational settings (Hachey, 2013; McCrone & Dossey, 2007). The majority of educators' experiences with mathematics curriculum comes from books, which often provide curriculum mapping where guides are provided for the concepts to be taught in a sequence and approximate timing during the year, based on typical developmental trajectories. However, these curriculum books often fail to provide assistance with how to teach the concepts or what supports to provide if children struggle along the way.

One example could be an educator who is teaching connecting skills, such as one-to-one correspondence and stable order counting, which should be in a curriculum map for preschool-aged children. The developmental trajectory is provided in the curriculum mapping and states what the child should be working towards, for example stable order counting to ten while demonstrating one-to-one correspondence. However, the child is struggling with one-to-one correspondence within ten objects and is only stable order counting to six. Within the curriculum, there do not seem to be any intervention or instructional strategies for use to provide support. Therefore, the educator could be left struggling to support the child in learning new skills, frustrated by the lack of resources or support provided, or experiencing mathematics anxiety themselves. There do exist, however, some supplemental curricular books available that provide methods for teaching, reinforcing, and practicing early mathematics concepts through play and hands on experiential learning activities (see Moomaw & Hieronymus, 2011). Utilizing such books and building on play-based strategies with educator created games, like those presented in Chapter 4, make a considerable difference in early childhood classrooms. Educators benefit from comprehensive curricular resources and supports where meaningful experiences with mathematics can be designed for children. The following discussion explores the evidence presented in the research regarding how integrating play-based instructional strategies when designing mathematics curriculum benefits children in early childhood educational settings.

Curriculum Planning and Instructional Strategies

Another major outcome of the dissertation pertains to curriculum planning and instructional strategies as they relate to early mathematics concepts, which can be seen throughout every chapter of this dissertation. Curriculum planning and instructional strategies evolve around the idea that educators are assisting children to engage with mathematics concepts in their classroom environments, therefore building foundational skills that allow for expansion as children go through formal schooling (McCray & Chen, 2012). A critical aspect in teaching and learning mathematics concepts is the arithmetic processes and logical reasoning used for solving various types of problems (Lee & Md-Yunus, 2015). Without plenty of exposure and opportunities for practice with mathematics concepts and processes, children are at a greater risk of struggling during formal schooling due to being unfamiliar with procedures and foundational concepts (Ardoin et al., 2018; Evans & Ullman, 2016; Laski & Siegler, 2014; Rosenshine, 2012; Watts et al., 2017).

Chapters 3, 4, and 5 of this dissertation demonstrate the need for educators to first identify effective research-based instructional strategies with which they are familiar and comfortable utilizing and can be molded to fit specific children's needs in the classroom (Toll & Van Luit, 2012). Chapter 3 provides information regarding specific play-based instructional strategies that promote a growth mindset, which can be used to build positive attitudes towards mathematics when educators structure learning opportunities for success focusing on foundational number sense concepts early on. Chapter 4 highlights the possibilities for learning through differentiation using play-based instructional strategies when practicing mathematics concepts. Implications from the research conducted in Chapter 5 specifically address the importance of explicit instruction, repeated practice, and experiential learning through play-based learning. Through the utilization of a combination of instructional practices including picture books, manipulatives, and structured game play or learning activities around a targeted skill such as symbol recognition, arithmetic procedures, and foundational number sense skills play-based interventions can be designed in a thoughtful manner. The following discussion in regard to concepts that impact planning for instruction of mathematics, such as those described in Chapter 1, will be explored further as well as how interventions are influenced by special factors.

Planning for Early Childhood Intervention Specialists

A plethora of special factors exist when considering curriculum planning and instructional strategies in education. Chapters 1, 3, and 5 address such concepts and provide clarity regarding special factors including speech or language impairments, atypical play behaviors, barriers to play-based instruction, mathematics anxiety, lower SES, mathematics difficulties, and working memory. Educators are apt to struggle when designing interventions to meet the needs of individual children when they engage with a wide range of diverse and exceptional children from year to year, rarely are individual needs exactly the same.

As seen through Chapter 5, speech or language impairments can drastically affect the learning trajectories of mathematics during the early years of development (Durkin et al., 2013; Cross et al., 2019; Mononen et al., 2014; Toll & Van Luit, 2015; Vukovic & Lesaux, 2013). Working memory, which is an integral part of the language system, plays a role in the ability to effectively apply mathematics to real world situations and build automaticity or fluency within this academic area (Archibald & Griebeling, 2015; Buchsbaum & D'Esposito, 2008; Gathercole & Alloway, 2007; McLeod, 2012). Lower SES can be seen as a special factor due to circumstances and trends surrounding achievement gaps within academic areas throughout the formal school years (Geist, 2015; Hachey, 2013; Harvey & Miller, 2016; Jordan, 2007; Lee et al., 2016). It is through research based instructional practices that educators design interventions for mathematics based on the individual needs of students in order to narrow the achievement gap in early education.

Informing Mathematics Interventions. The research presented in Chapters 4 and 5 directly impact mathematics interventions and instructional practices by providing evidence based instructional strategies such as intentional grouping for small groups, graphic organizers, educator created materials and games, questioning with varied levels of difficulty, providing wait time, offering choices, blending instructional strategies, explicit instruction, repeated practice, and using appropriate manipulatives. Designing effective interventions is a multi-step process where an educator first has to identify the specific need and target skills to be developed. Once that is complete knowing the individual child and their learning profile is key in order to utilize effective research based instructional practices and adapting strategies to work for the child.

Providing a context for success is another important aspect of interventions, if the child does not experience some success then the risk is the child giving up all together and exhibiting avoidance behavior or refusal to participate in activities. The next steps include progress monitoring for growth over the length of the intervention and periodic reflection of instructional practices to adjust when necessary if no growth is occurring. In blending instructional strategies careful consideration should be paid to what outcome is desired and how the child learns best. Through this process effective interventions can be cultivated around early mathematics concepts which address special factors as seen in Chapter 5. Which leads to a larger discussion about conversations in early childhood centered on mathematics curriculum.

Implications for the Discussion of Mathematics Curriculum in Early Childhood

One of the major outcomes of the dissertation is as a catalyst for conversations in the field of early childhood and special education about mathematics curriculum and instructional planning. Chapter 1 brings attention to the importance of mathematics as a foundational academic area in early childhood along with appropriate developmental trajectories for the number sense domain. Building such pedagogical content knowledge for educators is important so that effective instructional strategies can be integrated for the benefit of children in the learning environment. Play-based learning is an integral part of the instructional delivery system as Chapter 1 and 3 explain in great detail and boosts engagement of learning activities. Early childhood educators understand that play is how children learn, because it is experiential in nature but can also be structured and purposeful at the same time. When administrators and educators engage in meaningful discussions about mathematics, play becomes an avenue for inspiration and connection, which allows for difficult conversations to deepen.

Implementation using Play-based Instructional Strategies

Utilizing play-based instructional strategies to engage children in mathematics is a natural way to approach learning in early childhood settings (Hassinger-Das et al., 2017; Hoisington, 2007; Moomaw et al., 2010; Shin & Partyka, 2017). By reinforcing the mathematics that children are observing and experiencing in real life on a daily basis, educators are making mathematics real and providing meaning for the learning that is expected to take place. Chapter 3 describes why play-based instructional strategies are an integral part of early childhood education. The research from Chapter 4 illustrates how play can be used as an effective delivery method for content while reinforcing intrinsic motivation and engagement for repeated and guided practice in the classroom. Chapter 5 explores the concept of play-based strategies as a foundation for intervention practices to fortify mathematics content.

Through play children are able to access, manipulate, and engage in a variety of mathematical ideas and processes (Colliver & Veraksa, 2019; McGrath, 2021; Shin & Partyka, 2017; Vermeulen, 2012; Vygotsky, 1967). Such play enables children to build a growth mindset and foster a positive attitude towards mathematics as they move towards formal education (Duckworth, 2016; Dweck, 2006). Chapter 4 provides an opportunity for the mathematics discussions to move in the direction of instructional practices and differentiation to meet the needs of children. While Chapter 5 adds specific instructional strategies in light of difficulties that arise with children identified with speech or language impairments. In having such discussions in the field, educators are able to identify areas where growth can occur and begin to look at how to best accomplish such growth. Mathematics anxiety seems to be one of the highest need areas moving forward in the conversation.

Overcoming Mathematics Anxiety

Mathematics anxiety and its symptoms, effects, and outcomes for children are discussed in depth during Chapter 1. Educator beliefs and confidence in teaching mathematics has an effect on curricular implementation and practices in the classroom, which directly affects the children in their care (Platas, 2014). Educators who experience mathematics anxiety tend to focus on correct answers rather than the processes used for solving problems (Celik, 2017), however the process for solving problems should be the focus and practiced often in order to alleviate mathematics anxiety for children. Providing ample opportunities for practicing and engaging with mathematics that are structured for success, in a positive way lessens the likelihood that mathematics anxiety will have a chance to manifest early in a child's formal schooling.

By providing comprehensive developmental trajectories for mathematics to educators, as well as evidenced based instructional strategies we can begin to remedy achievement gaps and negate mathematics anxiety. Curricular choices made every day in classrooms can have a large impact on outcomes for children. Therefore, educators require access to effective research based professional development trainings to further the conversation and work towards building connections to assist in overcoming mathematics anxiety. Which leads to a discussion regarding the state of teacher preparation programs and how mathematics pedagogical content knowledge is constructed.

Implications for Preparing Future Educators

Research in teacher preparation programs is calling for a stronger emphasis in the area of mathematics (Benz, 2012; Chen et al., 2014; Lee & Ginsburg, 2009; McGrath, 2021; Parks & Wager, 2015). To broaden the scope and build confidence in mathematics pedagogical abilities, teacher candidate require an abundance of exposure with early mathematics concepts, familiarity with developmental trajectories, and experiences in educational contexts regarding delivery of curriculum via a variety of instructional practices. Curriculum sets the stage for what is to be learned in the classroom, it is the jumping off point for most educators when planning instruction and grouping children to optimize learning outcomes.

During teacher preparation programs there are several literacy classes at various levels to ensure comprehension of the subject and bolster confidence in ability to teach the academic area. However, mathematics experiences are fewer and generally only occur minimally in the course requirements for teacher candidates (Lee & Ginsburg, 2007; McCray & Chen, 2012; Platas, 2014). Generally there are a few basic courses in mathematics, which often teach the history of mathematics as a foundation, and one to two methodology courses specializing in pedagogical practices. While this is seen as a foundation in early mathematics it does not often teach developmental trajectories, this is especially true for the preschool years. Teacher candidates require a good foundational understanding of early mathematics concepts, how to analyze where children are in the developmental trajectory, and appropriate instructional strategies to incorporate that will provide meaningful mathematics experiences to reduce the opportunity gap.

Throughout the dissertation there is evidence to support the idea that teacher preparation programs are in need of revising the requirements for mathematics within early childhood programs. It would benefit teacher candidates to have more exposure in how to teach early mathematics at various levels such as preschool, kindergarten, and early elementary grades (i.e. 1-3 grade). Pedagogical knowledge along with strengthening the comprehension of developmental trajectories in mathematics could go a long way in strengthening the understanding and value of mathematics curriculum in the world of early childhood education. Teacher candidates would benefit from engaging with a plethora of comprehensive resources for curricular planning and instructional practices to build competence and alleviate mathematics anxiety before formally entering the field of early education.

Reflection as an educator is of great importance so that we may continue to grow and benefit the children we serve on a daily basis. In the last section of Chapter 2 a discussion regarding personal implications as a result of conducting the research for the dissertation will be explored as well as possibilities for future research.

Personal Implications for the Future

So far we have discussed several implications for the field of early childhood education and special education as it relates to curriculum planning and instructional practices. However, there are a plethora of personal implications that the research explored throughout the dissertation has had on my career in the form of interventions with children, content for courses taught in higher education, and collaborations with colleagues.

Early Childhood Intervention Instruction

Through completing the research for this dissertation and realizing a passion for early mathematics, my instructional planning practices and content knowledge have grown exponentially. By completing the process of designing interventions for Chapter 5, it has enabled me to better serve the children with whom I work. So many of the children I serve are identified with speech or language delays and in turn display delayed mathematics abilities. With mathematics being a foundational academic area and important for future success, I have been able to integrate early mathematics concepts during intervention sessions with students in a play-based atmosphere which promotes more engagement overall.

Collaborating with the speech and language pathologists in the organization I work for has opened my eyes to new opportunities and how mathematics concepts play into speech and language as a whole. Various aspects regarding the quantitative concepts covered in the area of speech and language also cover early mathematics concepts such as big/little, more/less, empty/full, long/short, heavy/light, equal, together, same, different, opposites, etc. Through this collaboration I began to understand that language plays a huge part in mathematics and children with difficulties in the area of speech and language could be at a higher risk of struggling in the area of mathematics as a result. This led to the research for Chapter 5 and designing interventions for children experience difficulties with speech or language in mind.

The research conducted for Chapters 3 and 4 laid the foundation for Chapter 5. Highlighting the concepts of differentiation and play-based instructional strategies presented in the dissertation has provided a platform for many conversations with various administrators, educators, teacher candidates, and the general public. All three chapters have had a direct impact on my work in teacher preparation programs, working with resident educators, and colleagues as evidenced in the following sections.

Work with Teacher Candidates

During the time I was working on this dissertation, I also served as an adjunct instructor of Teacher Education for mild/moderate intervention specialist and early childhood general education candidates. I have instructed several courses in both programs of study regarding instructional strategies, assessment, progress monitoring, curriculum design, and interventions for various areas of development. The research I have conducted has shaped, in part, what and how I engage students and teach at the higher education level. Throughout several semesters and lesson plan assignments I have rarely seen teacher candidates choose mathematics as an area of focus. Often I will provide examples in terms of mathematics lessons and interventions used with children who are struggling in that area. I hope by sharing examples and initiating conversations in this area to ignite a spark that will allow growth for teacher candidates and help them to build confidence when supporting children they encounter who are struggling with mathematics.

As an educator, there have been several resident educators I have had the pleasure of working with in a mentor capacity. They have often engaged me in conversations regarding instructional strategies, play as a means of learning, and mathematics interventions for children in their programs. My goal is generally to engage them in the process of teasing out what the child needs, starting from where the child is and making a goal of where the child needs to be for Kindergarten readiness and formal learning environments. It seems the research presented in Chapters 3, 4, and 5 are at the center of these conversations. Engage the children with play-based activities that foster repeated experiences, guided practice and explicit instruction while providing an explicit language based experience where vocabulary is the foundation for building knowledge in the area of mathematics.

Professional Collaborations

During the time spent working on the dissertation, I have presented at several conferences that have allowed me to share my work on a local, state, and national level. Interactions with educators and researchers from across the P-20 educational system has impacted my work and allowed me to view my contributions through a different lens. After the Chapter 4 manuscript was published I received communications from educators and administrators from different parts of the United States asking if I could elaborate on strategies that I use to incorporate and teach early mathematics. One memorable interaction was with an administrator for a school for the deaf. At the time I was working on designing interventions for the Chapter 5 research, which I was then able to share with the administrator to inform curriculum design and planning at that institution.

Interacting with colleagues to share my research in the field of early childhood at a local level has been rewarding, in that I can see first-hand the impact it is having on the children often in real time. Designing interventions and using the knowledge gained from Chapter 3 to inform the setting for implementation of early mathematics concepts enables educators to draw children in utilizing intrinsic motivation. Strategies such as repeated practice, explicit instruction, differentiation, and structured play facilitate several avenues for practicing mathematics concepts and build on as children are ready.

A final opportunity presented during the completion of the dissertation process as a direct result of the research I conducted was being asked to provide a professional development training centered around mathematics instructional delivery in Head Start classrooms. The Head Start administration approached me based on word of mouth about my growing expertise in the area of early mathematics, they are familiar with me because I work closely with some of the educators in their program as an itinerant teacher. The Head Start program in our area has identified mathematics as a weak point, leading to an interest in professional development that offers information regarding foundational knowledge, developmental trajectories, curriculum design elements, and instructional strategy delivery options. Designing and sharing the knowledge gained through the dissertation process and being able to directly impact my local community to benefit the children I serve everyday gives me a real sense of accomplishment.

Future Research

Given the insights and implications from the dissertation, future research may focus on curricular resources, educator supports, specific interventions with other special interest populations, and various environmental or contextual factors that could contribute to lessening of the opportunity gap before formal schooling begins. The exploration of curricular resources may include specific manipulatives and their benefits to mathematics play-based activities or the use of support resources for planning curriculum and instructional delivery in various general and special education contexts. Various supports for educators which could further the research include focusing on specific developmental trajectories, other than the number sense domain, training opportunities to strengthen confidence and abilities, technology related resources for educators and benefits of utilizing such resources within an educational environment. A major avenue for further research includes combining instructional practices with special interest populations including autism, developmental delay, visual or hearing impaired, specific learning disability, traumatic brain injury, or intellectual disabilities to determine effective intervention practices within the area of early mathematics. This would be an extension of the research specific to Chapter 5 and of high interest to the field or early childhood intervention specialists in particular.

Another area of interest moving forward would be a deeper dive into cultural contexts and the interplay with early mathematics, specifically what are the impacts and how can educators use this to narrow the opportunity gap once children begin attending preschool or kindergarten? Finally, there are a plethora of environmental and contextual factors that come into play in the early childhood setting that may have an impact on early mathematics development. Future research could delve into the impacts of educator preparation programs, mathematics anxiety and the impact for young children, availability of resources in the classroom, how educators utilize resources, ability to plan curriculum and analyze when children are struggling, progress monitoring techniques in conjunction with specified interventions, or early childhood mathematics curriculums as a whole. Depending on interest and areas of need, an abundance of recommendations have been made for further research moving forward.

Conclusion

In conclusion, the implications explored throughout the research presented in the dissertation, generates an impact to the field of early childhood general and special education regarding the planning and delivery of mathematic concepts. Through the intentional planning of mathematics curriculum and utilizing research based instructional strategies educators can strive to narrow the opportunity gaps in the area of mathematics during the preschool years. The following manuscripts presented in Chapters 3, 4, and 5 contributed to the overarching conversations regarding mathematics curriculum planning and instructional practices in unique ways as described by the first two chapters of the dissertation.

Chapter 3: Incorporating a Growth Mindset into Play-based Education: Teaching Strategies for Early Childhood Educators

Growth mindsets are important to incorporate within play-based approaches and curriculums, considering that this mindset builds student confidence, perseverance when faced with challenging tasks, and resilience (Dweck, 2006). Resilience is fostered when young children learn to persevere in the face of a challenge, follow through with frustrating tasks, and continually learn throughout a process. Children who do not rely solely on talent or ability but recognize their efforts to achieve and accomplish such skills as independence, perseverance, metacognition, and resilience, may define successful adults (Duckworth, 2016). The purpose of this manuscript is to discuss growth mindsets and provide context within play-based approaches that build these mindsets in children during the early childhood years.

With that intention, an authentic definition of what a growth mindset incorporates includes accepting challenges to grow personally and not as a definition of failure. Dweck (2006) states, "The passion for stretching yourself and sticking to it, even (or especially) when it's not going well, is the hallmark of the growth mindset" (p. 7). Encouraging and praising a young preschool student for their perseverance through a challenging task, such as writing their name when they become frustrated due to not being able to control the writing utensil as they would like, would be an example of encouraging a growth mindset. Individuals with a growth mindset tend to be highly successful because they have determination, a purpose, and know what they want (Duckworth, 2016). In contrast, individuals with a fixed mindset focus on ability and talent and do not accept that effort and practice have a great deal to do with their accomplishments. Both growth and fixed mindsets will be discussed later in this manuscript, along with self-efficacy, perseverance, and resilience.

Educators may offer a child's first experience with the growth mindset and could help determine how each child may approach learning experiences and play in the classroom. Therefore, teaching our students to practice a growth mindset early and persevere when met with a challenge that could expand their knowledge instead of running from it, would be a foundational skill for success later in life. Play is the basis for experiential learning for early childhood students; play-based approaches become immersive for students to build social-emotional, cognitive, and communication skills for their development (Shin & Partyka, 2017). Play-based approaches are developmentally appropriate practices (DAP) that occur within the early childhood curriculum and are specifically stated within the NAEYC position statement (2020). Through play-based activities, students learn important executive functioning and social skills including self-regulation, perseverance, impulse control, sharing, turn taking, appropriate communication skills, and how to maintain friendships. Play-based approaches and why they are important will be discussed later in this manuscript. Using play-based approaches provides an organic way for learning to occur and become meaningful for individual students.

Further, several teaching strategies can be used within the context of play including engagement, motivation, praise, intentional or purposeful play, role-playing or simulations, open-ended questioning techniques, play-projects, modeling, games, assessments and progress monitoring, all of which will be discussed in forthcoming sections. Additionally, research indicates there are several barriers to using these strategies within early childhood classrooms (Baron et al., 2016; Colliver & Veraksa, 2019; Shin & Partyka, 2017; Worthington & Van Oers, 2016), which will also be addressed.

Mindsets

The type of mindset one adopts is critical to the development of perspectives and the interactions we have with our world. The type of mindset, growth or fixed, and other influences which impact our mindset including self-efficacy or perseverance and resilience will be discussed in-depth throughout this section.

Growth Mindset

For individuals with a growth mindset, the experience of learning is the priority; they pay close attention to information that has the potential to stretch their knowledge. Dweck (2006) states, “People in a growth mindset don’t just *seek* challenge, they thrive on it. The bigger the challenge, the more they stretch” (p. 21). By cultivating an educational atmosphere where learning is synonymous with accepting and accomplishing challenging tasks, educators are creating an environment where children can begin to understand that effort and perseverance will take them where they want to go in life (Martin, 2015). It is valuable to teach young children how to accept mistakes as learning opportunities and work with each other to solve difficult problems. By incorporating strategies that increase attention, memory, and judgement through play in educational settings, educators are providing tools for children to enhance aspects of a growth mindset to generalize skills in other contexts (Cash, 2011; Dweck, 2006).

When cultivated early in childhood, growth mindsets encourage a predisposition for a student to become a lifelong learner, where learning becomes autonomous and the individual is intrinsically motivated to seek and expand their knowledge of the world around them. Learning holds more meaning for people when it is experiential and relevant to their immediate situations or current interests. Individuals with a growth mindset pay closer attention to information that could enhance their learning experiences, making learning a priority (Dweck, 2006). Educators can nurture a love for learning through the atmosphere created in the classroom, which begins with trust that they are there to teach and not judge the children. Through education and instructional methods, children can learn to think autonomously, hopefully creating a sense of accomplishment in their efforts and the ability to problem solve as a result. Growth minded educators provide students with the truth about their performance in a respectful way and provide children with the tools to meet high expectations (Dweck, 2006). There are many social skills that benefit from the development of a growth mindset including communication, taking responsibility, showing initiative, positive attitude, and self-regulation. Cash (2011) claims, “Having a growth mindset encourages the development of self-regulation and valuable life skills” (p. 73). Developing such non-cognitive skills as being punctual, taking responsibility, and showing initiative translates into skills for success in the professional workforce. In contrast, a fixed mindset can undermine the building of such skills by inaccurately judging individuals based on achievement scores, aptitude assessments, strengths or weaknesses, and personality traits (e.g., shyness, temperament).

Fixed Mindset

Within a fixed mindset, talent or ability is key; one must only exert effort if they do not already possess the desired ability or talent. Dweck (2006) states, "[Failure] has been transformed from an action (I failed) to an identity (I am a failure). This is especially true in the fixed mindset" (p. 33). It is strongly concluded within the larger society that children's confidence and self-esteem must be protected and preserved from failure (Elkind, 2001). However, a larger problem has been incidentally introduced by this movement: children who never experience failure, either though talent alone or being sheltered from failure by adults, become entitled in that they do not feel they have to overcome challenges to continue to grow. A majority of children may believe they no longer need to work through challenges and put forth effort because their innate ability has gotten them what they need and want up to the point where they encounter challenges and may not know how to overcome them. For example, when a child is presented with an opportunity to practice a new skill such as riding a bike without training wheels, when they have been very successful with tricycles and bicycles with training wheels in the past. When the child is faced with a challenge like falling off the bike for the first time, a child with a fixed mindset may view this as a failure and that they are not good at riding bikes after all, which leads to not working through the challenge to continue learning the new skill. The child with a fixed mindset chooses not to engage with the activity beyond their current skill level possibly due to a fear of failure.

Therefore, Martin (2015) suggests that students with a fixed mindset see their competencies as difficult to address, leading to less inclination to aim for and target growth or stretch their current knowledge. Children with a fixed mindset may focus on what they cannot do and see setbacks as permanent; they may not participate in activities because they worry about what others will think of them if they make a mistake or give an incorrect answer (Collet, 2017; Elkind, 2001). Lack of participation could stem from a fear of judgement by peers and educators. Bullying may present a further problem if children have prior exposure at home or in the educational setting regarding this type of behavior. In some instances, bullying or verbal outbursts during instructional time may be a result of misdirection in the behavior of the child so no one will notice their insecurity about their abilities. In a fixed mindset, the individual is constantly competing against others, never against themselves to achieve growth. The focus for these individuals becomes, *How do I measure up to everyone else?*, *Am I worthy of that place?*, and *Where does society say I fit in?*, when the focus should be, *What strategies will get me to where I want to go?* This concept would be self-efficacy or perseverance to get through the frustration, problem, or challenge to achieve the desired goal.

Self-efficacy and Perseverance

All individuals have potential or ability; how this is used and built upon can make the difference in what lessons are learned and what drives later learning experiences (Duckworth, 2016). Talent and ability can be a solid foundation, but when met with determination, passion, and effort, these are then sculpted into perseverance. Accepting that talent can be developed through effort and practice, and valuing that effort regardless of the outcome, allows an individual to meet their full potential (Dweck, 2006). Underestimating abilities within an individual in any given context will either chip away at self-efficacy or build upon it, depending on the individual's personality, temperament, and resilience. For example, telling a child they are not capable of putting a challenging puzzle together, a child with a fixed mindset might give up easily and move to another activity; however, a child with a growth mindset may use strategies to move forward with the challenge until the puzzle is completed. Without self-efficacy and perseverance to overcome challenges, students are no more than their current abilities and talents or unmet potential (Duckworth, 2016).

Therefore, abilities matter as a foundation of skills to be built upon or strengthened as growth occurs; whereas effort builds skills which enables a person to overcome challenges and provides meaningful learning experiences, resulting in the combination of ability and effort to build self-efficacy (Duckworth, 2016). Working through challenging situations or correcting a mistake encourages perseverance. Educators should teach young children through modeling that making mistakes is acceptable, and to turn those mistakes into learning opportunities. By explaining that mistakes are situations where constructive criticism, presented in a respectful way, is a platform for growth and learning to occur; along with encouraging educators to provide trusting and safe atmospheres for meaningful learning experiences where failure is a strength and not a weakness can promote the development of self-efficacy (Dweck, 2006). In early childhood education, children should not be afraid to make mistakes, display curiosity, and ask a lot of questions, as this reflects a willingness to engage in trial and error where changes and challenges provide opportunities for learning. Through such insights where mistakes are valued and the subsequent learning that occurs, a result in special interest projects or a stirring passion for a new subject may grow, which otherwise may never have been explored.

Furthermore, passion or motivation built on special interests should be embraced within early childhood curriculum by teachers and administrators alike. Self-efficacy and perseverance will serve our students more in the long run if we can provide them with a passion for learning and exploring the world around them. Duckworth (2016) explains that self-efficacy is about having enough passion to persevere through challenges no matter how insurmountable the obstacles seem, for the growth that will be achieved on the other side is greater. Interest and passion, more than ability and talent, provide a natural hook for learning concepts at a young age and can easily be incorporated into many play situations. Providing appropriate challenges throughout play settings, which can promote deeper more meaningful cognitive development for children, aids in the building of self-efficacy, perseverance, and resilience (Elkind, 2007).

Resilience

Resilience is a skill that can be cultivated and nurtured throughout childhood and helps to builds stronger more autonomous individuals who are successful in navigating the world and whatever happens to come their way. The American Psychological Association (n.d.) defines resilience as,

> The process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress. It means 'bouncing back' from difficult experiences.

> Resilience is not a trait that people either have or do not have it involves behaviors, thoughts, and actions that can be learned and developed in anyone. (para. 4)

The consistency of effort over time defines an individual who is resilient; they persevere when presented with challenges and resolve problems instead of giving up out of frustration or feelings of failure (Duckworth, 2016). Educators can foster resilience by recognizing and valuing effort when observed in children and then providing immediate praise, such as ‘I like the strategy you used to solve that problem’ or ‘I see that you worked very hard on your assignment, you should be proud.’ Resilient individuals tend to be problem solvers who ask, *What can I do differently next time?* or *What could I have done differently to get the outcome I wanted?* instead of shifting the blame to others when they are presented with challenges (Collet, 2017).

Educators can reinforce resilience through teaching strategies, such as play-based approaches, and providing resources to students while encouraging them to use such tools when faced with difficult or challenging situations. Resiliency factors that educators promote in an educational setting include meaningful experiences, building relationships, developing social-emotional skills, consistency with expectations and boundaries. Rita Pierson (2013), illustrates this concept during her Ted Talk by stating, “Every child deserves a champion; an adult who will never give up on them, who understands the power of connection and insists that they become the best they can possibly be” (7 minutes). Educators can and often are resiliency factors for the children in their care, by being that champion when possible, through providing attention, compassion, nurturing, and being consistently present when needed. By being an example of resilience in the classroom for children, educators display fundamental characteristics for success in life. The following section will explore why play-based approaches in early childhood are important and discuss developmental types of play seen in early childhood classrooms.

Why Play-Based Approaches?

Play is the work of children; therefore, it is the responsibility of educators to build an environment where children can construct the knowledge of their world through play. Vygotsky (1967), a key theorist for education, describes play:

> In play a child is always above his average age, above his daily behavior; in play it is as though he were a head taller than himself. As in the focus of a magnifying glass, play contains all developmental tendencies in a condensed form; in play it is as though the child were trying to jump above the level of his normal behavior. (p. 16)

Play is the platform on which educators can integrate resiliency and protective factors through several developmental domains for children to practice valuable life and academic skills during early childhood contexts. Children explore and learn about their world through play; they learn about physics, communication, perseverance, relationships, and, in general, how the world works (Hoisington, 2007). Several theorists under the umbrella of Constructivism have contributed to developing the concept of play and the vital role it holds for children's education (e.g., Vygotsky, Bruner, Piaget, Sutton-Smith, Smilansky, Elkind). Play-based approaches should be paramount within early childhood education, considering the implications for growth encompassing all developmental domains: gross motor, fine motor, adaptive (self-help), pre-writing, academic, cognitive, language/communication, and social-emotional.

Notably, Vygotsky emphasizes the development of social tools, primarily communication and language skills, to engage in play and enhance learning through social interactions, preferably with a peer or an adult as a more knowledgeable other, within the zone of proximal development (ZPD). Oers and Duijkers (2013) reasoned,

> The ZPD should be seen in the context of activities that are meaningfully accessible for the child. That is to say, imitation is basically the core of the ZPD and lies within the sociocultural activities that a child can and wants to imitate. (p. 513)

This enables the child to explore and learn about adult roles within a safe place (incorporating Maslow's hierarchy of needs) through structured socio-dramatic play with peers, and the teacher intentionally guiding, scaffolding, and providing appropriate materials within the environment (Reynolds et al., 2011). Mature or high-level play engages children in learning using socio-dramatic situations and roles, peer collaboration which supports language through communicating ideas (Baron et al., 2016). Self-regulation and other social aspects of development can be scaffolded using high level dramatic play scenarios, such as a small group of children playing school using specific roles (teachers, students, principal, teachers aid, parents, etc.) and props (books, paper, writing utensils, etc.). Several types of play are described in Table 4.

Table 4

Types of Play

Play Stage	Description
Unoccupied play	The child is stationary and engaged in random movements.
Solitary play	The child is completely engaged in play often alone and doesn't notice others.
Onlooker play	The child takes an interest in watching others play but rarely joins in.
Parallel play	Children play next to each other using the same toys or materials, but never cooperatively played together.
Symbolic or pretend play	Play where common objects are used to represent other objects (e.g., a block for a telephone).
Physical play	Physical or large motor play (e.g., playground equipment, outdoor play, rough and tumble, indoor gymnasium games, etc.).
Associative play	Children are interested in others and begin to play together, but not working towards a common goal.
Constructive play	Children manipulating their environment to create objects or a product (e.g., towers, forts, sandcastles, racetracks, etc.)
Social play	Making and keeping friends, mutual play scenarios where empathy can build and a foundation for cooperative play scenarios.
Cooperative play	Children begin to share, take turns, and work together to achieve common goals.
Socio-dramatic play	Begin to see rules and roles within play settings.
Body and movement play	Movements that promote exploration of one's environment, how they interact with the world around them, begin to think in motion and spatial awareness and relationship to others around them.
Object play	Curiosity about objects, how they can be manipulated, cause and effect toys.
Imaginative play	Impulse to create narratives based on interactions with the real world, is a key component to developing empathy.
Rough and Tumble play	Assists with self-awareness, cooperation, fairness, and fosters a sense of give and take for mastery of social competence. Can be seen as play wrestling or play-fighting between friends or play that involves bodily contact.
Creative play	Fantasy play may be a result of developing new ideas and ways of being, often referred to as daydreaming.
Atypical play	Uncommon play or approaches to play, unusual social interactions, and limited or delayed play skills.

Note: This list was compiled using resources and information from Brown & Vaughan, 2009; Casper & Theilheimer (2009); Edwards & Cutter-MacKenzie (2013); Elkind (2007); Hart & Nagel (2017); and Morrison (2015).

Atypical Play

Atypical play can be defined as behavior that falls outside of normal expectations, unusual social interactions, odd behavior, limited or delayed play skills, perseveration of play objects or activities, rigid play structure or rules, or aloofness towards playmates (Biel & Peske, 2009; Simms & Schum, 2000; Vermeulen, 2012). Atypical play can manifest in a variety of ways depending on the child's exceptionalities and possibly cultural backgrounds. In some cultures, it is not acceptable to make direct eye contact, while in western cultures this would be considered atypical behavior in eastern cultures making direct eye contact can be seen as a sign of disrespect and rudeness (Bauer, 2015). Children identified with Autism Spectrum Disorder, various speech and language impairments, developmental disorders, as well as various mental disabilities make social interactions difficult. This may be due to complications with developing theory of mind, limited understanding of social contexts such as body language and reading facial expressions (Biel & Peske, 2009; Vermeulen, 2012). In turn these limitations may delay the developmental of play skills, requiring intervention for children to reap the benefits of play with their neurotypically developing peers (Christakis, 2017; Elkind, 2007). Intervention strategies that may benefit children who struggle with atypical play development include play therapy, adult and peer modeling, intentional or purposeful play, guided practice, and repeated opportunities within structured environments (Fleer, 2011; Shin & Partyka, 2017; Stagnitti et al., 2016). The stated interventions strategies assist in developing play through immersive experiential learning opportunities that could be adult, or child directed.

Therefore, play is important for children because they can manipulate materials and observe results based on their physical interactions or relationships, which help children understand that they can and do impact their environments (Moomaw et al., 2010). Using a developmentally appropriate practice, such as play-based approaches, organically embeds social emotional skills that are modeled by adults within the normal routines throughout the classroom environment. Young children incorporate and practice a great many skills during play (Shin & Partyka, 2017), NAEYC's statement regarding developmentally appropriate practice (2020), suggests that play supports skills which are foundational to academic learning including: impulse control, planning for and enacting roles, developing and adhering to rules while playing. During play situations, the modeling of appropriate social behavior can occur naturally as a part of the daily routine where children may observe what behaviors are expected instead of being explicitly taught. Utilizing peer modeling provides children with examples of appropriate behavior for their peers and helps reinforce other students through praise. Several effective instructional strategies incorporate play-based criteria including engagement, motivation, praise or encouragement, intentional teaching, roleplaying or simulations, open-ended questioning techniques, projects, assessment and progress monitoring, which will be discussed in the following section.

Play-based Teaching Strategies

Play as a pedagogical tool provides a rich and pleasurable environment that easily facilitates learning experiences including active cognitive participation, engagement, socially interactive, relevant to children, and builds meaningful connections (Hassinger-Das et al., 2017). Educators can provide a safe place and promote play within the classroom by being available for advice or coaching, observations, structuring the environment, planning time for play, modeling behavior (e.g., how to appropriately ask to join play, sharing, turn taking, etc.) and respecting students' play without undue intervention. Tomlinson (2014) affirms, "Healthy classrooms are characterized by thought, wondering, and discovery" (p. 56). When young children create knowledge through experience it is meaningful, which forges deeper mastery and ownership of those concepts better enabling them to generalize their learning (NAEYC, 2020). Play is an easy way to engage children when considering various learning objectives and developmental domains; therefore, engagement plays a fundamental role in play-based approaches for learning.

Engagement

Engagement is the time children spend discovering their interests and exploring their surroundings in appropriate ways for their age and abilities (McWilliam & Casey, 2008). Developmentally appropriate practices regarding play facilitate engagement of students with their peers, educators, and the environment to create meaningful learning experiences. Sophisticated engagement encompasses some of the most complicated behaviors from children, including: pretending, object substitution, using imagination, talking about someone or something which may not be present, and persistence, which are all parts of socio-dramatic play.

Persistence is a higher level of engagement and is often indicated by a first failed attempt at a task which creates a challenge to be overcome by the student, thereby promoting resilience (McWilliam & Casey, 2008). Therefore, a growth mindset can be reinforced through creating higher levels of engagement and increasing intrinsic motivation to learn and grow. For this reason, an educator might choose a child's interests (e.g., animals, alphabet, numbers, cars, etc.) to help facilitate engagement while presenting several puzzles ranging in difficulty, all while providing appropriate scaffolding to work through each puzzle. Educators can increase opportunities and the possibility for student engagement by making use of student interests, providing access to multiple activities, and providing choices to enable student autonomy. Motivation is heightened within play scenarios because children are interested in continuing said play. Engagement and motivation are closely linked; when children are engaged in activities their intrinsic motivation increases.

Motivation

Intrinsic motivation helps develop a growth mindset within children during early stages of development when challenges are presented during play-based activities and the environment or situation is set up for success. Conversely students who are not challenged will not develop important life skills such as perseverance, patience, and persistence (Cash, 2011). Students who are presented with appropriate challenges are given the opportunities to develop important life skills independently or with adult support. Without challenge, a growth mindset is unable to be cultivated because everything is gained due to talent or pure ability; no time is spent problem solving, creating, observing, and dealing with emotions such as frustration, and overcoming doubt (Dweck, 2006). If there is potentially nothing to be obtained in the achievement of a set goal or completion of a task, it may lead to the development of a fixed mindset.

Choice as a powerful motivational tool can allow children attempt appropriately challenging tasks and commands responsibility or ownership of learning (Kobelin, 2009). By providing choices of activities, or choice within activities, children gain a sense of ownership regarding their learning and they have a sense of control in those moments about what they want to learn, which furthers their motivation to complete tasks. A sense of ownership or responsibility happens when students are proficient in their learning, expand upon their abilities, meet a goal, and overcome challenges (Cash, 2011). Most children are intrinsically motivated to challenge themselves if provided the time and an appropriate environment that incorporates organization and structure on a consistent basis. As a social motivator, play can facilitate children to interact within social play groups by forming and maintain friendships through cooperative pretend play that requires them to negotiate roles and tolerate frustrations when problem solving (Casper & Theilheimer, 2009). Young children play because they want to, not because there is an external reward provided. For most children, the act of playing is the reward, which makes play intrinsically motivating. Praise may also play a part in motivation; with appropriate praise and scaffolding challenges may suddenly become achievable.

Praise

A growth mindset can be reinforced during play-based activities using praise and encouragement from familiar adults. When educators use praise, it should always be student- and context-specific. Providing feedback and encouragement that is genuine helps students to understand that growth and improvement are related to effort and not simply observations of their abilities or talents (Collet, 2017). For praise to be genuine, the student needs to understand that their efforts (e.g., that they really did try hard, or do their best) were noticed by the adult and deemed important enough to remark on. Praise is meant to build up students' confidence; however, when children know praise is not genuine (e.g., 'good job,' 'you did it,' or 'that's beautiful'), it often diminishes their self-worth. One way of teaching young children how to praise one another and value their own hard work is by integrating the powerful word of *yet* if they feel they must use the phrase *I can't*; in this way, they are learning resilience. For example, instead of a child saying, "I can't do this math problem," the educator could provide constructive phrases such as "You may not be able to do that math problem yet" or "You have not practiced this type of math problem enough yet." The language educators use can be powerful for young children.

Therefore, beginning from an early age and when used appropriately, praise and encouragement that values hard work and effort can promote resilience and grit. Duckworth (2016) states, "There is language that subtly sends the message that life is about challenging yourself and learning to do what you couldn't do before" (p. 182). Not all fixed mindset praise is bad; however, educators should keep away from language that judges' children's intelligence or abilities (e.g., you're so smart, you did that so quickly, your very talented at this), which can harm their internal motivation to take on challenges. Table 5 illustrates the difference between praise that values a fixed mindset (talent and ability) versus a growth mindset (effort, practice, and using strategies).

Table 5

Fixed mindset vs. Growth mindset Praise

Fixed Mindset: Praise that values ability and talent	**Growth Mindset: Praise and encouragement that values hard work and effort**
• You're so smart.	• You worked so hard on _____, I'm very proud of you.
• Great job!	• Don't give up you almost have it!
• Nice work!	• I love the way you worked so hard on ________.
• I'm proud of you!	• That didn't work, what should we try next?
• That is beautiful.	• You should be proud of yourself, you worked very hard!
• I like what you've done.	• I like how dedicated you are!
• Let's show _______ your work.	• This is hard but keep working and you'll get it.
• You're so talented!	• You may not be able to do it yet but keep working and you will.
• You are very good at ________.	• You tried so hard, be proud of what you accomplished!

Note: This list was compilied using personal experiences, resources, and information including Collet (2017), Duckworth (2016), and Dweck (2006).

With this in mind, educators can also promote a growth mindset by using constructive criticism within their praise (e.g., I am sorry you are dissappointed with your grade, if you practice and work hard the next time will be better.). This helps promote problem solving, using effective strategies to overcome challenges, and the idea that mistakes are learning opportunities. By setting high standard and using constructive encouragement and praise, educators can foster children's personal interests, growth, and learning within the classroom setting (Dweck, 2006). Praise during intentional or purposeful play activities can deepen participation and incorporate meaningful connections to students' lives.

Intentional or Purposeful Play

Play can be intentionally designed by an educator who has carefully considered the environment and the needs of the children in their care, while scaffolding to incorporate challenges that promote a growth mindset. Elkind (2001) reminds us, "Children need time to grow, to learn, and to develop" (p. 21). Intentionally planned play experiences may provide needed time for children to experience and build knowledge and concepts through play. Carefully planning an environment and structuring play requires educators valuing and reflecting on criteria for play-based learning, Edwards and Cutter-Mackenzie (2011) share theirs:

1. Play-based learning needs to draw on and recognize children's existing cultural competencies;
2. Acknowledge and actively include the role of the adult educator in connecting children's play activities to conceptual and content-based ideas;
3. Promote the importance of teacher planning for learning in relation to children's play and the acquisition of content knowledge. (p. 52)

For these reasons, structured play can be seen throughout various activities including learning centers, small group and large group games, outside play, and modeling play situations by peers or familiar adults. By intentionally planning for developmental domains or learning goals and objectives for individual students or groups of students, educators can specifically address student needs and help close the achievement gap. Three common educator-facilitated play types are explained in Table 6.

Table 6

Educator Facilitated Play

Type of play	Description of play
Open-ended	The educator provides materials with minimal adult engagement and allows for exploratory or discovery of concepts by the children.
Modelled or facilitated play	Educators model the use of materials or specific concepts before children can use the materials independently.
Purposefully framed or learn and teach	Educators provide specific materials or concepts for open-ended play, followed by modeling, and then teacher-child interactions are introduced during play.

Note: This list was compilied using information from Edwards and Cutter-Mackenzie (2013).

Using the facilitative play types, activities could be easily structured in a variety of ways based on the goals or concepts being taught. Cohrssen et al. (2016) report "that the provision and enactment of a purposefully designed suite of play-based mathematics activities may enable educators to develop increasing confidence in the intentional teaching of mathematics in early learning environments" (p. 9). Using mathematics instruction as an example, educators could facilitate mathematics-related play by providing manipulatives in open-ended scenarios to assess where children are on the developmental spectrum and then model targeted skills or concepts that are appropriately challenging using these same manipulatives. This work creates a context for further engaging in games that continue to promote the generalization of skills over the course of several days and promoting mastery of concepts (Worthington & Van Oers, 2016). Providing stacking cubes for open pretend play is one example of how to assess if children are counting them. On the first day of instruction within this example, if they child is counting stacking cubes, how high can they stable order count? On day two, the teacher can plan to model stable order counting while building structures (e.g., educator takes five cubes, counts and stacks them, then the child imitates, and the teacher counts and adds on more cubes). After a few days of this behavior, the educator introduces dice with one to six dots on each side (if appropriate), and the educator and child then take turns rolling the dice to determine the number of cubes to stack, making the interaction into a game. Through scaffolded interactions children progress to meet challenging situations while learning persistence via adult modeling and encouragement, which is part of a growth mindset. Role-playing or simulations are another play-based approach that easily facilitates a growth mindset.

Sociodramatic Play

Sociodramatic play is an instructional strategy that could be used to explain situations, resolve traumatic events, model appropriate behavior, and explore societal roles. Through these play scenarios children are learning appropriate social-emotional skills and behaviors which may also resolve and assimilate traumatic events or help them overcome fears. For example, a child who has witnessed a relative being arrested may play cops and bad guys to comprehend and work out their emotions regarding that event. The child may need to play the scenario out over several days and play each role to resolve the conflict autonomously. Oers and Duijkers (2013) believed that role-play could be defined as a sociocultural activity with precise formatting, which includes "(implicitly or explicitly) shared rules; some degrees of freedom for the participants regarding how the activity should be carried out; [and] high levels of personal involvement" (p. 515).

Using these criteria, educators can intentionally create a space with appropriate materials for exploration of roles (e.g., doctor, veterinarian, teacher, chef, grocery clerk, police, etc.) in a socio-dramatic play setting. Intentional placement of mathematics instruments such as tape measures, registers, play money, scales, writing implements, paper (various sizes with and without lines), clipboards, etc., could be considered a meaningful contribution to children's play regarding the development of mathematical and literary concepts for assimilation. By working through sociodramatic play scenarios, children are meeting and overcoming challenges and, therefore, building resilience, persistence, and learning how to generalize strategies in various contexts. Through the active participation or observation of the educator during play, questions at the right time can provide added structure, details, and depth to children's natural conversations. This may lead to educators asking open-ended questions during sociodramatic play scenarios to challenge children's thinking or to gauge their thoughts and feelings at the time, so that play can be expanded to accommodate the child's needs.

Project Approaches using Play

A project approach is authentic learning based on discovery or exploration of high interest topics that integrates concepts, ideas, developmental domains, and academic standards across a curriculum (Morrison, 2015). This strategy is very child-centered and based on individual or small group interests that are investigated and result in a final product facilitated by the educator. Autonomy is encouraged, motivation is increased due to student choice and high interest, and educators are providing respectful constructive feedback or praise based on student progress, which is all part of encouraging a growth mindset. Projects enable students to work together across multiple ages and boost their creativity, especially within their classrooms or grade bands (e.g., preschool and kindergarten, kindergarten through second grade, third grade through fifth grade, and so on), which promotes a plethora of growth for all students in the learning community (Piescor, 2017). For example, a group of preschool children (3-6 years old) begin playing with a pendulum, which turns into a classroom investigation of how pendulums work. By building various pendulums out of different materials and exploring movement though setting up and knocking over objects, the children are discovering the properties of pendulums. For a final project regarding pendulums, the educator may facilitate the building of a large pendulum out of plastic pipe to use outside, the children can use several colors of paint (to illustrate different patterns) on a large piece of bulletin board paper and, finally, display their science-based artwork for the school community.

Throughout the process of a project approach, observation and progress monitoring is essential in moving forward with each step to create a final product.

Assessment and Progress Monitoring

Assessment and progress monitoring are vital for the planning of instruction in an early childhood education setting and are largely conducted through observations, anecdotal records, portfolios, work samples, and checklists. Through observation, educators pay close attention to conversations, interactions, and students' play to intentionally plan experiences that coincide with specific learning goals or targets for each child. Developmentally appropriate assessment is continuous, planned, and based on student performance or work, and is used by educators to reflect and plan appropriate instructional strategies or experiences based on individual student needs and developmental levels (Morrison, 2015).

Authentic assessments such as observations, anecdotal records, work samples, and portfolios can be used as progress monitoring tools for educators to reflect on student progress. This enables educators to make decisions regarding a student's mastery of concepts and skills, whether intervention is needed, or to determine what goal a student is ready to move towards next. If intervention is needed, then the progress monitoring information provided by reviewing authentic assessments could reveal strategies that may need strengthened or new ones that could work better for the individual student. An educator with a growth mindset is better able to consider options objectively, by looking at themselves first and questioning if they need to do something different, instead of questioning the child's abilities to complete a task or challenge. Educators can create a learning community by possessing a growth mindset (believing all children are capable of growth and learning), setting high standards for all children, and creating trust and rapport with a deep commitment to teach every child in their classroom (Dweck, 2006). Assessments and progress monitoring are tools that provide educators with a compass that points them in the direction in which to move forward.

Barriers

Baron et al. (2016) state,

> *Attitudinal* barriers are focused on the teachers' and administrators' personal value of play, as well as the perceived value of how others view play. *Structural* barriers include those associated with curricula, time, space, and availability of play-based materials. *Functional* barriers address factors associated with the supports needed to allow teachers to use play effectively in the classroom, such as lack of professional development training or coaching support. (p.106)

Preparing children or preschoolers to become 'kindergarten- or school-ready' would be an attitudinal barrier towards play-based learning because educators or parents may be neglecting important aspects of development as they are not identified as academic. Many administrators or principals do not come from an early childhood education background; therefore, they may undervalue play and its role in strengthening and integrating multiple developmental domains through play as a means of practicing skills and meeting learning objectives (Colliver & Veraksa, 2019; Shin & Partyka, 2017).

A structural barrier could include an assessment tool that supports and evaluates mature or high-level play only and does not give value to the child's effort. Another example could be not having a range of appropriate and functioning play-based materials available within an educational environment to promote engagement and meaningful learning experiences. Educators often feel isolated within their classrooms, which may also lead to functional barriers of play-based learning, such as not providing enough time for educator collaboration or professional development that facilitates planning for rich play opportunities within the classroom environment (Worthington & Van Oers, 2916). Although there are several barriers to implementing play-based strategies in an early childhood classroom it is well worth the effort for the children in our care. There are plenty of strategies which can be incorporated and instructional aspects to consider during planning which include level of engagement, motivation, praise, intentional or purposeful play, sociodramatic play, project approaches, assessment and progress monitoring. Through play-based instructional strategies great discoveries can be made through the act of exploration by children.

Conclusion

Growth mindsets, perseverance or grit, and resilience are fundamental skills worthy of development during early childhood as they lay the foundation for a well-rounded successful individual later in life. The experiences and strategies resolving challenging situations or scenarios promote healthy social-emotional development, communication skills, executive functioning skills, along with other cognitive and academic skills needed for healthy overall development. Embedding a growth mindset within a play-based curriculum is developmentally appropriate practice in the early childhood setting because play-based approaches are a holistic approach to nurturing young children. However, Cohrssen et al. (2016) state, “This is particularly difficult in the teaching environment if the changes do not align with the individual’s personal beliefs and goals for children’s learning” (p. 2).

Barriers (attitudinal, structural, or functional) may stem from a lack of training, lack of comprehension regarding play-based approaches, lack of support from administrators, or feelings of isolation by educators. Therefore, it falls to educators to support and prepare children for the challenges they will face throughout school and into adulthood, while creating resilient persistent individuals. By providing young children with a solid foundation, the freedom to explore, and opportunities to learn about themselves through play, we can build confidence through a growth mindset using appropriate praise, encouragement, motivation, and various other strategies. Duckworth (2016) affirms, “Mindsets have been shown to make a difference in all the same life domains as optimism” (p.181). Therefore, educators fostering growth mindsets through pleasurable play-based approaches are not only ensuring that knowledge is being acquired but providing a means for children to become resilient and learn strategies to shape their own happiness throughout life.

Chapter 4: Learning Mathematics through Everyday Play Activities: Enhancing Exposure and Mastery

Introduction

This chapter contains the manuscript written by Sarah Good and Jennifer Ottley that was published during the summer of 2019 in *Young Children* which is a journal published by the National Association for the Education of Young Children (NAEYC). *Young Children* is a peer-reviewed journal for early childhood practitioners which focuses on blending research and evidence based practices to meet the needs of all children from birth to third grade. The sections, which were edited out for space, include a section of the introduction, important early mathematics concepts (quantification and importance of the linear number line), implications for practice, and blending instructional strategies for effective teaching. Such ideas and connections between concepts are important to explore for a thorough understanding of mathematics and differentiated instructional strategies that benefit young learners. This manuscript focuses on such aspects within the broader sense of the dissertation and connects to other chapters through the various themes discussed in Chapter 1.

The first section of the chapter is the published manuscript as it appeared in *Young Children* without the accompanying images. The second section of this chapter will discuss what appeared in the original draft of the manuscript but not in the final publication due to revisions made to adhere to space constraints by editors of *Young Children*. The final section of this chapter will explore developmentally appropriate practices and instructional planning recommendations as they relate to this manuscript, with a reflection regarding the original publication.

Original Manuscript

Opening Vignette

Ms. Brinkman sits next to 4-year-old Mariana, who has just started playing a board game. The board has 10 places, from the starting point (a dormant volcano) to the end point (an active volcano), and Mariana is playing with a die that is limited to one to three dots per side. She rolls the die and, pointing to each dot, counts them using one-to-one correspondence: “One, two, three.” Then, pointing again, she counts the first three places on the board and leaves her marker on the third place. Turning to Ms. Brinkman, Mariana says, “Okay, your turn.”

To help Mariana begin to grasp simple addition, Ms. Brinkman uses two dice. After rolling them, she asks, “Can you help me count all of my dots?” Pointing to one die, then to the other, Ms. Brinkman says, “One, two. Now the other die: three, four, five. I have five dots.” She moves five places on the board, then gives the dice to Mariana: “Your turn.”

Mariana rolls the dice and looks up. Ms. Brinkman asks, “How many dots are there?” Mariana shrugs her shoulders, saying, “I don’t know.” Ms. Brinkman gets a little closer: “Let’s count them together.” She points to the dots on the first die, “One, two,” and then on the second, “three, four. Four dots.” Mariana moves four places on the board (pointing as she goes), then hands the dice back to Ms. Brinkman. The teacher rolls them and asks, “How many dots are there?”

Throughout life, games can be a wonderful way to develop mathematics knowledge and skills. From Chutes and Ladders to chess, many games use and build math abilities. In early childhood, play provides children an avenue for exploring math concepts, expressing math knowledge, and seeing math relationships (Moomaw et al., 2010). Educators using play-based curricula can inspire conversations about math while engaging children in games and other activities that let them manipulate, count, and add tangible objects.

Mariana's board game—especially with Ms. Brinkman's support—helps her practice one-to-one correspondence and cardinality (i.e., when she finishes pointing to each dot on the dice, the last number tells her how many dots there are). Understanding cardinality is critical for Mariana's future math achievement (Gunderson & Levine, 2011).

The National Research Council recommends that early childhood math experiences focus on foundational goals in the content of numeracy, geometry, spatial relations, and measurement, with particular attention devoted to numeracy (Cross et al., 2009). While numeracy includes basic arithmetic, the great challenge for young children is understanding quantity and counting (Fuson et al., 2015; Gunderson et al., 2012). Seminal work published four decades ago established the following five principles of counting (Gelman & Gallistel, 1978), the first three of which are most relevant to early childhood educators (Moomaw et al., 2010):

- The one-to-one principle: Instead of counting, "One, two, three, three, four," a child needs to understand that each counted item needs a unique tag or label.

- The stable-order principle: Instead of counting "One, three, two," a child needs to understand that numbers have a set order.
- The cardinal principle: After counting "One, two, three, four," a child needs to understand that the last number, four, represents the quantity in the set of objects counted.
- The abstraction principle: A child needs to understand that many different things and ideas can be counted—mixed sets of toys, books, sounds, etc. can be counted together.
- The order-irrelevance principle: Although it is helpful to have children line up objects and count them from left to right when they are just beginning to grasp the one-to-one principle and stable-order principle, eventually children need to understand that things can be counted other ways, such as right to left or in a group.

(For an in-depth discussion of these principles, see Marmasse et. al., 2000.)

From Principles to Practice: Differentiating Instruction

To ensure that all children are appropriately engaged and challenged, learning environments and activities should be differentiated in ways that support young children's brain development, curiosity, and creativity (Cash, 2011). Because children have different experiences, knowledge, and skills, educators must intentionally craft opportunities in which all children actively and meaningfully participate in the classroom (DEC, 2014). But knowing the importance of differentiating is one thing—doing it well is another (Hachey, 2015; Wasik, 2008). Offering young children an appropriate range of opportunities for learning math can be especially difficult for educators with little confidence in their own math abilities (Beilock et al., 2010; Chen et al., 2014). The following sections describe a variety of differentiation strategies that help teachers build on children's strengths and address areas where they need to grow.

Organizing Small Instructional Groups. One strategy to differentiate instruction is forming small groups of children (five or fewer) that are intentionally organized to accomplish specific learning goals (Wasik, 2008). The goal of the small group activity should determine the number of children in the group; this enables the educator to provide the appropriate amount of assistance and attention to each child in the group while directly teaching or reinforcing the target math concept and skill. In small groups, educators can hold children's attention to task for a longer period of time, model target concepts, determine each child's current understanding (and misunderstandings), and provide focused and timely feedback.

While small group work is occurring, there also should be independent activities for other children. This keeps all children engaged in the content and reinforces previously taught concepts when there are not enough adults to work with several small groups simultaneously (Wasik, 2008).

Using Graphic Organizers. There are so many graphic organizers that it can be difficult to select the most useful ones for supporting young learners. Graphic organizers are best used to help children reflect on an activity. Discussing a project and the materials used—and documenting learning—facilitates comprehension and assimilation of core concepts. The table "Different Graphic Organizers and Examples of Their Uses" presents several options.

Table 7

Different Graphic Organizers and Examples of Their Uses

Graphic Organizer	Example of Mathematics Use
KWL chart	**Learning geometry vocabulary** What do you *know* about shapes or geometry vocabulary? *Children may respond with the names of three- and four-sided shapes.* What new geometry vocabulary do you *want* to learn? *Children may wonder about the names of five- to ten-sided shapes and two- and three-dimensional shapes.* What new geometry vocabulary did you *learn*? *With teacher support, the children can list and discuss the geometry vocabulary they have learned*.
Venn diagram	**Sorting, comparing, and contrasting attributes of dinosaurs** As children learn about the types of food different dinosaurs ate, they can sort carnivores into one circle and herbivores into another, and they can place omnivores in the middle, where the two circles overlap. After sorting children are then able to compare quantities of the various groups. *Such mathematical skills are important vocabulary foundations, which further build measurement and data concepts.*
Concept/spider web	**Identifying shapes in the classroom** Start with "Shapes" in the middle, branch off to specific shapes, then to objects that have those shapes.
KWHLAQ chart	**Mixing colors to understand *more* and less; questions and possible answers from children** What do I *know*? Colors. What do I *want* to know? How to make lighter colors. *How* do I find out? Mixing colors with more or less white paint. What have I *learned*? More white paint makes lighter colors. What *action* will I take? Mix more colors. What new *questions* do I have? What makes darker colors?
Graph	**Learning one-to-one correspondence, stable-order counting, cardinality, and *most* and *least*, with everyday data** Use graphs to visually display data gathered by students. For example, children may ask, "How do you get to school in the morning, bus, car, or walking?" and make a bar graph of the class's answers.
Ten frame or grid	**Practicing one-to-one correspondence, cardinality, simple addition and subtraction** Use a die with 1–3 dots per side and a ten frame. Cover a square for every dot that is rolled until the entire board is covered.
T chart	**Comparing, contrasting, and sorting objects that sink or float** One column is objects that float, and the other column is objects that sink. Why do they float or sink? How many objects can we find for each column?

Creating Materials and Games. Practice with math concepts involves repeated experiences with tangible objects that are meaningful and relevant to children. Educator-made materials are the easiest to individualize; for example, like Mariana's volcanoes, any child's interest can be incorporated into a board game. More important, educator-created materials can be differentiated based on the knowledge and skills to be taught or practiced. Grid games, for instance, are easily adapted. Children who need to practice with small quantities may practice with a grid of two rows of five squares each, while children who are ready for larger quantities may have five rows with five—or even ten—squares each.

Another way to vary an activity for differing developmental needs is to use assorted dice or spinners. An educator may use one die with one to three dots for a child who is developing counting concepts with a small grid, and two dice with one to six dots each for a child who needs addition practice with a large grid. Differentiation of materials like this also facilitates peer modeling during centers.

With path games that progress as children master independent play skills, math knowledge and skills can also be introduced. In early childhood, path games often range from short, with 1 to 10 spots in a straight line from start to finish, to long, with 15 to 30 spots on the board in a straight or winding path, to long and complex, with multiple paths, as in Chutes and Ladders. These path games can be used to introduce and practice anything from one-to-one correspondence to arithmetic.

For a list of different math games that can be played in the classroom and concepts that can be taught using these games, see "Examples of Mathematics Games and

Content." The games are customizable to reflect children's interests, which is likely to prolong engagement in the game and, thus, in the math content.

Table 8

Examples of Mathematics Games and Content

Math games	Math concepts and skills
Grid games	One-to-one correspondence, stable-order counting, cardinality, simple addition and subtraction
Roll/spin and graph games	Stable-order counting, subitizing (i.e., recognizing small quantities without counting), one-to-one correspondence, cardinality
Short and long path games	One-to-one correspondence, stable order counting, cardinality, subitizing
Card games (dot cards, playing cards)	Stable-order counting, most and least, one-to-one correspondence, cardinality, comparing quantities
Patterning games	Classification, measuring, geometry, counting, patterning
Sorting games	Classification, geometry, spatial awareness, comparing quantities
Matching games	Geometry, counting, cardinality, one-to-one correspondence
Dominoes games	Subitizing, stable-order counting, cardinality, comparing quantities

Questioning with Varied Levels of Difficulty. Frequent conversations, open-ended questions, repetition, and extension enhance children's math vocabularies and conceptual understandings (Cohrssen et. al., 2014a). Open-ended questions are particularly useful for promoting creative thinking and collaboration to arrive at a plausible answer (Kobelin, 2009). Varying question types and levels enables all children to contribute—and more complex questions allow those with more advanced knowledge to model age-appropriate vocabulary for their peers, which enhances learning for all children.

Using a guide such as Bloom's Taxonomy is a helpful place to start when differentiating lessons. An updated version (Anderson & Krathwohl, 2001) of Bloom's Taxonomy ranges from questions that require recall of information to questions that require children to analyze content. An example of math content spanning basic to advanced questioning in the early childhood context is given in the table "Differentiated Questioning to Promote Learning of Spatial Relationships."

Table 9

Differentiated Questioning to Promote Learning of Spatial Relationships

Bloom's Taxonomy category	**Questioning example: Spatial relationships**
Remember	Name the objects that are *inside* the refrigerator.
Understand	Alicia and Kyle are sitting *beside* Ramond. Explain what *beside* means.
Apply	Park your tractor *behind* the barn.
Analyze	Which sandwich shows the meat and cheese *between* the bread?
Evaluate	Which toys in the bag would be best to play with *outside,* not *inside*?
Create	Draw a map of the playground that shows what is *beside* the swings, *behind* the basketball hoop, and *between* the fence and the seesaw.

Note: This table is based on Anderson and Krathwohl's (2001) revision of Bloom's Taxonomy.

Providing Wait Time. *Wait time*—simply waiting for children to respond—is effective in extending conversations with children because it gives them time to think and to reach an answer on their own. Wait time should be at least three to five seconds (Cohrssen et al., 2014b), depending on the children in the conversation. Wait time during conversations allows for the assessment of children's skills, encourages thoughtfulness, and provides opportunities for children to engage in the process of correcting their own and each other's mistakes, deepening comprehension.

Offering Choices. Choice is a powerful motivational tool that allows children to take on appropriately challenging tasks and necessitates children being responsible for their own learning (Kobelin, 2009). Most young children are intrinsically motivated to learn when provided the time and environment in which to do so. Choices can be given within activities that incorporate children's interests while still reinforcing the math concepts and skills they need to learn. For example, when learning about collecting data and creating graphs to summarize and display the data, children's interests can drive what data are collected, such as classmates' favorite toys, foods, or games. This customization supports children's engagement in the activity, which extends the time they devote to it, promoting mastery of mathematics concepts and skills.

Concluding Thoughts

The effectiveness of these strategies is magnified when they are combined. For example, small group instruction that is deliberately structured based on criteria, such as depth of knowledge and interests, provides an avenue for intentionally teaching core early math concepts. This can be done through well-conceived, play-based curricula that use such activities as card games, patterning with concrete objects, and projects that incorporate graphing. Children can move from highly structured and facilitated game play to independently playing with their peers in learning centers. These types of activities provide time for educators to become part of children's discussions and to carefully ask a variety of questions that reinforce math concepts and vocabulary in natural settings, as demonstrated in the following vignette.

Closing Vignette

During learning centers, Ms. Scott sits next to 4-year-old Jon and asks to join his card game. Jon nods yes. Ms. Scott asks him what he is doing; Jon shows her by picking up a card that is face down, turning it over, and placing one counting bear on each dot.

Ms. Scott follows Jon's lead, picking up a green card, turning it over, and placing a bear on each dot. She asks, "Which card has more bears on it? Yours or mine?"

Jon responds, "Mine; it has eight bears and the other one only has eleven."

As he points to his card, Ms. Scott inquires, "Which group is bigger, eight or eleven?" She waits to give Jon time to think while he looks at the cards. "Look carefully and tell me which group has more bears in it."

Together, Ms. Scott and Jon examine the cards in front of them on the table. Jon points and explains, "That one is a bigger group; it has 11 bears. It has more bears than my card, eight bears."

They continue in this fashion for several rounds. Ms. Scott is pleased to see Jon's progress in moving from one-to-one correspondence to a better grasp of cardinality and quantity.

When combining strategies to differentiate instruction and reinforce math concepts, early childhood educators are limited only by their imaginations—opportunities to engage with math concepts abound in every classroom. By incorporating children's interests and current knowledge and skills, educators can use play-based activities to provide both educator- and child-led learning opportunities for children to practice math concepts in meaningful ways that meet their individual needs.

Original Sections of the Manuscript not Included in the Publication

The following sections were edited out of the original manuscript due to space constraints for publication. Therefore, they have been included within this chapter to highlight their importance to the original manuscript and make further connections to Chapters 3 and 5 of the dissertation. The mathematics concepts of quantification and estimation discussed within this section also relate to Chapter 1 where developmental trajectories for mathematics are explored.

Introduction

Early childhood (EC) educators ask questions as a method to promote children's learning. However, EC educators ask a lot of the same questions when it comes to mathematics activities, hoping that the concepts will be absorbed as if by osmosis. For example, it is common for educators to ask, "Which one is…?" for number identification, "How many are there in…?" for counting and cardinality, and "Where does this belong…?" for sorting. In the research conducted by Parks and Wager (2015), it was indicated that many EC educators have a fear or anxiety of teaching math concepts because they are not often clear on how or what they should be teaching, nor are they aware of the importance of mastering these concepts for future success with mathematics. This is also addressed in more length during Chapter 1 of this dissertation.

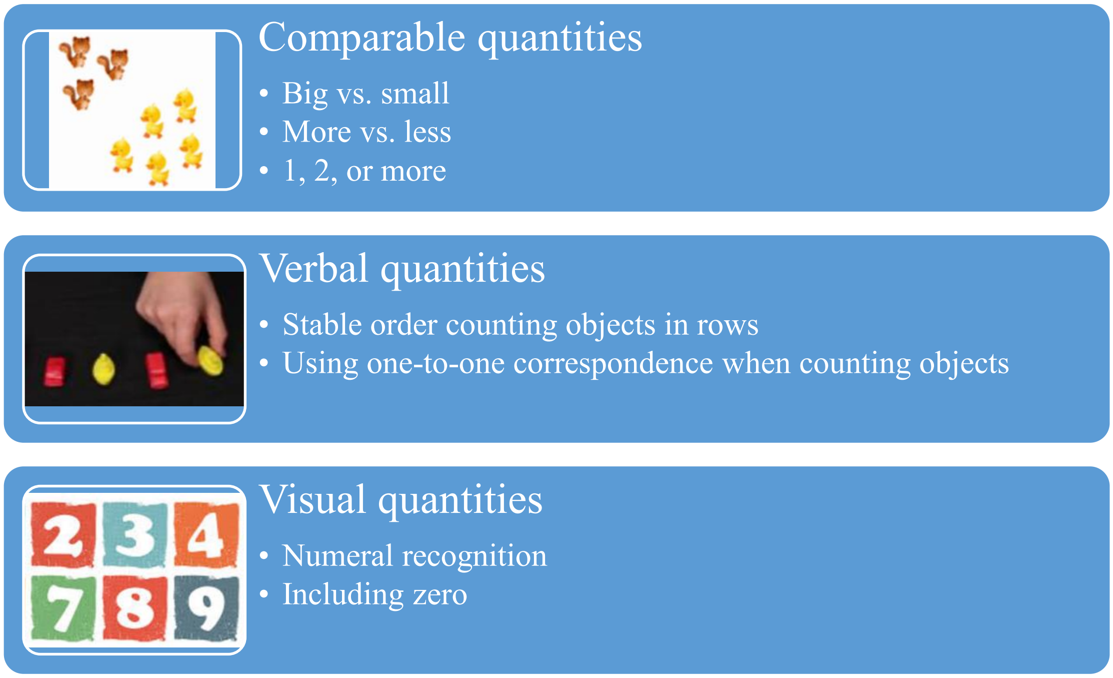
This is problematic, because children need adults to demonstrate confidence in their skills in order to contribute to the confidence in children's achievements (Beilock et al., 2010). If children perceive that their teachers find mathematical concepts to be hard, difficult, or unimportant as Adams and colleagues' research indicated, the children will likely develop the same attitude towards mathematics content as well. The links between educator attitudes and instruction of early mathematics concepts is well researched (Anders & Rossbach, 2015; Celik, 2017; Geist, 2015; Karatas et al., 2017; Sayers, 2013; Theil, 2010), and has a vast impact on the concepts that are taught within early childhood classrooms. The following section will explore a few important mathematics concepts outside of the counting principles mentioned earlier in the published manuscript.

Important Early Mathematics Concepts

Quantification is at the heart of mathematical development and in order to apply counting to this process children must understand cardinality. Early pre-verbal quantification of small numbers (Sayers et al., 2016) allows for quick comparisons of sets (i.e. 2 objects versus 8 objects) and leads to subitizing of slightly larger numbers (3 to 5 items). Three types of quantity representations which aid young children with interpreting and developing quantification of magnitudes (Dehaene, 2001; Toll & Van Luit, 2014). Figure 3 explains the development of the three types of quantity representations.

Figure 3

Three Types of Quantity Representations



Note: Information for this figure was obtained from Dehaene et al., 1993, and Toll & Van Luit, 2014.

Research by Gunderson and Levine (2011) suggests that quantification is reliant on the ability to estimate larger numbers (between five and fifteen) which only occurs after developing the cardinal-number principal, and the ability to subitize (see small amounts of objects and know how many there are without counting) up to four objects. Children who struggle with numeral recognition may experience difficulty with subitizing and estimation later in mathematical development (Sayers et al., 2016).

However, linear number lines can facilitate number recognition and spatial relations among other skills, it is also predictive of later symbolic numerical representations, which will be explored further in Chapter 5. Gunderson et al. (2012) describes how the ability to correctly create and interpret linear number lines relates to skills involving categorizing and recalling numbers, approximate calculation, and symbolic estimation. This ability also incorporates the three principles of counting and provides a foundation for concepts of quantification. Concepts of measurement, geometry (shapes), spatial relations are also very important in building successful mathematics students at later stages in their school careers. Next an exploration of blending instructional strategies for effective teaching regarding early mathematics concepts.

Blending Instructional Strategies for Effective Teaching

There are infinite combinations of strategies to differentiate mathematics activities for preschoolers. Educators are only limited by their imagination and ingenuity for creating concrete experiences that enable children to engage with mathematics concepts in the preschool environment. The key consideration is identifying which evidence-based strategies are most beneficial to meet the needs of the children in your classroom.

Blending Instructional Groupings and Engaging Games

Small-group instruction that is deliberately structured based on criteria such as developmental level, readiness levels, and interests provides an avenue for educators to focus on and intentionally teach core concepts of early mathematics (i.e., number sense, geometry, measurement, and spatial relations). This can be done through well-conceived play-based curriculum such as grid games, short and long path games, card games, sorting activities, patterning with concrete objects, projects that incorporate graphing and measurement. The students can move from highly structured and facilitated game play to independently playing with their peers during learning centers or free play times when materials are provided, and child interest can take hold firmly. These types of activities also provide enough time during play for educators to become part of the discussion naturally and not through constant direct teaching strategies. The more naturally educators use mathematics vocabulary or talk with children the more likely the children are to use these terms in their regular conversations with each other.

Blending Instructional Groupings and Wait Time

Wait time during conversations also provides for assessment of children's skills and use of relevant vocabulary or a teachable moment in which to introduce vocabulary. Observations during free play for assessment of children's use of mathematics vocabulary can be very useful in planning for small-group instruction. This is also in line with the joint statement regarding early mathematics (NAEYC & NCTM, 2010), which discusses ongoing assessment for the benefit of the children.

Blending Engaging Games with Varied Levels of Questioning

Most games are easily altered to meet the needs of all children at every level of development, often within the same activity at the same time. This allows for peer modeling for older and younger children who prefer to play together, where one child is demonstrating a skill. This benefits both children in that the child at the lower level has another person, other than the teacher, explaining and demonstrating concepts. The child at the higher level is demonstrating critical thinking skills, enrichment opportunities, by explaining or teaching a skill he/she has already mastered which often leads to deeper learning of the concept.

Blending Graphic Organizers with Choice Making

These provide opportunities for students to share information with their peers in a group setting. KWL and KWHLAQ chart provide a lot of opportunities to incorporate student interest, especially if there are several students with the same interests. Concept webs are easily built upon at any time when provided enough space and access to add to at any time. When educators are providing choices for students regarding graphic organizers it is advisable to provide no more than three choices for young students. Educators can provide suitable choices of graphic organizers, but children are still able to choose the one that works best for them. This might be incorporated within small group times and large group times might serve as a foundation for introducing the various graphic organizers. Venn diagrams are well suited for comparing and contrasting concepts as well as sorting objects and discussing characteristics or attributes of objects. T-charts are good for predictions and tallying votes. Choices regarding these charts and graphs can be as broad as student interest and as specific as what writing utensil the student prefers to use to write their name. The following will discuss implications for practice regarding instructional strategies for mathematics concepts and differentiation as a whole.

Implications for Practice

All of the previously mentioned strategies (e.g., small group instruction, graphic organizers, creating materials and games, questioning with varied levels of difficulty, wait time, and offering choices) within the published manuscript are developmentally- and individually-appropriate methods to differentiate instruction in preschool classrooms to enhance the mathematics learning of young children with diverse abilities. The usefulness of these strategies is magnified when we consider utilizing one strategy in combination with another (Cash, 2011; Tomlinson, 2014). Early childhood educators implementing instructional strategies have a plethora of considerations when planning curriculum regarding mathematics such as: special factors, time management, learning preferences, domain standards, as well as several other circumstances. The blending of complimentary instructional strategies mitigates some of the previously mentioned factors during planning and implementation of curriculum. Next a discussion of new considerations and connections since publication.

New Considerations and Connections

Since the publication of this manuscript in *Young Children* (2019) and upon reflection of sections that were edited or removed from the original submission prior to publication, new areas such as developmentally appropriate practices and play-based strategies have taken on more importance. The concept of developmentally appropriate practice deserves its own recognition, including a deeper discussion of commonality, individuality, and context.

Developmentally Appropriately Practice (DAP)

Developmentally appropriate practice as defined by NAEYC (2020) includes methods that promote every child's highest level of development through evidence and play-based learning practices which are meaningful, engaging, and spark joy for young children. Throughout Chapters 1 and 3 engaging play-based instructional practices were explored. The following paragraphs will discuss aspects of the core considerations that should inform decision making according to the revised DAP statement from NAEYC (2020), and how it relates to the dissertation.

Commonality

The first core consideration incorporates such views as the importance of social-cultural perspectives of development (Agar, 1996), foundational aspects of all developmental domains occur between birth and age eight (Biel & Peske, 2009; Morrison, 2015), and the importance of language development. Play as a large part of development varies across cultural context in that it may look different depending on cultural and societal expectations (Veresov & Barrs, 2016). Socio-cultural contexts play a powerful role in development which is recognized by a plethora of research (Agar, 1996; Brown & Vaughan, 2009; Edwards & Cutter-Mackenzie, 2011; Fleer, 2011; Kinkead-Clark, 2019), where play is a persistent force and lens for engaging with the world.

When educators plan for play or teaching using play-based constructs, groupings can have a large impact on instructional strategies which are incorporated. How children are grouped can make a difference depending on the desired learning outcome. Knowing a child's background, development, and any special factors assist educators in making decisions about grouping. There are several flexible ways to structure groups such as by ability, cultural commonalities, cultural differences, peer modeling, developmental level, targeted skill to be learned, or size (individual, small, large, etc.). Planning using the idea of commonalities between children offers a sense of belonging and acceptance as well as common ground to build upon.

Individuality

The second core consideration values uniqueness and the attributes that comprise each child's background knowledge and experiences to reinforce the learning environment and builds bridges between families, communities, and educators (NAEYC, 2020). Building rapport as educators with children and their families benefits all involved and leads to open lines of communication between educators and families. Such interactions allow educators to better learn the unique characteristics which makeup the children they are engaging with on a regular basis.

Once rapport has been built and educators have an understanding of each child with which a learning profile can be constructed and utilized to plan for effective instructional strategies which enable learning to occur. Familiarity with children, from a teaching capacity, can allow for subtle changes to be noticed and if needed measures can be taken to address any difficulties that arise. Such factors could be disabilities that affects ones capacity for learning or a need for enhanced or more challenging learning activities within the educational environment. Recognizing what each child brings to the learning environment through strengths and weaknesses for the benefit of themselves and others is part of being an effective educator, followed by setting up each child for success during opportunities that lead to personal growth.

Context

The third and final core consideration takes a holistic look at cultural and social context not only for the child but the educators and programs the children are expected to develop in (NAEYC, 2020). For the purposes of this discussion, context includes personal and broader cultural circumstances including language, beliefs, traditions, and perspectives with all the multidimensional aspects that impacts today's global society (Agar, 2019). Educators must also be aware of any bias, experiences, personal perspectives, and such they inherently bring to the environment and may affect decisions and planning for instructions of diverse groups of children. In an effort to reinforce positive images and development for all children within an early childhood program, all aspects of culture within a global society should be carefully considered and delivered through a positive approach.

When planning educators may reflect on their personal perspectives then adjust based on diversity within the program and children which are being served. One example of this could be an educator from a smaller city who serves a group of diverse children primarily in a rural area whom either have or know relatives that keep farm animals. While planning a lesson on pets materials are gathered for pets which are expected based on what can be found in a pet shop. The lesson materials might be adapted before-hand to include typical farm animals to make sure all aspects of the diverse group are included, and everyone feels like they belong. Educators are expected to be and foster life-long learners. Which requires them to be reflective, keep up on research, and build relationships with families while incorporating what is being learned within such contexts to benefit each and every child in their care. The final discussion of this chapter includes personal reflections on the original published manuscript.

Reflections of the Published Manuscript

I do feel the editorial staff at *Young Children* chose wisely when cutting sections for the published article due to space constrictions, that does not take away from the importance or effectiveness of the sections themselves. Throughout this chapter the edited sections have proven their connections and importance to the published manuscript and the dissertation as a whole; therefore, I would not have done anything differently. Writing this manuscript ignited my passion for early childhood mathematics and gave me numerous insight for negating my own personal anxieties surrounding the teaching of the subject within my personal classroom. It also led to the development of the Chapter 5 manuscript and research as one of the children in my care the year this was being written was non-verbal at the time. Through him, I learned to differentiate various mathematics games and became very interested in the plethora of instructional strategies for play-based learning to improve mathematics in diverse populations of children in special education settings. My curricular toolbox grew exponentially, and I have since been able to share my research and evidence based instructional methods with colleagues to the benefits of their classrooms.

Chapter 5: Comparing Mathematical Interventions for Children with Speech or Language Impairments in Preschool

Introduction

Children who experience speech and language impairments tend to struggle with mathematics (Mononen et al., 2014; Van Luit & Toll, 2015; Vukovic & Lesaux, 2013) and mathematics symbol comprehension in preschool and kindergarten. Therefore, a majority of the time, children with speech and language impairments enter school already experiencing a delay in language and mathematics (Durkin et al., 2013; Mononen et al., 2014; Toll & Van Luit, 2014). Research indicates that a well-developed number sense may lead to more success later in school and possibly into career pathways (Durkin et al., 2013; Sayers et al, 2016). Although concepts of quantity and estimation may occur and function non-verbally, exact quantities and the counting principles, which are the foundation of formal mathematics, are predominantly dependent on verbalization and appropriate use of language (Vukovic & Lesaux, 2013). For this reason, mathematical language and interventions that target symbol recognition should be utilized as early as possible during the preschool years, for children with speech and language impairments in an attempt to circumvent further struggles when formal mathematics is introduced (Cross et al., 2019; Van Luit & Toll, 2015).

This research is an explicit experiential-based mathematics intervention that incorporates mathematical picture books, manipulatives, developmentally appropriate word problems, and the use of symbols that can be manipulated (e.g., <, >, =, +, -). The researcher will use an alternating treatment single-case research design with randomized assignment of two intervention modules across three phases over a six week time period. The students participating in the intervention modules will include four preschool-aged children that are identified with a speech or language impairment. Each session will be in a small group setting within a familiar environment in their larger school community.

Literature Review

How Children with Speech or Language Impairments Struggle with Mathematics

Language and Symbol Comprehension

Children experiencing language impairments are at increased risk of delays regarding their early numeracy development and application of mathematical concepts within their environment (LeFevre et al., 2010; Van Luit & Toll, 2015). The acquisition of verbal counting or the counting sequence is known to play a vital role in early calculation or algebraic reasoning skills (Toll & Van Luit, 2012). Due to the fact that children with speech or language impairments may not be able to rely as heavily on their phonological system and working memory as their peers without disabilities, they may experience greater difficulty with the counting sequence; therefore, learning arithmetic or computational processes becomes error-prone and a slow developmental process (McLeod & Harrison, 2009; Mononen et al., 2014). Supporting children to overcome these differences is important to promote their development of mathematical proficiency.

The appropriate use of language is foundational for the comprehension and application of abstract symbols (e.g., <, >, =, +, -) within mathematics (Toll & Van Luit, 2014; Vukovic & Lesaux, 2013). Some children experience frustration due to speech and language difficulties when decoding specialized language and abstract symbols used during mathematics-related activities or contexts. Such language difficulties can pose a dilemma when dealing with novel concepts, especially when interacting with materials and following verbal- or written-only instructions (Durkin et al., 2013). Some research indicates that the mathematical vocabulary used within word problems may further compound the difficulties that children with speech and language impairments experience, which can influence how they represent symbols and work to solve such problems (Vukovic & Lesaux, 2013). It is possible that children with speech and language impairments struggle due to the verbal requirements of educational settings and tasks in general (Cross et al., 2019). However, researchers have yet to identify the extent to which explicit support in mathematics language and symbols promotes mastery of mathematics concepts.

Benefits of Preschool Intervention for Mathematics Outcomes

Early identification of mathematical difficulty relating to speech or language impairments could be the key to providing appropriate interventions and supports for children as they are making the transition from pre-academics to formal schooling in kindergarten (Harrison et. al., 2009). Some scholars (e.g., Cross et al., 2019; Mononen et al., 2014; Vukovic & Lesaux, 2013) have found that children with speech or language impairments have difficulty demonstrating learning when required to do so through written or oral mediums. These scholars have encouraged teachers to use instructional methods that incorporate more visualization and understanding of concepts through repeated practice using manipulatives and scaffolding of experiences (Mainela-Arnold et al., 2011), rather than rote learning approaches where memorization is the mode of acquisition.

Additionally, interventions that are engaging and designed to target language and mathematical skills during the preschool years (ages 3 to 5) often have a strong positive effect on the learning outcomes and later careers for many students (Clements & Sarama, 2011). Targeted interventions utilizing explicit instruction and repeated practice for students with speech and language impairments that focus on sequence, process, and symbols when completing mathematical tasks may increase their proficiency and help close the achievement gap with their peers without disabilities (Mainela-Arnold et al., 2011). The use of mathematical language, which is targeted vocabulary that is specifically stated and used during interventions, is crucial for understanding concepts in both verbal and written forms (Durkin et al., 2013; Hughes et al., 2016). Adult guidance during the preschool years and supporting early mathematical concepts at this age can have a positive impact on young children and can promote a strong sense of mathematics through repeated experiences (Cross et al., 2019; Durkin et al., 2013; Toll & Van Luit, 2012).

Using various modalities such as manipulatives, interactive activities, and picture books, to reinforce mathematical language and symbols within interventions to promote engagement with and application of content can strengthen children's learning (e.g., Clements & Sarama, 2011; McGuire et al., 2012; Moomaw, 2015; Jordan, 2007). Previous research in the area of mathematics instruction for preschool children with disabilities has focused on one mode of intervention (e.g., Cohrssen et al., 2016; McGuire et al., 2012; Moomaw, 2015). These interventions have primarily included the use of systematic instruction including explicit instruction with guided practice of mathematical symbols and mostly written numerals.

For the purpose of this research, I am proposing a combination of systematic instruction with an interactive book intervention, utilizing picture books and complimentary activities with manipulatives. The use of physical symbols that students can manipulate, within developmentally appropriate word problems, will add to the comprehensiveness of the interventions and support students' understanding of the abstract nature of mathematics concepts. Interventions that incorporate rich, meaningful materials can be used to create experiences that support mathematical concepts (Sarama & Clements, 2009) and may contribute to the ability of children to pull from their prior experiences and build upon them (Watts et. al., 2017). When such interventions take place as early as preschool, it provides a plethora of rich prior knowledge and time for children's automaticity of mathematics facts and foundations to form, thereby allowing children to build upon this knowledge throughout subsequent grade levels.

First Intervention Module. The first intervention module will utilize mathematical picture books and use of explicit mathematical language applicable to the condition phase. At least one set of complementary game or set of manipulatives will be incorporated for the sessions. The teacher will read the book aloud and explicitly teach the appropriate mathematical vocabulary. Then the small group will engage with the complimentary activity with scaffolding provided by the teacher. Repeated practice through the use of manipulatives and games will help to reinforce the use of mathematics vocabulary within the context of novel and familiar situations.

Second Intervention Module. The second intervention module will follow the same format of the first intervention phase with the addition of developmentally appropriate word problems for additional repeated practice. These word problems will use manipulatives, pictures, or objects and at least one set of symbols that students can manipulate within comparisons of groups or sets as in the first condition, as well as equations presented in the second condition. They will also be complementary to the picture book as to foster engagement and provide continuity between activities.

Instructional Strategies: Explicit Instruction and Repeated Practice

Explicit Instruction

Explicit instruction, when utilized by educators, means that opportunities are purposefully and meaningfully created and that, through these opportunities, educators utilize scaffolding and time to experience and apply strategies for solving problems using mathematical vocabulary and concepts (Hachey, 2013; Van Luit & Toll, 2015). There are several components of explicit instruction, which include the following: teacher modeling and clear explanation of concepts/skills, verbalizing the process or make thinking visible for students, providing opportunities for individual and group practice of concepts/skills, and providing feedback based on observations and monitoring of practice opportunities (Doabler et al., 2019; Rosenshine, 2012). Observations during explicit instruction can be used to help assess whether concepts/skills have been mastered and enrichment activities are needed, or if further guided practice is required to help reinforce skills (Cohrssen et al., 2016).

Repeated Practice

Repeated practice is an instructional strategy where the teacher provides multiple opportunities for students to practice concepts and skills over time, while incorporating familiar and novel situations (Ardoin et al., 2018; McGuire et al., 2012). With each opportunity for repeated practice the student is reinforcing concepts such as stimulus control which is correctly responding to stimuli and identifying errors as they happen, retention of information, and automaticity or fluency of skills (Ardoin et al., 2018). Some key principles of repeated practice include the following: multiple opportunities in novel and familiar contexts, questions and discussion during practice to check for understanding, feedback from the teacher during practice, and 80% success rate which illustrates concept achievement, that children are being appropriately challenged during practice, and fosters independence when they are presented with similar problems spontaneously (Ardoin et al., 2018; Rosenshine, 2012).

Early Mathematics Number and Arithmetic Concepts

Early mathematics number and arithmetic concepts consist of the following: enumeration, which comprises quantification and comparing quantities of objects, stable order counting, one-to-one correspondence, cardinality, and subitizing (Fuson et al., 2015; Hachey, 2013; Moomaw, 2015; Rudd et al., 2010). The following sections will discuss in detail each mathematics concept and its corresponding criteria for number and arithmetic as a whole, which is considered one of the largest and foundational domains in early childhood education (McGuire et al., 2012; Jordan, 2007; Sayers et al., 2016; Stock et al., 2009).

Number and Arithmetic

Number sense is the ability to compare quantities of objects, nonverbal and verbal counting skills, representation of quantity such as cardinality and one-to-one correspondence, and the ability to apply these number concepts within various contexts (McGuire et al., 2012; Moomaw et al., 2010; Sayers et al., 2016). Research indicates that a well-developed number sense may lead to more success later in school and possibly into career pathways (Sayers et al., 2016). Children that struggle with symbol recognition generally have more difficulty with acquiring and applying mathematical concepts later in their education, especially with the process of subitizing (Sayers et al., 2016). There are three principles of counting that develop sequentially: (1) stable order counting, (2) one-to-one correspondence, and (3) cardinality. The ability to incorporate the three principles of counting provides a foundation for concepts of quantification.

Enumeration. Enumeration is the ability to determine a set's or group's numerical value, which can then be compared to and distinguished from other groups or sets of objects (Ginsburg & Ertle, 2008; Moomaw, 2015). Often, symbols (e.g., <, >, =) and corresponding vocabulary including greater than, less than, and equal too, are used to represent relationships between groups of objects. Quantification is the ability to determine and indicate both verbally and non-verbally, as a quantity or mental representation, the number of something (Laski & Siegler, 2014). Comprehension of numerical magnitudes is foundational for mathematical development (Laski & Siegler, 2014), and in order to apply counting to this process, children must understand cardinality. Quantification is reliant on the ability to estimate larger numbers between five and fifteen, which only occurs after developing the cardinal-number principal, and the ability to subitize up to four objects (Gunderson & Levin, 2011). Although quantities or numerical magnitudes exist outside of verbal language, linguistic representations are vital for formal mathematics to occur (Vukovic & Lesaux, 2013). These skills are combined to reinforce a foundation in the domain of number sense, which then plays a part in arithmetic concepts.

Stable Order Counting. Stable order counting is the ability to recognize that number words are used in a sequence that has a set meaning during counting (Moomaw, 2015; Moomaw, et al., 2010). For example, when counting a set of objects, the child says: one, two, three, four, five, etc., in the correct sequential order. This skill is generally accompanied by one-to-one correspondence to ensure the accuracy of counting.

One-to-one Correspondence. When the one-to-one correspondence principle is applied to objects while counting, the child understands that each object is counted once and only once (Moomaw, 2015; Sarama & Clements, 2009). Between the ages of two and six, children often comprehend a more rigid concept of one-to-one correspondence where every part of one set such as objects matches every part of another set such as the number words as they are counting (Sarama & Clements, 2009). For example, when a child is touching each object in a group once and only once as they are counting one, two, three, etc.

Cardinality. Cardinality is defined as the concept that the last object counted represents the total number of objects in a set or group (Moomaw et al., 2010). McGuire, Kinzie, and Berch (2012) indicate that for children to correctly use the cardinality principle, they must comprehend that cardinality is dependent on stable order counting and its relations to quantity. For example, if a child counts in stable order a quantity of six objects then the numerical representation or total of that group is six.

Subitizing. Subitizing is defined as the ability to recognize quickly a small set of objects between 0 - 6, and know how many there are without counting (Sarama & Clements, 2009). This is the first preverbal level of number sense, which allows for the comparison of small quantities including greater than >, less than <, and equal to =. Research indicates that children as young as four years of age can subitize sets of objects up to five items (Sayers et al., 2016), which may predict knowledge of cardinality while counting and the ability to use such skills in mathematical processes (Sarama & Clements, 2009). When children are able to mentally represent objects often through arrays, they begin to make comparisons between groups more easily, which contributes to the building of their number sense foundation (Sarama & Clements, 2009; Toll & Van Luit, 2014). Building automaticity within early number sense concepts is beneficial for later mathematics fluency. Specifically, automaticity proposes that as children build fluency they are able to focus less on symbol recognition (i.e. 1, 2, 3, a, b, c, etc.) and concentrate more on the meaning or process of the task they are completing such as reading new words, comprehension, solving problems/equations (Ardoin et al., 2018; Rosenshine, 2012). Subitizing allows for automaticity of small groups of quantities

(Cross et al., 2019) and therefore may lessen the load on working memory while solving mathematical problems; automaticity is found within reading research on fluency and should be transferable for mathematics fluency.

Comparing Quantities or Magnitudes. Students having difficulty in mathematics often struggle with comparing numbers using vocabulary such as greater than, less than, and equal too, and perform lower on such tasks compared to their peers that do not have mathematics difficulties (Powell & Fuchs, 2012; Price & Wilkey, 2017). With time and practice, the majority of children will understand the operations associated with the plus or addition sign and the minus or subtraction sign; however, a smaller group of children struggle with the equal sign and inequality symbols for greater than and less than comparisons (Hattikudur & Alibali, 2010; Heath, 2010; Mann, 2004; Powell & Fluhler, 2018; Powell & Fuchs, 2012).

Symbol Comprehension in Preschool and How it can Affect Kindergarten Mathematics

Core mathematics instruction, which encompasses symbol recognition and spans numeral identification to operations, begins in kindergarten and sets the foundation and determines the trajectory of mathematics achievement moving forward (Doabler et al., 2019; Driver & Powell, 2015). For example, early proficiency in number sense in kindergarten is a substantial indicator of later mathematical trajectory and achievement (Toll & Van Luit, 2012). The majority of numerical activities involving counting and comparing quantities requires the use of symbols for completion of the task (Powell & Fuchs, 2012). Children with speech and language impairment often have difficulty with basic enumeration, symbol identification, and application regardless of whether they are presented in verbal or written format (Mononen et al., 2014). By reinforcing appropriate symbol identification and application through explicit experiential interventions with scaffolded repeated practice, this population could reduce the achievement gap.

Difficulty of Various Mathematics Symbols

Symbol comprehension is necessary for the foundation of arithmetic and transition to algebraic processes; being able to understand and interpret mathematical symbols for equations is crucial to formal mathematics (Doabler et al., 2019; Li et al., 2018; Powell & Fluhler, 2018). There is a plethora of research noting the importance of the equal sign and the corresponding difficulty child can have with the relational interpretation meaning of the phrase same as (Hattikudur & Alibali, 2010; Heath, 2010; Mann, 2004; Powell, 2012; Powell & Fluhler, 2018; Tabbone & Terrades, 2014;). To think of the equal sign as balancing a scale where both sides of the equation are the same and not simply as a signal to answer an equation. This is a fundamental understanding needed for completing algebraic equations and other higher mathematics processes. Heath (2010) notes the difficulty interpreting symbols utilized with non-equivalence concepts such as greater than and less than. Children often have difficulty mastering such abstract symbols but do fairly well with the underlying concepts. The addition and subtraction signs can also be inherently difficult due to multiple meanings, such as how the minus sign is used both in subtraction equations and to note negative numbers later on in higher mathematics. Children are capable of learning symbols and their corresponding meanings within mathematics; however, continual instruction and practice is required with the meanings of the symbols for comprehension and application (Powell & Fluhler, 2018).

Methodology

Problem Statement

Vocabulary with dual meanings, such as mathematics vocabulary, can be difficult for children to comprehend or expressively articulate understanding. This is especially true for children with speech or language impairments, because verbal skills are important for demonstrating receptive or expressive language abilities and various aspects of mathematical achievement (Cross et al., 2019; Evans & Ullman, 2016). Lee and Ginsberg (2009) have identified a plethora of mathematical terminology within our everyday language. However, these mathematical terms are not readily recognized as being related to mathematics content knowledge (Lee & Ginsberg, 2009). Concepts such as tall, short, big, little, skinny, and fat relate to measurement; over, under, in front of, behind, first, and last align with special relations; and slide, rotate, reflect, roll, spin, and flip relate to ordinal sequence and transformations. The consistent use and explicit teaching of appropriate mathematical language by adults is important for young children (Vukovic & Lesaux, 2013) because language allows them to reflect and express mathematical thoughts about the world (Ginsburg et al., 2008).

To assist children with speech or language impairments to improve mathematical achievement, explicit language-based experiential learning interventions incorporating mathematical picture books, manipulatives, activities, and specific symbol representations (<, >, =, +, -) should be explored (Cross et al., 2019; Hughes et al., 2016;

Mainela-Arnold et al., 2011). Research on these interventions can help to determine which aspects of instruction could benefit children with speech or language impairments and assist in closing the achievement gap for mathematics development during early childhood.

IDEA Definition of Speech or Language Impairment

Under section 300.8 (c) (11) of IDEA (2004), a speech or language impairment is defined as, "a communication disorder such as stuttering, impaired articulation, a language impairment, or a voice impairment that adversely affects a child's educational performance." Ohio disability categories (Ohio Department of Education, 2016) further states:

- A communication disorder such as stuttering provides an example of a fluency disorder; other fluency issues include unusual word repetition and hesitant speech.
- Impaired articulation indicates impairments in which a child experiences challenges in pronouncing specific sounds.
- A language impairment can entail difficulty comprehending words properly, expressing oneself and listening to others.
- A voice impairment involves difficulty voicing words; for instance, throat issues may cause an abnormally soft voice. (para. 1)

Given the diversity of speech and language impairments for the purposes of this research, we will be using this identification category in a general sense for all speech and language impairments. From my professional experience, the majority of preschool students served under IDEA struggle with articulation and/or language impairments, either in conjunction with other disabilities such as autism spectrum disorder, down syndrome, fragile X syndrome, or as a stand-alone speech or language identification. According to the National Center for Education Statistics (2019), during the 2017-2018 school year 19% of students aged three to 21 served in public schools were identified as having a speech or language impairment making this category the second highest served under IDEA for school-aged children.

Statement of Purpose

The purpose of this research is to assess the impact of explicit language-based mathematical interventions with four- and five-year-old preschool children experiencing speech or language impairments as defined by IDEA (IDEA, 2004) eligibility standards. Two specific intervention modules will be created that include mathematical picture books with coordinating activities accompanied by explicit mathematical vocabulary and pairing them with either (a) the use of manipulatives, or (b) developmentally appropriate word problems with symbols that can be manipulated. Both interventions promote experiential learning opportunities to build relevant mathematical symbol representation utilizing language.

Research Questions

To examine the effects of mathematical methods of interventions that are explicit, language based, and grounded in experiential learning, the researcher identified the following two research questions:

1. Which components of explicit language-based mathematics strategies provide the greatest benefit for preschool children with speech or language impairments?

2. What is the impact of explicit language-based mathematical strategies for preschool children with speech or language impairments?

Research Design

The researcher will use a single-case, alternating treatment design (ATD) with three phases or conditions, consisting of five to seven sessions or data points each. This provides room for additional data in each phase if needed, while still meeting the standards for the most rigorous research design as defined by the What Works Clearinghouse (2014). The dependent variable or interventions will be systematically manipulated in a randomized order across conditions (WWC, 2014). This study will include at least three attempts to demonstrate the effects of each intervention module at three different points in time during the intervention phases (WWC, 2014). The design will be replicated between all phases including baseline, module one, and module two interventions in a randomized order after baseline phase is complete. This should help strengthen the validity of the study.

Participants

Criteria for student inclusion in this research includes being preschool age; specifically, it must be after the students' third birthday and before their sixth birthday at the start of the research. Students must also qualify under the Individuals with Disabilities Education Act (IDEA) for an Individualized Education Plan (IEP) and have a goal on their IEP in the area of speech and language. Participation in the study will be voluntary for children and adults.

Measures

To aide in data collection, a procedural fidelity checklist for each condition and intervention session were used. In addition, pre- and post-assessments conducted before baseline and after Phase 2 interventions were complete were collected for analysis. To ensure reliability and validity of data collected, video recordings of each session were completed, and percent of correct in-session answers provided on three word problems at the conclusion of each session were recorded.

Data Analysis

Graphed data of intervention sessions from video recordings will allow for a comparison of means using averages of scores across all conditions. This will aid in establishing evidence for a relationship between the interventions and increased use of the targeted symbols. Checklists, pre- and post-assessments, and three-word problems provided at the conclusion of the sessions will help determine if there is a causal relationship between the interventions and use of the targeted symbols at the conclusion of sessions. The following examination of data points from What Works Clearinghouse (2014) will be used: level, trend, variability, immediacy of the effect, overlap, and consistency.

Steps of Visual Analysis (WWC, 2014). Step one includes documenting baseline data and determining if the problem is demonstrated; that is, is there a disconnect between vocabulary and symbol recognition for the child? The process involves demonstrating that there is a predictable pattern the child exhibits which can be used to assess the effects of the proposed intervention; for example, if the child resists beginning the activities or requires significant support from the adult to engage with and use materials for the learning activities presented. Step two includes assessing the data points for patterns in response to the stimuli presented, which includes comparing the level, trend, and variability of the data in each phase of the study with all other phases. Does behavior and data points change in response to the interventions? Step three includes comparing the overlap, immediacy of the effect, and consistency of patterns in all phases of the study. This compares the extent to which the first three data points and the last three data points in each phase are similar and different. Step four includes combining the data sets from each phase comparisons in order to determine if the study has documented three demonstrations of an effect (from interventions) during different points in time.

Procedural Fidelity

Checklists were used during each condition of the interventions including baseline, module one, and module two to aid in coding for calculating averages and determining the extent to which the interventions were implemented in the manner they were designed. These checklists include a short script for the beginning of each session, materials to be used, and the overall procedure of the session. These forms were completed during the data analysis phase using the video recordings. See Appendix E for all procedural fidelity checklists.

Procedures

The first condition was the baseline, which consisted of sessions that mirror what early childhood educators in the region typically do during mathematics activities on a daily or weekly basis. The second condition was the first intervention phase concentrating on the greater than >, less than <, and equal to or same as = symbols. The third condition was the second intervention phase concentrating on the addition or plus sign + and subtraction or minus sign – symbols, while keeping the same as or equal = symbol to form a complete equation. Table 9 illustrates the differences between the baseline lessons, Module 1, and Module 2 interventions.

Table 10

Differences between Baseline, Module 1, and Module 2 Interventions

Baseline	**Module 1**	**Module 2**
• Picture books covering: counting, measuring, comparing quantities, sorting objects, big and little • Manipulatives • Games	• Picture books covering: comparing quantities and equality of sets, addition, and subtraction • Manipulatives • Games or hands-on activities • Explicit mathematics language • Repeated practice opportunities	• Picture books covering: comparing quantities and equality of sets, addition, and subtraction • Manipulatives • Games or hands-on activities • Explicit mathematics language • Repeated practice opportunities • Using physical representations of symbols during activities • Word problems built into activities for practice

Condition 1: Baseline. Typical mathematics activities within an inclusive preschool setting generally include picture books that are available for children to interact with, various mathematics manipulatives, worksheets with mathematics problems, and various mathematics games such as grid, short and long board games, and ten frames. Picture books are read to the whole group and, while they may pertain to mathematical concepts, the vocabulary is not explicitly discussed during the read aloud. Mathematics activities are presented during centers in a small group of no more than five children, with an adult supervising two centers at a time. Baseline activities for this research will include a read aloud mathematics picture book and at least one game with manipulatives for each session.

Condition 2: Module 1. This intervention condition focused on specific symbols including: > greater than or most, < less than or least, and = same as or equal too. Both intervention modules focused on comparisons of groups or sets of pictures, objects, manipulatives, etc., and the explicit mathematics vocabulary that accompany the symbols listed previously.

The child was presented with a book that illustrates the concept of greater than, less than, or equal too, then they engaged with manipulatives that relate to the book while repeatedly practicing the vocabulary and working with word problems using the symbols within the appropriate context. During the intervention the child had adult support for vocabulary and concepts when appropriate.

Condition 3: Module 2. This intervention condition focused on specific symbols to be used with word problems in the second module including: + more or counting on or addition, - minus or taking away or left, and = same as or equal too. Both intervention modules focused on simple equations where sums and differences are within 10 using grids/ten frames, pictures, objects, manipulatives, etc., and the explicit mathematics vocabulary that accompany the symbols listed previously.

The child was presented with a book that illustrates the concepts of simple addition and subtraction with the use of the equal sign in an equation format. Then, they engaged with more manipulatives that relate to the book while repeatedly practicing the vocabulary and working with word problems using the symbols within the appropriate context. During the intervention, the child had adult support for vocabulary and concepts when appropriate. Table 10 demonstrates the differences in symbols during each phase of the study.

Table 11

Differences in Symbols per Phase

Baseline	**Phase 1**	**Phase 2**
Greater than >, Less than <, Equal too =, Addition/Plus +, Subtraction/Minus -	Greater than >, Less than <, Equal too =	Equal too =, Addition/Plus +, Subtraction/Minus -

Randomization Procedure

To randomize which children would be receiving Intervention Module 1 or 2 during each lesson for Phases 1 and 2 the researcher utilized randomizer.org. The Baseline phase did not undergo this step as there were no use of Module 1 or 2 for this phase. Parameters for the website included: four sets of numbers including one for each child in the study; six numbers per set; number range from one to two representing the intervention module; each number set did not need to be unique; the numbers did not need to be sorted, and; no place markers were requested for viewing of the number sets. This was done twice, once for Phase 1 and once for Phase 2 of the study. See Appendix H for the randomization order for each phase of the study per child.

Researcher Perspective

The perspective taken while in the role of the researcher was as an intervention specialist first and foremost. When considering the needs of the children in the study, it was imperative that I drew on my pedagogical content knowledge, understanding of mathematic developmental trajectories, and speech or language impairments to design the interventions, plan instructional strategies, and deliver the lessons with each child throughout the study. When considering the configurations of the rooms to be used, I chose quiet rooms with very little traffic and distractions that could accommodate the needs of preschool-aged children. At the time, attention also needed to be paid to COVID protocols and restrictions. Three of the four children worked with me in the previous two years in my role as their intervention specialist while the fourth was exposed to me in an educational setting, through co-treating with a speech and language pathologist, in the previous year. There was rapport with each of the children to a degree before the study began, which made the children comfortable working with me in the role of a teacher.

Study Conditions

Sample Demographic Information

The sample for this study included four children, all of whom were boys, which resided in South Central Ohio across two school districts. They all have a speech or language delay as defined by the Individuals with Disabilities Education Act of 2004, and each has an Individualized Education Program with at least one speech or language goal. See Appendix C for inclusion criteria forms. They all have some prior preschool experience, ranging from six months to two years. Two of the boys turned five during the course of the study, one boy was already five at the start, and one boy turned four during the course of the study. Two boys attended school in the same district but were in different classrooms, while the other two boys in a different school district, where in the same classroom. Two of the boys attended four full days a week, Monday through Friday, and the other two boys attended two full days each week due to school district decisions regarding COVID. A visual of the information provided is outlined in Table 11.

Table 12

Sample Demographic Information

Subject	Age	Preschool Experience	District A	District B	Attendance	Days
Child 1	5	2 years	Classroom 1		2 days per week	Thursday & Friday
Child 2	5	2 years	Classroom 1		2 days per week	Thursday & Friday
Child 3	5	2 years		Classroom 2	4 days per week	Monday - Thursday
Child 4	4	6 months		Classroom 3	4 days per week	Monday - Thursday

All four boys were comfortable with the teacher implementing the lessons for various reasons. Either the child was a previous student in an itinerant setting or had exposure to the teacher while working with another therapist, generally in conjunction with a speech and language pathologist, during a therapy session in a small group setting. Table 12 provides the start and end dates per child for the six week study.

Table 13

Dates Study Began and Ended

Child	Start Date	End Date
Child 1	9/29/2020	11/12/2020
Child 2	9/30/2020	11/12/2020
Child 3	9/29/2020	11/05/2020
Child 4*	9/29/2020	11/11/2020

* Child 4 was in a COVID quarantine as was his whole preschool classroom for two weeks of the study. When lessons resumed, he was seen four times a week to make up for the lost time.

Session Routine

Each child had their own individual lesson kits with all of the manipulatives they needed and some play items that were left in the classroom and retrieved by the teacher when she arrived at the location. The materials for the lesson were taken from the kit and laid out in preparation for the lesson. The teacher had her own kit as well, so there was minimal sharing of materials due to COVID regulations and concerns. See Appendix I for COVID related research protocol. All materials were sanitized after the completion of the lesson and the child was back in their classroom. Every lesson was one-on-one with the teacher and child due to COVID restrictions, and the table, chairs, and manipulatives were sanitized before and after each session as noted on the cleaning logs.

The teacher walked the child to the designated room for the session and asks them to sit in the chair at the table. The teacher then turned on the camera and microphone and asked the child if they would like to read the book or play for a few minutes. If they replied that they wanted to read the book, the lesson began with the reading of the book. If the child replied that they would like to play for a few minutes, which was the typical answer, they were provided with a manipulative toy and a visual timer was set for two minutes and positioned so the child could view the face of the timer. During this time the teacher would record temperatures in a log for the child and make sure all needed materials were in close proximity.

Once the timer was finished the teacher asked the child to put the toy away in the container or bag that was provided. Then the teacher would introduce the book for the session. Often the title and illustration on the cover were discussed and then the read aloud would proceed. The child was able to see the illustrations at all times during the reading and various comprehension questions and vocabulary, mostly related to mathematics concepts, were discussed throughout the reading of the book.

When the book was finished the teacher would bring out the needed materials for the activity or game. The activity would be explained to the child and the teacher would model the activity twice before the child engaged with the materials. The child would be provided with at least three opportunities, though often more, to practice the concept for the lesson during the activity or game. Once the activity was completed the child would be asked to help clean up the materials with the teacher.

When the materials were put away, the teacher would provide manipulatives for the three age-appropriate word problems for the child. Then, the teacher would ask each word problem one at a time and move on once the previous problem was answered. The teacher would note on a form for each child how many prompts were provided for each question, if the symbol was used correctly or incorrectly, if more than two prompts were needed, if the teacher felt it was due to a lack of attention or a skill deficit, and the frustration level of the child during the word problem as noted as low, moderate, or high. All data related to this document sheet was recorded on each child's individual document sheet and transcribed to each table for a visual of the results of the word problems. Once all three word problems were completed, the child was asked to put the manipulatives back in the provided container or bag. The camera and microphone were turned off at this time and the teacher walked the child back to their classroom. At times, field notes were taken during the lesson on separate forms for any notable behavior in addition to the data already being collected.

Rarely, when breaks were needed, the video was stopped and a new one started when the break was done. Breaks were mostly for the bathroom; this occurred twice with one child in the weeks during the study. Table 14 highlights the duration, in minutes, of each session per child with an average duration per child at the bottom of the table. Such information may help identify if there were particular sessions in which any of the children struggled, noted by a significantly longer time compared to the other children. On average, each session ranged from 31 to 35 minutes in duration. The exception to this includes Phase 1 Lesson 1 which incorporated a longer picture book and long path game activity.

Table 14

Duration of Lessons in Minutes

Lesson	Child 1	Child 2	Child 3	Child 4
Baseline 1	34	28	35	31
Baseline 2	29	27	33	33
Baseline 3	28	27	31	31
Baseline 4	32	29	32	34
Baseline 5	27	26	30	30
Baseline 6	25	27	36	33
Phase 1-1	41	42	48	50
Phase 1-2	33	31	43	35
Phase 1-3	40	38	35	35
Phase 1-4	32	27	31	32
Phase 1-5	32	29	34	35
Phase 1-6	33	28	34	29
Phase 2-1	34	32	37	31
Phase 2-2	30	35	32	30
Phase 2-3	33	27	37	34
Phase 2-4	35	35	31	34
Phase 2-5	35	36	37	31
Phase 2-6	33	31	33	33
Average Duration	32	31	35	33

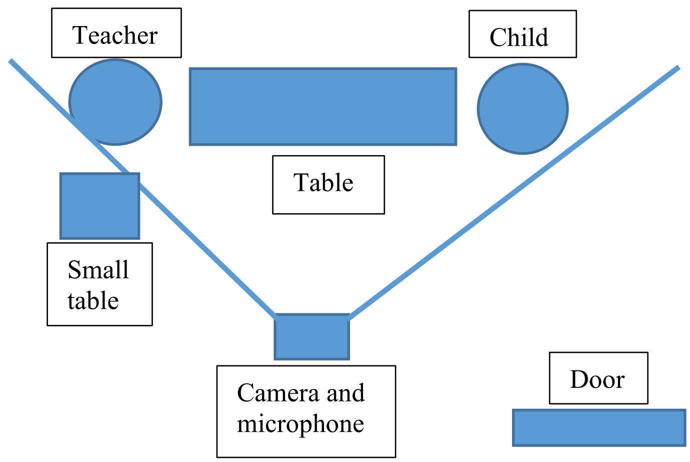
Learning Environment

Room Configuration for Children 1 and 2: Sensory Room

The sensory room was a smaller, quieter space to work in, when it was available, with minimal distractions, with the exception of some sensory equipment including a small trampoline, child size stationary bike, egg chair, light strings with a suspended swing, light table, upright bolster, foam hopscotch board, and a deep pressure canoe located along the edges of the room. The table and chairs were set up by the teacher before each session for the teacher and the child. The camera sat on top of a folding tripod with an external microphone attached. The small table was used to organize materials for the lesson and for taking field notes when necessary. The table and chairs in use for this configuration were developmentally appropriate for preschool-aged children. The children were able to sit or stand as they preferred at the table during each lesson. Figure 4 illustrates the configuration of the sensory room which was used during part of the sessions of the study with children 1 and 2.

Figure 4

Sensory Room Configuration

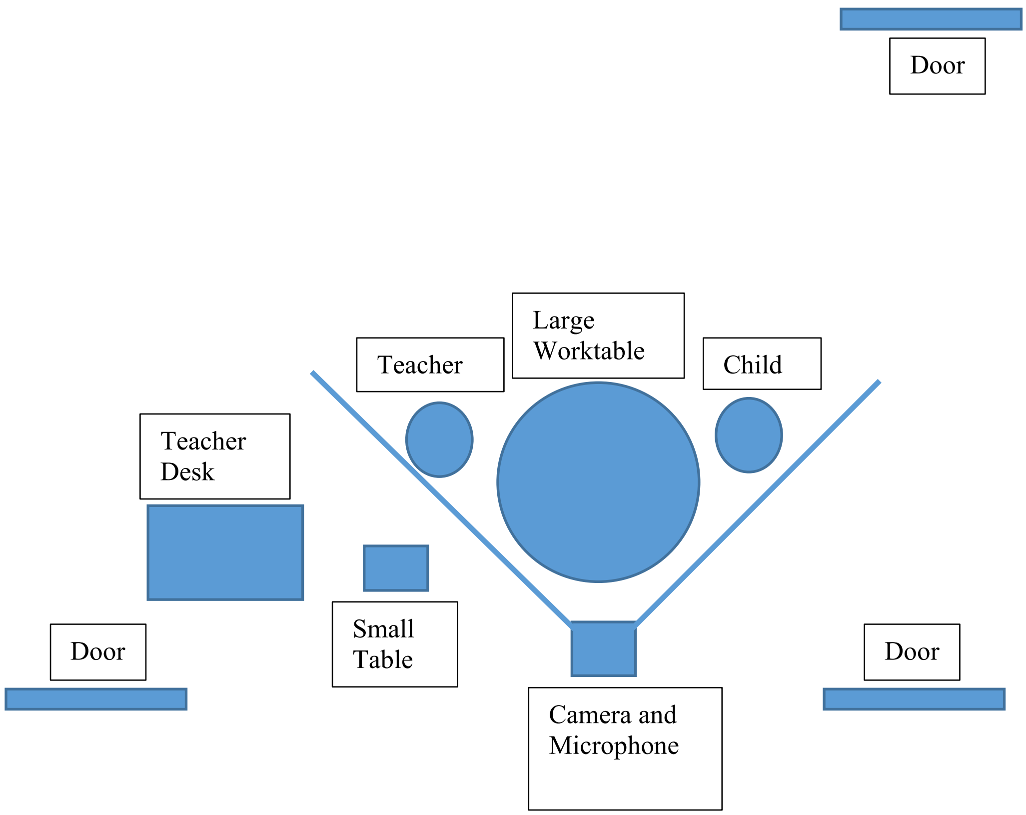


Room Configuration for Children 1 and 2: Computer Lab

The computer lab was a large room, that was generally quiet, in which to work with little traffic and minimal distractions. There were computers along three of the four walls except where the large round work-table and teacher's desk were located. The camera sat on top of a folding tripod with an external microphone attached. The small table was used to organize materials for the lesson and for taking field notes when necessary. The table and chairs in use for this configuration were not an appropriate height for preschool-aged children. They were designed for older children to use in the context of a lab setting for collaboration. The children were able to sit or stand as they preferred at the table during each lesson. Figure 5 illustrates the configuration of the computer lab which was used during some sessions of the study with children 1 and 2.

Figure 5

Computer Lab Configuration

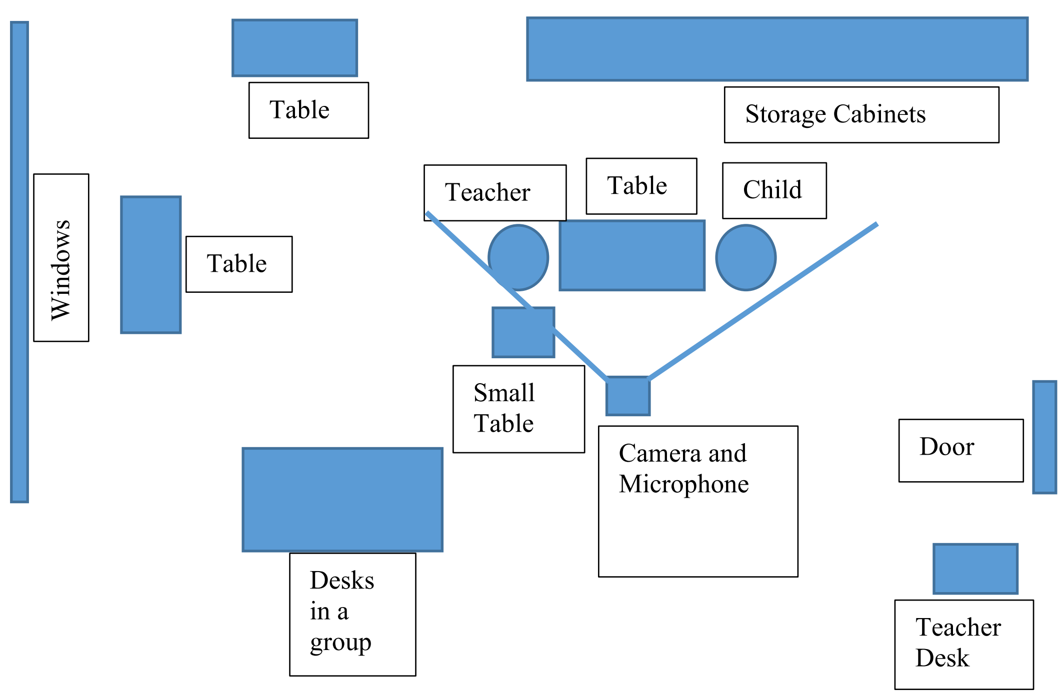


Room Configuration for Children 3 and 4

This classroom is used for the after school program and by various educational therapists including speech and language pathologists, occupational, itinerant teachers, and physical therapists during the week. There were various preschool age toys, elementary age toys, and craft materials around the room. Some clean-up of toys is required each time as well as setup of the small table, work-table, and chairs for the teacher and child in the space. This was generally a quiet space to work in with minimal distractions for the children. The camera sat on top of a folding tripod with an external microphone attached. The small table was used to organize materials for the lesson and for taking field notes when necessary. The table and chairs in use for this configuration were developmentally appropriate for preschool-aged children. The children were able to sit or stand as they preferred at the table during each lesson. Figure 6 illustrates the configuration of the after school program and therapy room used with children 3 and 4 for all sessions of the study.

Figure 6

After school program and Therapy Room Configuration



Results

Description of Assessment

The assessment used in this study includes items from the number sense domain of the early childhood standards (Ohio Department of Education, 2020). This assessment was developed in part by the preschool staff at Ross-Pike Educational Service District and is used by the two counties as part of their classroom curriculum assessments. See Appendix D for Pre and Post assessment forms. This was board approved during the 2016-2017 school year. It was modified for the use of this study to include items regarding recognizing symbols (<, >, =, -, +). Other items included: stable order counting to 20, one-to-one correspondence within 20 objects, cardinality within 20 objects, subitizing to five objects, matching numerals within a range of 0 to 20, identifying numerals within a range of 0 to 20, comparing quantities to 10 objects using greater than, less than, and equal to, simple addition/counting on, and simple subtraction/taking apart within 10 objects. Table 15 provides the pre and post assessment results along with the corresponding dates the assessment was given.

Table 15

Pre and Post Assessment Results

Child	Pre-Assessment Date	Score	Post Assessment Date	Score	Difference
Child 1	9/29/2020	20	11/12/2020	31	+11
Child 2	9/30/2020	24	11/12/2020	36	+12
Child 3	9/29/2020	27	11/05/2020	39	+12
Child 4	9/29/2020	15	11/11/2020	22	+7

Note: There were a total of 39 points possible.

Next, an analysis of the gains made and individual data per child for the study will be discussed.

Individual Data Analysis per Child

Data analysis conducted in conjunction with a methodologist was double-coded. All disagreements in the data were discussed until a 100% consensus was reached. See Appendix F for post session word problems and Appendix G for the recording form used to collect session data.

Child 1

Child 1 turned five just prior to the start of the study, was identified with a speech and language impairment, and qualified for an individualize education program two years ago while in preschool. He has good attendance and is generally very attentive with good attention to task for most activities. As illustrated in Table 15 Child 1 gained 11 points over the course of the study, with gains seen in the areas of subitizing sets to five, identifying numerals within a range of zero to twenty, recognizing symbols specifically equal to and minus (= and -), simple addition and subtraction equations. Child 1 seemed to enjoy the hands on activities that were presented and was generally engaged with all lessons conducted during the study. Child 1 maintained good eye contact, followed directions with minimal verbal prompts, initiated and participated in conversations, and never seemed to be concerned with failure or appear to be defeated by any part of the sessions.

Table 16 provides information from each session based on the three word problems conducted at the conclusion of each recorded lesson. In this table, we see that Child 1 experienced equally low and moderate levels of frustration during the word problems. Correct responses during the baseline phase for the questions was 39% and for the symbols was 0%. Correct responses during Phase 1 were 94% with equal opportunities for intervention Module 1 and Module 2 exposure, and 100% of the symbols correct. Correct responses for Phase 2 were 72% correct with the majority of the interventions being Module 2, and correct responses for symbols being 61%.

Table 16

Child 1: Data from Individual Sessions

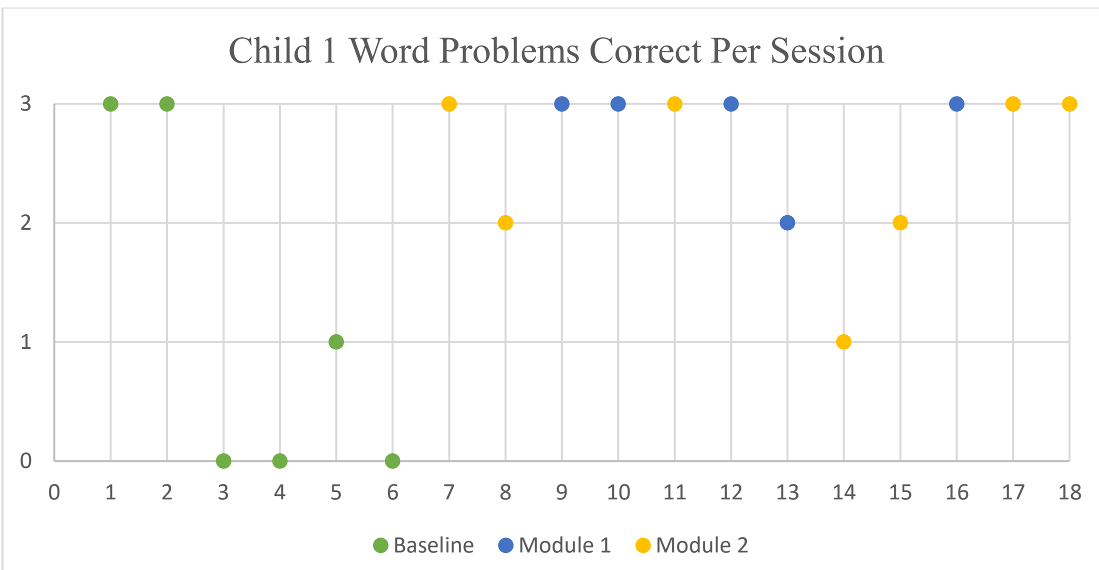
Module	Session	<, >, = or +, -	Responses correct out of 3	Symbol correct out of 3	Total prompts needed	Average Frustration Level
N/A	Baseline-1	<, >, =	3	0	4	Moderate
N/A	Baseline-2	<, >, =	3	0	3	Moderate
N/A	Baseline-3	+, -	0	0	2	Low
N/A	Baseline-4	+, -	0	0	6	Moderate
N/A	Baseline-5	+, -	1	0	3	Low
N/A	Baseline-6	+, -	0	0	4	Moderate
2	Phase 1 - 1	<, >, =	3	3	3	Low
2	Phase 1 - 2	<, >, =	2	3	4	Moderate
1	Phase 1 - 3	<, >, =	3	3	3	Moderate
1	Phase 1 - 4	<, >, =	3	3	5	Moderate
2	Phase 1 - 5	<, >, =	3	3	5	Moderate
1	Phase 1 - 6	<, >, =	3	3	4	Low
1	Phase 2 - 1	+, -	2	2	3	Low
2	Phase 2 - 2	+, -	1	1	3	Moderate
2	Phase 2 - 3	+, -	2	2	1	Low
1	Phase 2 - 4	+, -	3	3	2	Low
2	Phase 2 - 5	+, -	3	2	2	Low
2	Phase 2 - 6	+, -	2	1	3	Low

Note: Frustration level was assessed through observation, rapport with each child was already in place due to prior preschool experience with the educator, changes encountered in behavior with each individual child were noted. Behavior changes for Child 1 included: quietness during activity, looking at educator for direction without verbalizing need for help, recounting objects more than two times, and agitation or fidgeting behaviors.

Figure 7 and figure 8 are visual displays of the data from Table 16 in which we see an increase during Phase 1 and 2 of symbol recognition overall. However, there was a fluctuation throughout Phase 2 with symbol recognition and correct responses to the word problems. Child 1 averaged four prompts per session for the baseline phase, four prompts per session for Phase 1, and two prompts per session for Phase 2. If more than two prompts were needed per question, (i.e. six prompts per session total), it was due to a need for redirection to the task due to attention deficits.

Figure 7

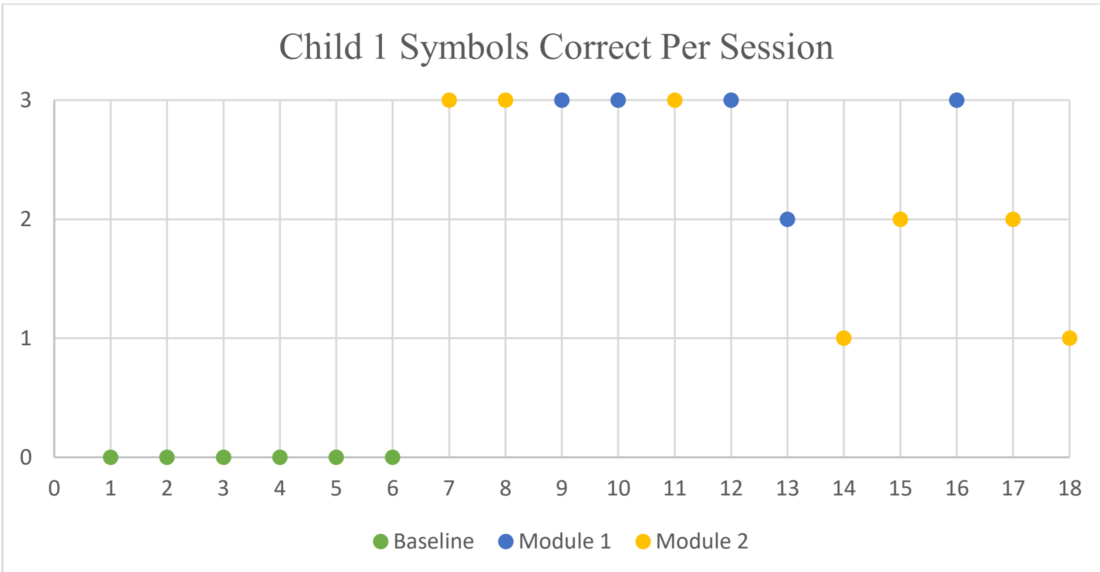
Child 1 Word Problems Correct Per Session



Note: Numbers 0-6 are Baseline phase, 7-12 are Phase 1, and 13-18 are Phase 2.

Figure 8

Child 1 Symbols Correct Per Session



Note: Numbers 0-6 are Baseline phase, 7-12 are Phase 1, and 13-18 are Phase 2.

Child 2

Child 2 turned five during the course of the study, was identified with a speech and language impairment, and qualified for an individualize education program two years ago while in preschool. Child 2 has good attendance and is generally interested in mathematics activities, but can be very distractible or fidgety. Child 2 preferred to stand at the table instead of sit during most sessions or move around the table as he was working through activities and word problems. As illustrated in Table 15 Child 2 gained 12 points over the course of the study, gains were seen in the areas of one-to-one correspondence to 20 objects, cardinality, symbol recognition (=, +, -), comparing quantities within 10 objects, simple addition and subtraction. Child 2 seemed to enjoy the hands-on activities that were presented and was generally engaged with all lessons conducted during the study. Child 2 stated during one session that his favorite activities were the board games and remarked on how much he enjoyed the game from baseline session 1. Child 2 maintained good eye contact, followed directions with some verbal prompts due to attention, initiated and participated in conversations, and never seemed to be concerned with failure or appeared defeated by any part of the sessions.

Table 17 provides information from each session based on the three word problems conducted at the conclusion of each recorded lesson. In this table we see that Child 2 experienced mostly low levels of frustration during the word problems. Correct responses during the baseline phase for the questions was 67% and for the symbols was 0%. Correct responses during Phase 1 were 100% with Module 1 being the majority of the interventions, and 67% of the symbols correct. Correct responses for Phase 2 were 78% correct equal opportunities for Module 1and 2, and correct responses for symbols being 44%.

Table 17

Child 2: Data from Individual Sessions

Module	Session	<, >, = or +, -	Responses correct out of 3	Symbol correct out of 3	Total prompts needed	Average Frustration Level
Not applicable	Baseline-1	<, >, =	3	0	4	Moderate
Not applicable	Baseline-2	<, >, =	3	0	3	Low
Not applicable	Baseline-3	+, -	1	0	2	Low
Not applicable	Baseline-4	+, -	2	0	3	Moderate
Not applicable	Baseline-5	+, -	2	0	5	Moderate
Not applicable	Baseline-6	+, -	1	0	3	Low
2	Phase 1 - 1	<, >, =	3	2	3	Moderate
2	Phase 1 - 2	<, >, =	3	2	3	Low
1	Phase 1 - 3	<, >, =	3	2	4	Low
1	Phase 1 - 4	<, >, =	3	1	2	Low
1	Phase 1 - 5	<, >, =	3	2	1	Low
1	Phase 1 - 6	<, >, =	3	3	0	Low
1	Phase 2 - 1	+, -	3	2	2	Low
2	Phase 2 - 2	+, -	2	1	3	Low
1	Phase 2 - 3	+, -	2	1	1	Low
2	Phase 2 - 4	+, -	3	1	2	Low
2	Phase 2 - 5	+, -	2	2	1	Low
1	Phase 2 - 6	+, -	2	1	2	Low

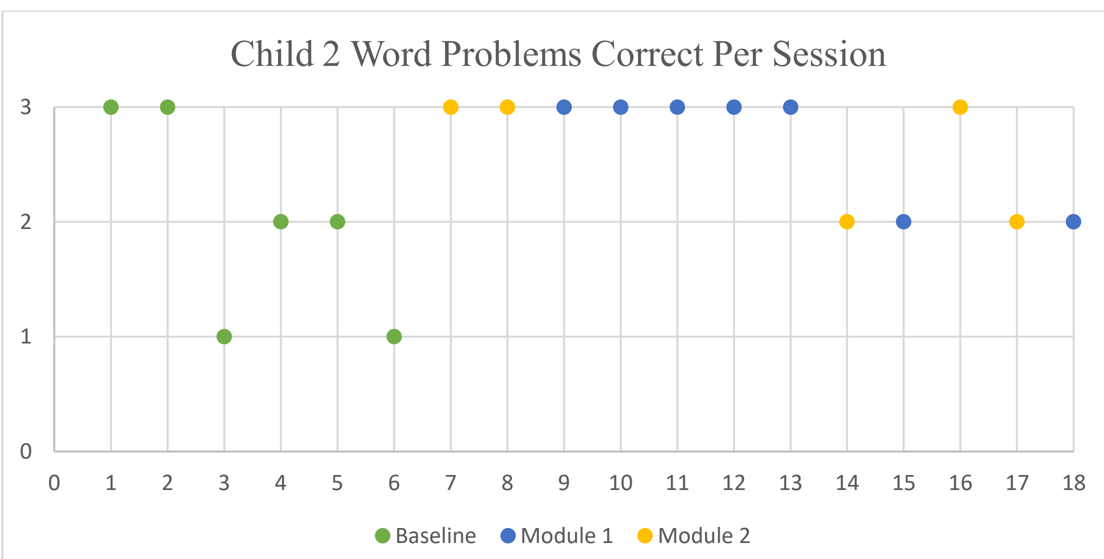
Note: Frustration level was assessed through observation, rapport with each child was already in place due to prior preschool experience with the educator, changes encountered in behavior with each individual child were noted. Behavior changes for

Child 2 included: quietness during activity, excessive fidgeting with materials, and overuse of the word um when attempting to answer a problem.

Figure 9 and figure 10 are visual displays of the data from Table 17, where we see an increase during Phase 1 and 2 regarding symbol recognition and correct responses overall. However, a fluctuation throughout out Phase 2 with symbol recognition and correct responses. Child 2 averaged three prompts per session for the baseline phase, two prompts per session for Phase 1, and two prompts per session for Phase 2. If more than two prompts were needed per question, (i.e. six prompts per session total), it was due to a need for redirection to the task due to attention deficits.

Figure 9

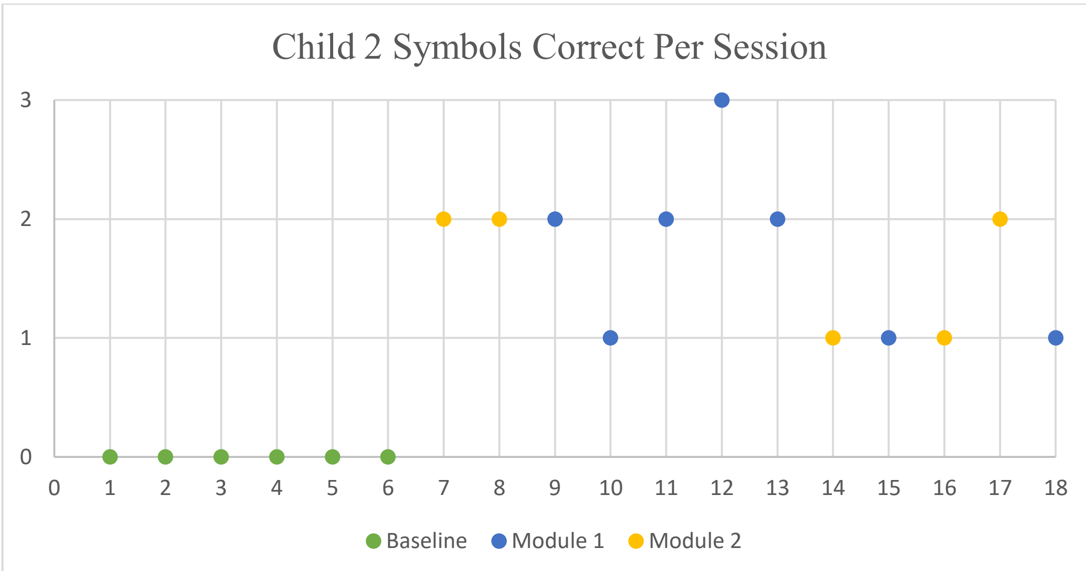
Child 2 Word Problems Correct Per Session



Note: Numbers 0-6 are Baseline phase, 7-12 are Phase 1, and 13-18 are Phase 2.

Figure 10

Child 2 Symbols Correct Per Session



Note: Numbers 0-6 are Baseline phase, 7-12 are Phase 1, and 13-18 are Phase 2.

Child 3

Child 3 turned five just prior to the course of the study, was identified with a speech and language impairment and qualified for an individualized education program two years ago while in preschool. Child 3 has good attendance, is generally interested in mathematics activities, maintains attention to task with minimal redirections the majority of the time, and participates in conversations with familiar adults. As illustrated from Table 15 Child 3 gained 12 points over the course of the study, gains were seen in the areas of stable order counting to 20, subitizing sets of objects to 5, symbol recognition (=, +, -), and simple addition and subtraction problems. Child 3 seemed to enjoy the hands on activities that were presented and was generally engaged with all lessons conducted during the study. Child 3 stated during several sessions that he liked playing with the plastic pumpkin manipulatives; when these were used in a session he often required more prompting to stay on task. Child 3 followed directions with minimal verbal prompts and never seemed to be concerned with failure or appear defeated by any part of the sessions.

Table 18 provides information from each session based on the three word problems conducted at the conclusion of each recorded lesson. In this table, we see that Child 3 experienced mostly low levels of frustration during the word problems. Correct responses during the baseline phase for the questions was 100% and for the symbols was 0%. Correct responses during Phase 1 were 94% with equal opportunities for intervention Module 1 and 2 exposure, and 100% of the symbols correct. Correct responses for Phase 2 were 78% correct with the majority of the interventions being Module 1, and correct responses for symbols being 78%.

Table 18

Child 3: Data from Individual Sessions

Module	Session	<, >, = or +, -	Responses correct out of 3	Symbol correct out of 3	Total prompts needed	Average Frustration Level
Not applicable	Baseline-1	<, >, =	3	0	2	Low
Not applicable	Baseline-2	<, >, =	3	0	2	Low
Not applicable	Baseline-3	+, -	3	0	3	Low
Not applicable	Baseline-4	+, -	3	0	3	Low
Not applicable	Baseline-5	+, -	3	0	1	Low
Not applicable	Baseline-6	+, -	3	0	3	Low
2	Phase 1 - 1	<, >, =	3	3	1	Low
1	Phase 1 - 2	<, >, =	2	3	5	Moderate
2	Phase 1 - 3	<, >, =	3	3	3	Low
1	Phase 1 - 4	<, >, =	3	3	4	Moderate
2	Phase 1 - 5	<, >, =	3	3	4	Low
1	Phase 1 - 6	<, >, =	3	3	4	Low
1	Phase 2 - 1	+, -	2	2	4	Moderate
2	Phase 2 - 2	+, -	3	2	6	Moderate
1	Phase 2 - 3	+, -	2	2	3	Low
2	Phase 2 - 4	+, -	2	3	1	Low
1	Phase 2 - 5	+, -	2	3	3	Low
1	Phase 2 - 6	+, -	3	2	3	Low

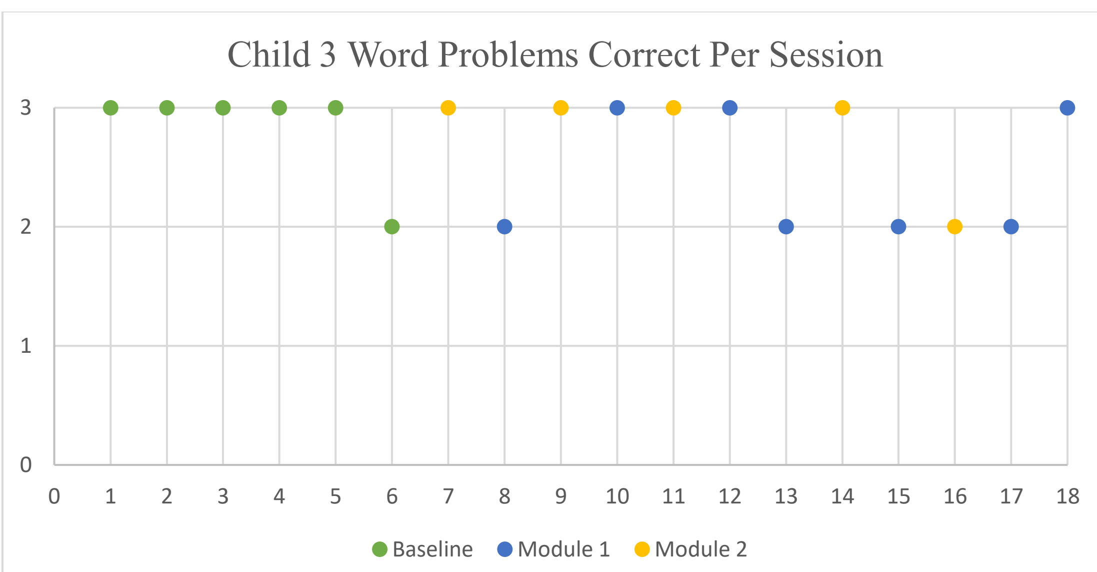
Note: Frustration level was assessed through observation, rapport with each child was already in place due to prior preschool experience with the educator, changes encountered in behavior with each individual child were noted. Behavior changes for

Child 3 included: perseveration or fidgeting with materials, watching and waiting on adult to answer the problem instead of asking for help, and playing with his hair.

Figure 11 and figure 12 are visual displays of the data from Table 18, where we see an increase during Phase 1 and 2 of symbol recognition overall. Child 3 demonstrated correct responses during the baseline phase with a fluctuation throughout out Phase 1 and 2 with symbol recognition and correct responses. Child 3 averaged two prompts per session for the baseline phase, two prompts per session for Phase 1, and three prompts per session for Phase 2. If more than two prompts were needed per question, (i.e. six prompts per session total), it was due to a need for redirection to the task due to attention deficits, or a favored manipulative used during the word problems.

Figure 11

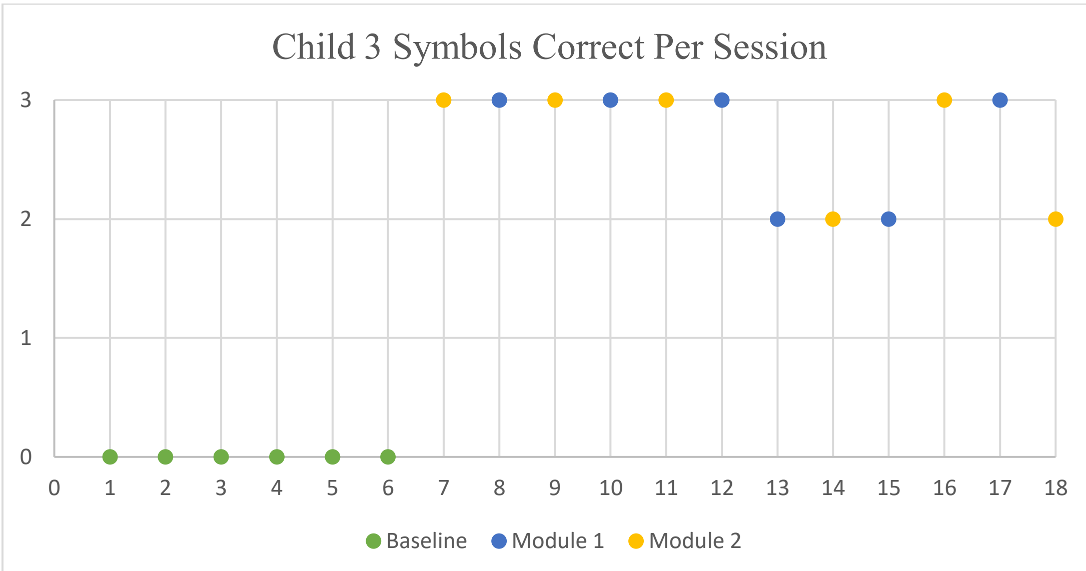
Child 3 Word Problems Correct Per Session



Note: Numbers 0-6 are Baseline phase, 7-12 are Phase 1, and 13-18 are Phase 2.

Figure 12

Child 3 Symbols Correct Per Session



Note: Numbers 0-6 are Baseline phase, 7-12 are Phase 1, and 13-18 are Phase 2.

Child 4

Child 4 turned four during the course of the study, was identified with a speech and language impairment and qualified for an individualized education program one year ago while in preschool. Child 4 has good attendance, maintains attention to task with minimal redirections the majority of the time, and participates in conversations with familiar adults. As illustrated in Table 15 Child 4 gained 7 points over the course of the study, gains were seen in the areas of one-to-one correspondence, subitizing sets of objects to four, cardinality, comparing quantities within 10 objects, and simple addition and subtraction problems. Child 4 seemed to enjoy the hands-on activities that were presented and was generally engaged with all lessons conducted during the study. However, he could become fatigued towards the end of the sessions if they were particularly taxing. Child 4 followed directions with some verbal prompts possibly due to avoidance of tasks he felt were too difficult. During those instances the teacher would help walk him through the steps required for the task while modeling for him. Child 4 never seemed to be concerned with failure or appeared defeated by any part of the sessions.

Table 19 provides information from each session based on the three word problems conducted at the conclusion of each recorded lesson. In this table, we see that Child 4 experienced mostly moderate levels of frustration during the word problems. Correct responses during the baseline phase for the questions was 33% and for the symbols was 0%. Correct responses during Phase 1 were 78% with the majority being Module 2 interventions, and 44% of the symbols correct. Correct responses for Phase 2 were 39% correct with equal opportunities for Module 1 and 2 interventions, and correct responses for symbols being 56%.

Table 19

Child 4: Data from Individual Sessions

Module	Session	<, >, = or +, -	Responses correct out of 3	Symbol correct out of 3	Total prompts needed	Average Frustration Level
Not applicable	Baseline-1	<, >, =	1	0	5	Moderate
Not applicable	Baseline-2	<, >, =	3	0	3	Low
Not applicable	Baseline-3	+, -	1	0	4	Moderate
Not applicable	Baseline-4	+, -	1	0	6	Moderate
Not applicable	Baseline-5	+, -	0	0	6	Moderate
Not applicable	Baseline-6	+, -	0	0	6	Moderate
2	Phase 1 - 1	<, >, =	2	1	5	Moderate
1	Phase 1 - 2	<, >, =	2	2	4	Moderate
1	Phase 1 - 3	<, >, =	2	2	4	Low
2	Phase 1 - 4	<, >, =	2	1	6	Moderate
2	Phase 1 - 5	<, >, =	3	2	3	Low
2	Phase 1 - 6	<, >, =	3	0	4	Low
1	Phase 2 - 1	+, -	1	1	2	Moderate
1	Phase 2 - 2	+, -	1	2	3	Low
1	Phase 2 - 3	+, -	0	2	5	Moderate
2	Phase 2 - 4	+, -	2	2	4	Moderate
2	Phase 2 - 5	+, -	1	1	5	Moderate
2	Phase 2 - 6	+, -	2	2	3	Low

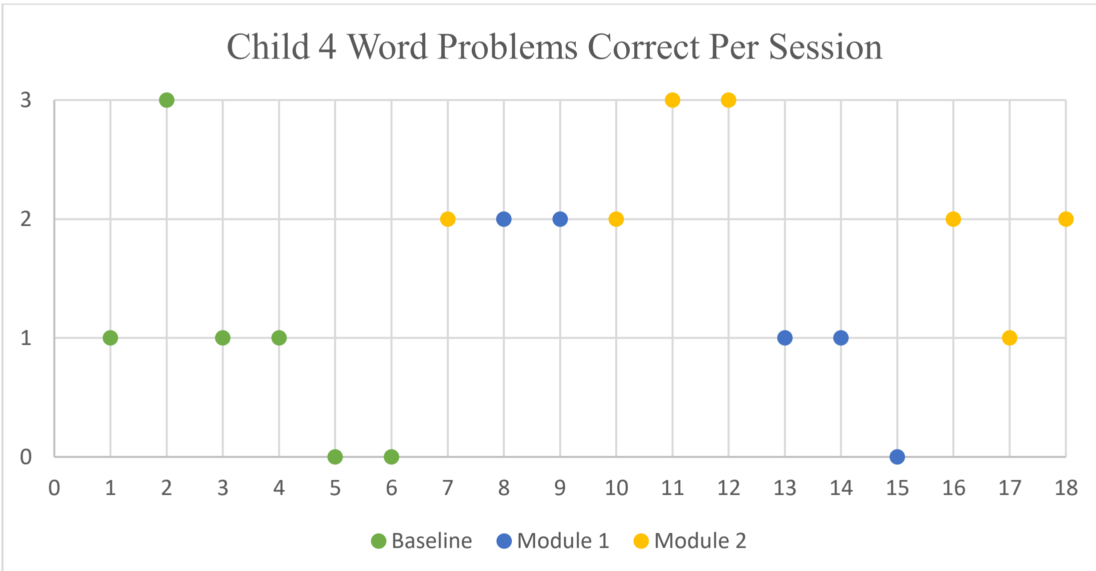
Note: Frustration level was assessed through observation, rapport with each child was already in place due to prior preschool experience with the educator, changes encountered in behavior with each individual child were noted. Behavior changes for

Child 4 included: fidgeting in his seat or space, avoiding eye contact, looking around the room, asking to use another manipulative, or engaging in off topic conversations.

Figure 13 and figure 14 are visual displays of the data from table 19, where we see an increase during Phase 1 and 2 of symbol recognition overall. Child 4 demonstrated a fluctuation throughout Phase 1 and 2 with symbol recognition and all three phases with correct responses. Child 4 averaged five prompts per session for the baseline phase, four prompts per session for Phase 1, and four prompts per session for Phase 2. If more than two prompts were needed per question, (i.e. six prompts per session total), it is presumed to be a skill deficit in this particular situation. Child 4 entered with lower foundational skills and it appeared, through the data, that he strengthened foundational skills over the targeted skills during the course of the study.

Figure 13

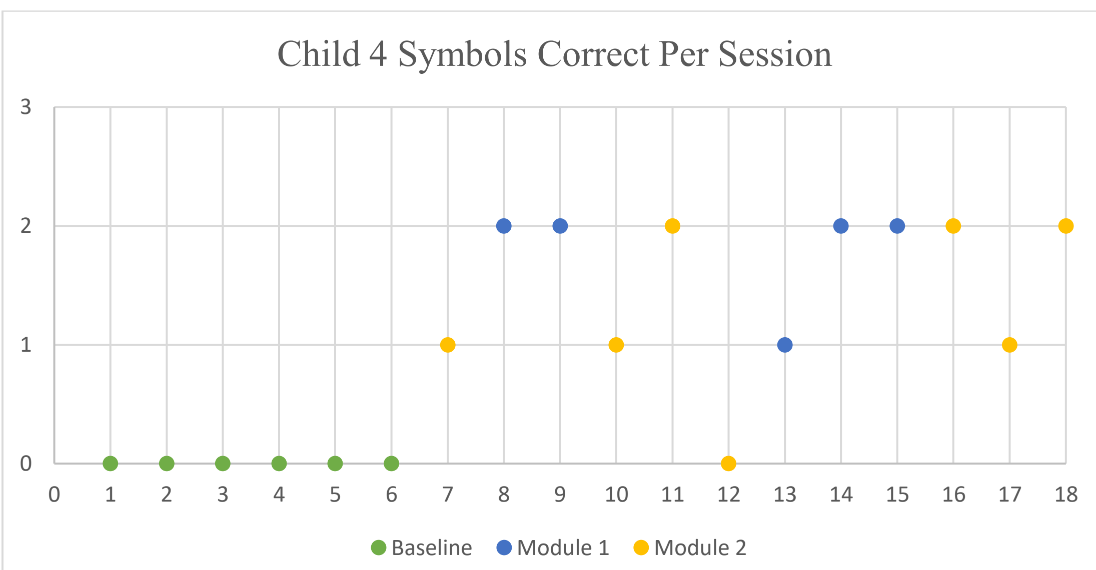
Child 4 Word Problems Correct Per Session



Note: Numbers 0-6 are Baseline phase, 7-12 are Phase 1, and 13-18 are Phase 2.

Figure 14

Child 4 Symbols Correct Per Session



Note: Numbers 0-6 are Baseline phase, 7-12 are Phase 1, and 13-18 are Phase 2.

All children in the study gained skills in the number sense domain; however, the skills gained varied due to the developmental level of each child. This is discussed further in the next section, and implications for practice and contributions to the field are also explored.

Conclusion

Implications for Practice

Several outcomes regarding the current study include: an exploration of the interplay between speech or language impairments and mathematics development, specifically with the consideration of abstract ideas such as symbol comprehension and use; constructing effective early interventions for this population, and; which components are important to include within interventions for children with speech or language impairments. The data shows a connection between abstract concepts such as symbols, mathematics vocabulary, and the ability of children with speech or language impairments to comprehend and use mathematics to solve problems in a structured educational environment. Data from the present study reveals insights regarding the acquisition of symbol recognition and application through repeated opportunities and explicit language-based instruction for children with identified speech or language impairments. Children 1, 2, and 3 demonstrated gains in this area while Child 4 displayed gains in more foundational areas of number sense, most notably in one-to-one correspondence, cardinality, and comparing quantities within 10 objects and labeling one quantity as greater than, less than, or equal too another quantity. This could be due to his young age

– four years of age as opposed to five – in conjunction with a speech or language impairment compared to typically developing peers.

Keeping in mind considerations for age and developmental level, educators can plan instruction to strengthen foundational concepts with younger students using varied combinations of evidence-based practices and play-based experiential learning strategies (Good & Ottley, 2019). For older preschool children, the introduction of symbols for engaging with simple equations can be practiced sooner given appropriate developmental levels in mathematics (Cross et al., 2019; Van Luit & Toll, 2015). Children in the study responded well to hands-on activities with turn taking opportunities such as board games, using an inpher balance scale, and various types of cards, spinners, and dice for game play. The use of manipulatives and developmentally appropriate picture books increased comprehension of abstract concepts such as how symbols are used, specifically with addition and subtraction (Ardoin et al., 2018; Donlan, 2003; Lee & Ginsburg, 2007). Thus, educators are able build effective interventions for children experiencing speech or language impairments using picture books, explicit instruction with mathematics-related vocabulary, repeated opportunities for practice with varied manipulatives and age appropriate word problems. However, it seems for the interventions to be highly effective, practice with symbols needs to be consistent over a prolonged period of time (Heath, 2010; Powell & Fluhler, 2018).

Over the course of the study and analysis of the data, it was noted that the children seemed to struggle with symbol identification for greater than and less than. However, they were able to correctly answer the questions attached to these concepts and use the symbols in context, aligning with Heath's (2010) findings regarding young children's difficulty with non-equivalence symbols such as < and >. The results from phase one questions regarding greater than, less than, and equal too and symbol recognition at the post assessment could be due to a lack of consistent practice during the last phase of the study where the focus was on addition +, subtraction -, and the equality = symbols. Powell and Fluhler (2018) posit that consistent practice with greater than and less than symbols will strengthen the association between concepts and symbol meanings over time. Thus, the more these skills are practiced in the early childhood curriculum, the stronger the foundation will be for children moving forward with formal mathematics. What follows are a few contributions to the field of early childhood education regarding the study and the previously mentioned implications.

Contributions to the Field of Early Education

The current study contributes to the research in the field of early childhood education and special education in that it demonstrates that combined evidence-based instructional strategies can benefit children with speech or language impairments in the area of mathematics. Given the results of the study, educators are better able to comprehend the link between speech and language impairments and early mathematics development (Cross et al., 2019; Ginsburg et al., 2008; Hughes et al., 2016; Okamoto, 2018). With this knowledge, better pedagogical constructs can be developed and engage educators to construct interventions that allow for more mathematical experiences in the classroom, thus enabling the opportunity gap for such children to decline providing better outcomes when entering formal educational experiences in elementary (Carter et al., 2013; Hachey, 2015; Lee & Md-Yunus, 2016). In addition, the instructional practices demonstrated throughout the study benefit children in the general education setting regarding mathematics curriculum and boosts confidence in mathematics overall. Engaging in mathematical play benefits all children at every level of development, by presenting opportunities for young children to be successful educators foster perseverance when faced with challenges regarding early mathematics.

When educators utilize research-based strategies such as explicit language-based instruction, repeated practice, and play-based experiential learning to design effective interventions for children, there is a decrease in the opportunity gap in the area of mathematics. Through illustrating the benefits to children by combining developmentally appropriate practices with effective instructional strategies as demonstrated in the study, interventions can be delivered in an engaging play-based atmosphere where children are able to experience mathematics in a positive way, thereby decreasing the likely hood of mathematics anxiety developing which would compound the deficits of the speech or language impairment in the area of mathematics as was described at the beginning of the manuscript (Bates et al., 2013; Beilock et al., 2010; Geist, 2015; Karatas et al., 2017). By incorporating picture books, developmentally appropriate word problems, manipulatives, and games to improve intrinsic motivation for sustained engagement with activities, children are able to practice foundational skills and working with abstract concepts that benefit them moving forward to more formalized mathematics instruction during elementary grade levels.

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Appendix A: IRB Approval Letter

Project Number	16-E-232
Project Status	APPROVED
Committee:	Office of Research Compliance
Compliance Contact:	Rebecca Cale (cale@ohio.edu)
Primary Investigator:	Sarah Good
Project Title:	Differentiation of math activities
Level of Review:	EXEMPT

The Ohio University Office of Research Compliance reviewed and approved by exempt review the above referenced research. The Office of Research Compliance was able to provide exempt approval under 45 CFR 46.104(d) because the research meets the applicability criteria and one or more categories of research eligible for exempt review, as indicated below.

IRB Approval:	06/22/2016 10:40:29 AM
Review Category:	1

If applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. In addition, FERPA, PPRA, and other authorizations / agreements must be obtained, if needed. The IRB-approved consent form and process must be used. Any changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

It is the responsibility of all investigators and research staff to promptly report to the Office of Research Compliance / IRB any serious, unexpected and related adverse and potential unanticipated problems involving risks to subjects or others.

This approval is issued under the Ohio University OHRP Federalwide Assurance #00000095. Please feel free to contact the Office of Research Compliance staff contact listed above with any questions or concerns.

The approval will no longer be in effect when the Primary Investigator is no longer under the auspices of Ohio University, e.g., graduation or departure from Ohio University.

Appendix B: Consent Forms

Ohio University Parental Consent & Video Recording Form

Title of Research: Comparing mathematical interventions for children with speech or language impairments in preschool.

Researchers: Sarah Good, Krisanna Machtmes, and Sara Helfrich

IRB number: 20-E-256

You are being asked by an Ohio University researcher for permission for your child to participate in research. For you to be able to decide whether you want your child to participate in this project, you should understand what the project is about, as well as the possible risks and benefits in order to make an informed decision. This process is known as informed consent. This form describes the purpose, procedures, possible benefits, and risks of the research project. It also explains how your child's personal information will be used and protected. Once you have read this form and your questions about the study are answered, you will be asked to sign it. This will allow your child's participation in the study. You should receive a copy of this document to take with you.

Summary of Study

The purpose of this research is to explore the benefits of direct language-based math activities with four- and five-year-old preschool children with speech or language impairments. Two specific activities will be created and compared which include math *picture books with activities with specific vocabulary and pairing them with (a) the use of manipulatives, or (b) developmentally appropriate word problems with symbols that can be manipulated. Both activities are experience based to build meaningful math symbol recognition (<, >, +, -, =) using language.*

Explanation of Study

This study is being done to explore the benefits of direct language-based math activities with four and five-year-old preschool children with speech or language impairments.

If you agree for your child to participate, your child will be asked to engage in 15 to 21 sessions lasting about 20 to 40 minutes each, where a picture book with math concepts will be read and activities related to the book will be completed. Your child will be given a pre and post assessment at the beginning and conclusion of the study by a familiar adult and will be ten questions long.

Your child should not participate in this study if he/she does not have a speech or language impairment or is younger than 4 or older than 6 at the time of the study. Your child's participation in the study will last approximately 6 to 10 weeks. Your child's participation in the study is voluntary. You may at any time withdraw your consent for your child's participation from the study.

You are not required to sign this consent form and you may refuse to do so without affecting your right to any services your child may be receiving. However, if you refuse to sign, your child cannot participate in this study.

Risks and Discomforts

No risks or discomforts are expected for this study.

Benefits

This study is important to society because it allows a more in-depth look at teaching activities to aid in developing math language and symbol use with early math concepts for students with speech or language impairments. The data gathered will help develop learning activities moving forward for the specific population of preschool children with speech and language difficulties who also struggle with math concepts. Your child may benefit from this research by developing or building mathematics skills as a direct result. There is also a chance that your child may not personally benefit directly from participation in this research.

Confidentiality and Records

Your child's study information will be kept confidential by placing the paper assessments in a locked filing cabinet, and data from the video recordings of sessions for data analysis will be stored in a file on a laptop with a secured passcode. The only persons that will have access to your child's information will include: Sara Helfrich, Krisanna Machtmes, and Sarah Good. Forms and video recordings will be destroyed within 5 years from the time the research is complete (as early as possible, but no later than May 2026). Additionally, while every effort will be made to keep your study-related information confidential, there may be circumstances where this information must be shared with:

* Federal agencies, for example the Office of Human Research Protections, whose responsibility is to protect human subjects in research;
* Representatives of Ohio University (OU), including the Institutional Review Board, a committee that oversees the research at OU;

Compensation

No compensation will be provided.

Future Use Statement

Data collected as part of this research, even if identifiers are removed, will not be used for future research studies.

Audio & Video Recordings

Audio and video recordings will be conducted during intervention sessions and last from 20 to 40 minutes depending on activities. Every effort will be made to keep your child's information confidential throughout this process. Only the research team will have access to these recordings for data analysis purposes. When not in use the recordings will be store on an external hard drive that is password protected. When the drive is not in use it will be stored in a locked cabinet in the researcher's office.

By signing this consent form, you are giving permission to Sarah Good to take audio/video recordings of your child in an educational setting during intervention activities and share these with the research team.

Contact Information

If you have any questions regarding this study, please contact the investigator ***Sarah Good* goods@ohio.edu *740-703-3122, Krisanna Machtmes* machtmes@ohio.edu**

740-597-1323, or the advisor **Dr. Sarah Helfrich** **helfrich@ohio.edu** ***740-593-4471***.

If you have any questions regarding your child's rights as a research participant, please contact Dr. Chris Hayhow, Director of Research Compliance, Ohio University, (740)593-0664 or hayhow@ohio.edu.

By signing below, you are agreeing that:

- you have read this consent form (or it has been read to you) and have been given the opportunity to ask questions and have them answered;
- you have been informed of potential risks to your child and they have been explained to your satisfaction;
- you understand Ohio University has no funds set aside for any injuries your child might receive as a result of participating in this study;
- you are 18 years of age or older;
- your child's participation in this research is completely voluntary;
- your child may leave the study at any time; if your child decides to stop participating in the study, there will be no penalty to your child, and he/she will not lose any benefits to which he/she is otherwise entitled.

Parent Signature____ Date_______________

Printed Name____

Child's Name____

Version Date: ***[09/05/20]***

Assent form

Title of Research: Comparing mathematical interventions for children with speech or language impairments in preschool.

Researchers: Sarah Good, Krisanna Machtmes, and Sara Helfrich

IRB number: 20-E-256

The participating children will be presented with the following script at the beginning of the first recorded session to provide assent to participate in the research project.

Script: You are going to be asked to participate in some activities where we will read a book and play some games together. I have already talked to your mommy and she said it was okay to work with me and do these activities. Would you like to come and work with me for a while?

The child's response will be documented on this form as well as video recorded.

- ☐ Yes

- ☐ No

____________________________________ ____________________

(Child's name) (Date)

____________________________________ ____________________

(Location) (Time)

Version Date: ***[09/03/20]***

Appendix C: Inclusion Criteria

Child: ________________________________

Date: ________________________________

- ☐ Child is able to answer yes and no questions and simple what questions.
- ☐ Child uses at least 3-word phrases.
- ☐ Child is able to follow novel 1 step directions without prompts.
- ☐ Child interacts with others appropriately 75% of the time.
- ☐ At least 50% of the child's speech is intelligible.
- ☐ The child has at least 1 speech or language goal in their IEP.
- ☐ Child is at least 3 and no more than 5 years of age.

____

(Signature of researcher)

Appendix D: Pre and Post Assessment

Child's name: ____________________________

Date for pre assessment: ____________________

Date of post assessment: ____________________

Date of Birth: _____________________________

Completed years of preschool: ________________ Full-day: _______ Half-day: _____

Speech or language impairment: _____________________________________

Pre-assessment score: ___________ Post-assessment score: __________

Score	Concept
/4	Stable order counting to 20: 0 points if skill is not yet exhibited, 1 point each for sequence to 5, 10, 15, and 20.
/4	One to one correspondence to 20 objects: 0 points if skill is not yet exhibited, 1 point each for sequence to 5, 10, 15, and 20.
/4	Cardinality when counting objects to 20: 0 points if skill is not yet exhibited, 1 point each for sequence to 5, 10, 15, and 20.
/5	Subitizing to 5 objects: 0 points if skill is not yet exhibited and 1 point each for 1 to 5 objects.
/4	Matching any numerals within range of 0 to 20: 0 = Not yet exhibiting skill 1 = 1 to 5 numbers 2 = 6 to 10 numbers 3 = 11 to 15 numbers 4 = 16 to 20 numbers
/4	Identifying any numerals within range of 0 to 20:

	0 = Not yet exhibiting skill 1 = 1 to 5 numbers 2 = 6 to 10 numbers 3 = 11 to 15 numbers 4 = 16 to 20 numbers
/5	Recognizing symbols to include <, >, =, +, - with appropriate vocabulary: 0 points if skill is not yet exhibited, 1 point each for symbol
/3	Comparing quantities to 10 objects: 0 points if skill is not yet exhibited, 1 point each for greater than/more, less than/fewer, and equal too/same
/3	Simple addition/counting on equations: 0 points if skill is not yet exhibited, 1 point for each equation completed of 3 opportunities
/3	Simple subtraction/taking apart equations: 0 points if skill is not yet exhibited, 1 point for each equation completed of 3 opportunities

Children will be given the opportunity to complete each task with no more than two verbal or visual prompts from the adult administering assessment. Manipulatives will be used during all tasks with the exception of stable order counting to 20 and cardinality tasks. When child exhibits frustration with a task administration will move to next task. The adult administering will use their knowledge of the child and make the judgement whether to come back to the frustrating task towards that end of the assessment to provide one additional opportunity. The adult administering the assessment will use two colored ink pens to differentiate between the pre and post assessments on the same form for each individual child.

All elements of this assessment with the exception of the symbol recognition section are based on the board approved preschool assessment developed by the Ross-Pike Educational Service District preschool assessment team. This assessment is used three times throughout the school year to gauge progress made by preschool students both typically developing and with identified disabilities. The full assessment has also been adopted by various other school districts throughout southern Ohio as well.

Appendix E: Procedural Fidelity Checklists

Baseline

- ___ Script: Are you ready to read our book now or would you like to do that in two minutes?
- ___ Visual timer if child needs two minutes before beginning and to use for session length when we reach activities.
- ___ Mathematical picture book
- ___ Manipulatives related to the book
- ___ Dice, spinner, cards for activities if needed
- ___ Board for child and teacher (i.e. grid, ten frame, short path game, long path game, etc.)
- ___ Vocabulary terms for the session are discussed (mostly signs and operations)
- ___ Teacher models** activity for children (two times before beginning the activity)
- ___ Teacher is a partner in the game or manipulative activities
- ___ Teacher and child participate in activities with manipulatives for 15-20 minutes (not including the reading of the book).
- ___ Three-word problems for child at the conclusion of the session (number range of 0 to 10 for objects used for word problems)

**Teacher will model how to take a turn before game play begins or manipulative activities start a minimum of two times. An example of this behavior may look like the following: The teacher may say "I am going to show you how to play this game." Rolls a six sided die then shows the turned up face to the child and counts the dots or states the numeral shown. Then the teacher will complete the action associated with the game or manipulative activity. An example may be positioning the number of objects on a board and counting the objects as they are placed.

First Intervention Module

- Script: Are you ready to read our book now or would you like to do that in two minutes?
- Visual timer if child needs two minutes before beginning and to use for session length when we reach activities.
- Mathematical picture book
- Manipulatives related to the book
- Board for child and teacher (i.e. grid, ten frame, short path game, long path game, etc.)
- Vocabulary terms for the session are discussed (mostly signs and operations)
- Teacher models** activity for children (two times before beginning the activity)
- Teacher and child participate in activities with manipulatives for 15-20 minutes (not including the reading of the book).
- Repeated practice opportunities of concepts imbedded in activities (at least 3 turns or opportunities per child and teacher)
- The use of numerical symbols or groups of object for subitizing (number recognition: 0 – 10)
- Three-word problems for child at the conclusion of the session (number range of 0 to 10 for objects used for word problems)

**Teacher will model how to take a turn before game play begins or manipulative activities start a minimum of two times. An example of this behavior may look like the following: The teacher may say “I am going to show you how to play this game.” Rolls a six sided die then shows the turned up face to the child and counts the dots or states the numeral shown. Then the teacher will complete the action associated with the game or manipulative activity. An example may be positioning the number of objects on a board and counting the objects as they are placed.

Second Intervention Module

- Script: Are you ready to read our book now or would you like to do that in two minutes?
- Visual timer if children need two minutes before beginning and to use for session length when we reach activities.
- Mathematical picture book
- Manipulatives related to the book
- Board for child and teacher (i.e. grid, ten frame, short path game, long path game, etc.)
- Vocabulary terms for the session are discussed (mostly signs and operations)
- Teacher models** activity for children (two times before beginning the activity)
- Teacher and child participate in activities with manipulatives for 15-20 minutes (not including the reading of the book).
- Repeated practice opportunities of concepts imbedded in activities (at least 3 turns or opportunities per child and teacher)
- The use of numerical symbols or groups of object for subitizing (number recognition: 0 – 10)
- The use of mathematical symbols to include (<, >, =, +, -) split between phase 2 and phase 3 of the study
- Opportunities for practicing word problems before the final three at the conclusion of each session

- Three-word problems for each child at the conclusion of the session (number range of 0 to 10 for objects used for word problems)

**Teacher will model how to take a turn before game play begins or manipulative activities start a minimum of two times. An example of this behavior may look like the following: The teacher may say "I am going to show you how to play this game." Rolls a six sided die then shows the turned up face to the child and counts the dots or states the numeral shown. Then the teacher will complete the action associated with the game or manipulative activity. An example may be positioning the number of objects on a board and counting the objects as they are placed.

Version 9/22/2020

Appendix F: Post Session Word Problems

At the conclusion of each intervention sessions each participant will be asked the same three word problems. They will be provided manipulatives to use to aid them in working through the word problems.

Baseline word problems will include a variety of comparison, addition, and subtraction problems. No symbols will be presented for manipulation in this phase.

Session 1 – Baseline

1. The owl found 5 leaves. The bat found 8 leaves. Which animal found the least or smallest amount?
2. The bird has 4 leaves. The squirrel has 3 leaves. The bat has 4 leaves. Which two animals have the same number of leaves?
3. The bat found 6 leaves. The bird found 2 leaves. Which animal found the most or greatest number of leaves?

Session 2 – Baseline

1. Emme has 5 apples. Paul has 1 apple. Who has the most or greatest number of apples?
2. Emme found 6 leaves, Paul found 3 leaves, and Aidyn found 3 leaves. Which two children found the same number of leaves?
3. Paul has 3 apples and Emme has 7 apples. Who has the least or smallest number of apples?

Session 3 – Baseline

1. There are 3 big baskets. The first one has 2 apples, the second has 4 apples, and the third has two apples. Which ones have the same number of apples?
2. The basket has 2 apples, and the tractor has 3 apples. Which one has the most apples?
3. There are 2 big baskets. One basket has 4 apples in it and the other basket has 2 apples in it. Which basket has the least number of apples?

Session 4 – Baseline

1. The apple tree had 8 apples. The wind blew and 4 apples fell off. How many apples are left on the tree?
2. The apple tree had 10 apples. The wind blew 3 apples off. How many apples are left on the tree?
3. The apple tree had 9 apples. The wind blew 7 apples off. How many apples are left on the tree?

Session 5 – Baseline

1. There were 10 black spiders crawling on the fence. The wind blew and 5 spiders flew away. How many spiders were left on the fence?
2. There were 8 black spiders crawling on the fence. The wind blew 2 spiders away. How many spiders were left on the fence?
3. There were 8 spiders crawling on the fence. The wind blew and 6 spiders fell off. How many spiders were left on the fence?

Session 6 – Baseline

1. The squirrel found 2 leaves. The bat found 4 leaves. The owl found 3 leaves. How many leaves did the animals find all together?
2. The squirrel found 7 leaves and the owl found 2 more leaves. How many leaves do the animals have all together?
3. The Owl found 4 leaves, the bat found 3 leaves, and the squirrel found 1 leaf. How many leaves do the animals have all together?

This phase only comparison word problems will be presented. During certain sessions symbols will be presented for children to use in conjunction with manipulatives to create a visual display to aid in solving the word problem.

Session 1 – Phase 1: <, >, =

1. Jackson has 7 pumpkins. Maddie has 5 pumpkins. Who has the most or greatest number of pumpkins?
2. Jackson has 10 pumpkins and Maddie has zero pumpkins. Who has the least number of pumpkins?
3. Jackson has 3 pumpkins, Maddie has 6 pumpkins, and Emme has 3 pumpkins. Who has the same number of pumpkins?

Session 2 – Phase 1

1. The squirrel has 8 acorns. The bird has 4 acorns. Which animal has the most or greatest number of acorns?
2. The squirrel has 10 acorns. The bird has 6 acorns. Which animals has the least number of acorns?
3. The squirrel has 4 acorns. The bird has 5 acorns. The owl has 4 acorns. Which animals have the same number of acorns?

Session 3 – Phase 1

1. The fence has 8 spiders crawling on it. The truck has 5 spiders crawling on it. Which has the most spiders on it?
2. The fence has 7 spiders crawling on it and the truck has zero spiders crawling on it. Which has the least number of spiders on it?
3. The fence has 3 spiders crawling on it. The truck has 7 spiders crawling on it. The ground has 3 spiders crawling on it. Which items have the same number of spiders crawling on them?

Session 4 – Phase 1

1. The black spider ate 2 bugs. The brown spider ate 4 bugs. The gray spider ate 4 bugs. Which two spiders ate the same number of bugs?
2. The brown spider ate 7 bugs. The gray spider ate 5 bugs. Which spider ate the most or greatest number of bugs?
3. The brown spider ate 1 bug. The gray spider ate 6 bugs. Which spider ate the least number of bugs?

Session 5 – Phase 1

1. There are 5 jack-o-lanterns sitting on the fence. There are 3 jack-o-lanterns sitting on the porch. Which has the greatest number of jack-o-lanterns?
2. There are 10 jack-o-lanterns sitting on the fence. There are 6 jack-o-lanterns sitting on the porch. Which one has the least number of jack-o-lanterns?
3. The ground has 3 jack-o-lanterns. The fence has 5 jack-o-lanterns. The porch has 5 jack-o-lanterns. Which ones have the same number of jack-o-lanterns?

Session 6 – Phase 1

1. The black spider ate 1 bug. The brown spider ate 6 bugs. The gray spider ate 6 bugs. Which two spiders ate the same number of bugs?
2. The brown spider ate zero bugs. The gray spider ate 5 bugs. Which spider ate the most or greatest number of bugs?
3. The brown spider ate 4 bugs. The gray spider ate 7 bugs. Which spider ate the least number of bugs?

This phase only addition and subtraction word problems will be presented. During certain sessions symbols will be presented for children to use in conjunction with manipulatives to create a visual display to aid in solving the word problem.

Session 1 – Phase 2

1. Emme saw 6 spiders on the porch. Then, 4 spiders crawled away. How many spiders are left on the porch?
2. Paul saw 3 spiders crawling on the porch. Emme saw 6 spiders crawling on the fence. How many spiders are there all together?
3. Emme saw 2 spiders crawling on the porch. Paul saw 5 spiders crawling on the fence. How many spiders are there all together?

Session 2 – Phase 2

1. The squirrel gathered 9 acorns. He dropped 2. How many acorns does the squirrel have left?
2. The squirrel has 4 acorns. The bird has 6 acorns. How many do they have all together?
3. The squirrel has 5 acorns and the bird has 5 acorns. How many do they have all together?

Session 3 – Phase 2

1. The truck is carrying 7 jack-o-lanterns. The tractor is carrying 3 jack-o-lanterns. How many jack-o-lanterns are there all together?
2. The truck is moving 10 jack-o-lanterns but 4 fall off. How many jack-o-lanterns are left?
3. The tractor is moving 8 jack-o-lanterns but 6 fall off. How many jack-o-lanterns are left?

Session 4 – Phase 2

1. The big basket has 10 leaves in it. When Paul jumps in the basket 6 leaves fall out. How many leaves are left?
2. The first big basket has 6 leaves in it. The second big basket has 4 leaves in it. How many leaves are there all together?
3. The big basket has 9 leaves in it. When Emme jumps in the basket 4 leaves fall out. How many leaves are left in the basket?

Session 5 – Phase 2

1. There are 7 turkeys on the ground and 3 on the fence. How many turkeys are there all together?
2. There are 5 turnkeys on the truck and 3 turkeys on the fence. How many turkeys are there all together?
3. There are 10 turkeys on the fence. 6 turkeys fly away. How many turkeys are left on the fence?

Session 6 – Phase 2

1. There are 10 pumpkins on the fence. 7 pumpkins roll away. How many pumpkins are left on the fence?
2. There are 8 pumpkins on the fence. There are 2 pumpkins in the truck. How many pumpkins are there all together?
3. There are 6 pumpkins in the truck. 3 pumpkins roll out of the truck. How many pumpkins are left in the truck?

Appendix G: Recording Form

Child: ________________________________

Module	Session	Correct	Incorrect	Symbol	Prompts	2 + Prompts	Frustration Level
	Baseline - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 6				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 6				☐ ☐	Attention Skill Deficit	Low Mid High
	Baseline - 6				☐ ☐	Attention Skill Deficit	Low Mid High

Module	Session	Correct	Incorrect	Symbol	Prompts	2 + Prompts	Frustration Level
	Phase 2 - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 6				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 6				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 2 - 6				☐ ☐	Attention Skill Deficit	Low Mid High

Module	Session	Correct	Incorrect	Symbol	Prompts	2 + Prompts	Frustration Level
	Phase 3 - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 1				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 2				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 3				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 4				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 5				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 6				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 6				☐ ☐	Attention Skill Deficit	Low Mid High
	Phase 3 - 6				☐ ☐	Attention Skill Deficit	Low Mid High

Appendix H: Randomized Session Checklist

Child # 1

Baseline Phase there is no randomization all children will receive the same sessions in the same order.

Session:

- Matching objects (1)
- Sequential counting to 10 (2)
- Forward and Backward counting to 10 (3)
- Size or magnitude (4)
- Equal groups counting to 12 (5)
- Measurement (6)

Phase 1: <, >, =

- More and Less Module 2
- More and Less Module 2
- Equal Module 1
- Equal Module 1
- Equal More and Less Module 2
- More and Less Module 1

Phase 2: +, -, =

- Subtraction Module 1
- Addition Module 2
- Addition Module 2
- Subtraction Module 1

- Addition Module 2
- Subtraction Module 2

Child # 2

Baseline Phase there is no randomization all children will receive the same sessions in the same order.

Session:

- Matching objects (1)
- Sequential counting to 10 (2)
- Forward and Backward counting to 10 (3)
- Size or magnitude (4)
- Equal groups counting to 12 (5)
- Measurement (6)

Phase 1: <, >, =

- More and Less Module 2
- More and Less Module 1
- Equal Module 1
- Equal Module 2
- Equal More and Less Module 2
- More and Less Module 2

Phase 2: +, -, =

- Subtraction Module 1
- Addition Module 1

- Addition Module 1
- Subtraction Module 2
- Addition Module 2
- Subtraction Module 2

Child # 3

Baseline Phase there is no randomization all children will receive the same sessions in the same order.

Session:

- Matching objects (1)
- Sequential counting to 10 (2)
- Forward and Backward counting to 10 (3)
- Size or magnitude (4)
- Equal groups counting to 12 (5)
- Measurement (6)

Phase 1: <, >, =

- More and Less Module 2
- More and Less Module 1
- Equal Module 2
- Equal Module 1
- Equal More and Less Module 2
- More and Less Module 1

Phase 2: +, -, =

- Subtraction Module 1
- Addition Module 2
- Addition Module 1
- Subtraction Module 2
- Addition Module 1
- Subtraction Module 1

Child # 4

Baseline Phase there is no randomization all children will receive the same sessions in the same order.

Session:

- Matching objects (1)
- Sequential counting to 10 (2)
- Forward and Backward counting to 10 (3)
- Size or magnitude (4)
- Equal groups counting to 12 (5)
- Measurement (6)

Phase 1: <, >, =

- More and Less Module 2
- More and Less Module 2
- Equal Module 1
- Equal Module 1
- Equal More and Less Module 1
- More and Less Module 1

Phase 2: +, -, =

- Subtraction Module 1
- Addition Module 2
- Addition Module 1
- Subtraction Module 2
- Addition Module 2
- Subtraction Module 1

Appendix I: COVID Research Protocol

Ohio University – Research Restart Form

Human Subject Research

Complete and submit electronically to your Chair/Director, who upon approval will submit to the Associate Dean for Research for review. Be as thorough as possible.

Research Operation Plan

1. Principal Investigator Name: Sarah Good
    a. Email address: goods@ohio.edu

2. Submission Date: September 1, 2020

3. Project Title: Comparing Interventions for Children with Speech or Language Impairments in Preschool
    a. Brief summary/description of research activities to be performed (brief paragraph – should match LEO form).
        - The purpose of this research is to assess the impact of explicit language-based mathematical interventions with four- and five-year-old preschool children experiencing speech or language impairments as defined by the Individuals with Disabilities Education Act of 2004 eligibility standards. Two specific intervention modules will be created that include mathematical picture books with coordinating activities accompanied with specific mathematical vocabulary and pairing them with either (a) the use of manipulatives, or (b) developmentally appropriate word problems with symbols that can be manipulated. Both interventions promote experience based learning opportunities to build relevant mathematical symbol representation (<, >, +, -, =) using language.

    b. Describe impact if activity is delayed.
        - If activity is delayed it would stall the dissertation process and I would not be able to complete my degree within timeline.

    c. Does this research include persons vulnerable to COVID-19 (e.g., advanced age, obesity, diabetes, HIV, etc.)?
        - No additional vulnerabilities known at this time within the preschool population or interest. None for the primary researcher either.

4. List of involved personnel. For each individual provide:
    a. Full name
    b. Status (faculty, staff, postdoc, grad student, undergrad)
    c. PID
    d. OU email

- Sarah Good, **PID:** P000847393, **status:** grad student, **email:** goods@ohio.edu
- Sara Helfrich, **PID:** P001275351, **status:** faculty, **email:** helfrich@ohio.edu
- Krisanna Machtmes, **PID:** P100194532, **status:** faculty, **email:** machtmes@ohio.edu

5. If undergraduate students are included on the personnel list, explain the necessity of their inclusion for the success of the project or completion of academic program requirements.
    - Not applicable

6. Describe the role of each of the personnel listed and their typical daily research activities.
    - Sarah good is the principal investigator and will be conducting the research, video recordings, and providing the interventions to participants. Typical daily activities may include: video recordings, planning intervention activities, data collection, and data analysis.
    - Sara Helfrich is in an advisory role providing consultation on research as needed.
    - Krisanna Machtmes is in a consultation role providing guidance and assistance with data analysis as needed.

7. Provide a list of research activity locations (buildings, rooms).
    - Adena Local Schools Elementary – Library and adjacent room
    - Huntington Local Schools Elementary – Therapy room (empty classroom)
    - Ross-Pike Education Service District – Conference room

Research / Creative Activity Health and Safety Plan:

8. Describe which of the research activities are going to be conducted in-person and which will remain remote only.
    - Remote only activities will be reviewing IEP documents for inclusion criteria and consultation between research team members regarding guidance and data analysis for video recordings.
    - Activities that will be in-person will be the delivery of interventions for comparison during the 3 phases of the research project.

9. Provide the information sheet used that will inform subjects of the added risk of exposure to COVID-19 and all the steps the research team is taking to minimize this risk.
    a. See attached forms at the end of this document.

10. Describe your daily COVID-19 pre-screening process for research personnel *and* participants.
    a. Include details as to where, how and by whom this COVID-19 pre-screening of participants will occur.
        - All researchers and participants will complete the vulnerability form before in-person contact. This will be completed before the first video recorded session, preferably during the meeting for consent to participate in research.
        - The form is to be completed by the researcher before meeting with anyone at the beginning of the research project. The form will be completed by the participants for both the parents and children.
        - A temperature log will be completed each session for the researcher and any participants for current sessions.

    b. See attached forms for specifics.

11. Plans for social distancing (if applicable)
    a. Physical distancing (strongly recommended) – e.g., space layout, separation of work-stations, coordination of movements (traffic flow) between and within shared spaces and work shifts to enable isolation
        - The space being used for the intervention sessions will be a minimum of 6 feet and a maximum of 9 feet from any other working centers (often we will be in a room to ourselves).
        - The researcher and any participants will share a 4 to 6 foot table to work at with appropriate distancing (6 feet between individuals) when able.
        - For materials that will be used across multiple sessions each participant and the researcher will have identical containers with said materials as to keep the possibility of sharing any materials extremely low.

    b. Temporal distancing (recommended – if possible) – e.g., staggering research activities or research study visits (recommendation ranges from 20 minute to 3 hours between study participants, based on quality of air circulation and existence of appropriate barriers)
        - Intervention sessions will be done on different days with students so that they are spread out across the week. Each child will participate in two to three sessions per week individually.

    c. Identify the maximum number of people to be working simultaneously in any research facility space (room).
        - 2 – one adult and 1 child.

    d. What measures are being used to ensure adequate space (e.g., removal of unused equipment) in the designated rooms to allow for social distancing?
        - The researcher and 1 participant will be the only ones scheduled in the setting at the designated times of intervention sessions.

- One large table (4 or 6 feet) will be used in the space for activities.

12. Describe any planned use of personal protective equipment (PPE), as applicable
    a. Describe this separately for study personnel and human subjects
        - The researcher will wear a cloth mask (or face shield when appropriate) and participants will be asked to wear a mask (since they are four years old they are not mandated to wear them). Gloves will be used for cleaning and when materials need to be moved between participants.
    b. Do you have sufficient PPE to start/maintain your proposed research activity?
        - Yes
    c. How will PPE be cleaned and maintained from day to day?
        - Gloves will be properly disposed of directly after use. The researcher's masks and clothing will be laundered and sanitized after each session. The face shield after use will be properly sanitized after each use as well.
    d. How will you manage clothing used in the research facility to mitigate pathogen transfer to home or other university areas outside of the laboratory/facility?
        - Clothing and masks will be sprayed with a fabric safe sanitizing spray (at least 70% alcohol) once the session is ended and then laundered once the researcher is home.
    e. How will lab clothing or PPE (masks) be cleaned and at what frequency (a minimum cleaning cycle is daily for any scrubs or lab clothing used for research, that is, a researcher may wear a set of scrubs for a day of lab work but that clothing must be laundered before another day of use is allowed.)
        - Cloth masks will be cleaned each day after use.

13. Describe hand washing / disinfecting stations available throughout the research space
    - All participants and the researcher will wash hands before going to the intervention session space at the nearest restroom. There will also be hand sanitizer in a pump type bottle available at all times during the sessions.

14. Describe equipment and high-touch surfaces (e.g., table surfaces and doorknobs) used for research activities, and plans for cleaning / disinfection (equipment list must match your LEO protocol):
    a. Frequency
    b. Cleaning or disinfecting materials used
    c. How this will be implemented and tracked. Provide checklists for tracking.
        - Doorknobs, chairs, tables, and any materials (manipulatives or toys) will be disinfected before and after each session. The disinfectant used is Becto Fight Bac RTU (the fact sheet is

attached to the IRB) in a spray bottle with paper towels. The tracking forms for these procedures are at the end of this document.

15. Identify any additional shared equipment facilities/core facilities to be used. Provide sample schedule for shared use and disinfecting
    - Currently there are no shared facilities at the same time as researcher will be using them.
    - There will not be any shared equipment for this research.

16. Describe other measures to be deployed that are unique to the specific research activity.
    - Due to the possibility of working with a child with hearing impairment or loss that uses an FM system while at school a face shield will be used to enable them to lip read as well if they are selected for participation in the research. The face shield has been approved for use by the schools educational board for use with this child by teachers and any adults that work with them.

17. Describe what will be required to stop or pause the research protocol if pandemic conditions necessitate another lockdown (if applicable).
    - Notification to parents that due to COVID pandemic conditions research will have to be stopped or paused until further notice.

Add digital signature/date lines for:

- Department Chair or School Director
- Associate Dean for Research
- Principal Investigator

_____________________ Department Chair or School Director ________________

(Signature) (date)

_____________________ Associate Dean for Research ________________

(Signature) (date)

_____________________ Principal Investigator ________________

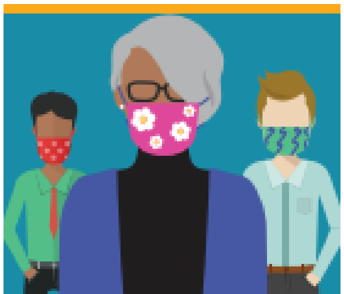
(Signature) (date)

Stop the Spread of Germs

Help prevent the spread of respiratory diseases like COVID-19.

Stay at least 6 feet (about 2 arms' length) from other people.

Cover your cough or sneeze with a tissue, then throw the tissue in the trash and wash your hands.



When in public, wear a cloth face covering over your nose and mouth.

Do not touch your eyes, nose, and mouth.

Clean and disinfect frequently touched objects and surfaces.

Stay home when you are sick, except to get medical care.

Wash your hands often with soap and water for at least 20 seconds.

CDC

cdc.gov/coronavirus

Vulnerability Check

To be completed one time, before study begins, for each member of the research team and each study participant before their participation in human subject research.

Researcher's Name or Participant ID Number: ____

Date: ____________________

Do you have any of the following conditions or consider yourself vulnerable to COVID-19 for some other reason? ☐ **Yes** ☐ **No**

- Chronic kidney or liver disease
- COPD (chronic obstructive pulmonary disease)
- Other respiratory illnesses (cystic fibrosis, moderate/severe asthma, emphysema, etc.)
- Current smoker
- Immunocompromised state (weakened immune system) from solid organ transplant or immune deficiencies (i.e., HIV)
- Obesity (body mass index [BMI] of 30 kg/m^2 or greater)
- Heart conditions, such as heart failure, coronary artery disease, or cardiomyopathies
- Sickle cell disease
- Type 1 or 2 diabetes mellitus
- Hypertension
- Thalassemia (or related blood disorders)
- Pregnancy

If you answered YES, you may choose to not participate in face-to-face research activities at this time or to seek reasonable accommodations where possible.

COVID-19 Exposure Log

This form must be up to date prior to participating in any research activities each day but it can be used for self-monitoring purposes.

To protect a researcher's privacy, specifics such as location name, name(s) of visitor(s) can be replaced with generic terms (i.e., indoor restaurant dining rather than a specific name of the restaurant). However, provide as much detail as possible for the PI to make a determination if it is safe for you to assist with research and for potential contact tracing.

Name: ____________________________

Date	Location Visited*	PPE Worn? (Describe)	Social Distancing? (Yes or No)
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	
		Mask Face shield gloves	

* For each location visited, list the details of the event (e.g., location details, personal visitation, etc.). Detailed tracking of each member of the research team will facilitate calculation of the overall risk of continuing human subject research. If there was no exposure on any given date, this also needs to be noted in this log.

COVID-19 Cleaning Log

This form will be used by the researcher to log the cleaning of materials between uses, contact surfaces (chairs and tables) before and after sessions, and any other high contact surfaces.

The date of the session will be recorded, the time and surfaces cleaned before the session started, time and surfaces cleaned after the session, and the time and loose materials cleaned that were used during the session. The loose materials once touched by a person will be placed within a basket on the table to be cleaned at a later time.

Name: ________________________________

Date	Beginning of session	End of session	Loose materials

Child & Researcher Temperature & Symptom log

This form will be used to log temperatures before each session of every participant. Any symptoms noticed during the session will also be logged.

Date	Participant ID	Temperature	Observed symptoms