DO PARENT-CHILD MATH ACTIVITIES ADD UP? A HOME NUMERACY ENVIRONMENT INTERVENTION FOR PARENTS OF PRESCHOOL CHILDREN

by

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For my grandparents, Andrew and Emma Napoli

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ABSTRACT

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Early numeracy skills are related to children's later mathematics and reading skills. Early interventions that target parent-child numeracy practices may be an effective way to promote these skills in young children. The aim of the current study was to evaluate the effectiveness of a home numeracy environment (HNE) intervention in increasing preschool children's early numeracy skills through a randomized controlled trial. The intervention was designed to incorporate practices that have been shown to improve children's numeracy development, in addition to a number of practices that have been shown to lead to effective outcomes for parenting interventions more broadly. Parents were randomly assigned to participate in either the HNE intervention or an active comparison condition. Both groups of parents attended a brief informational meeting and received daily text messages for four weeks; parents in the intervention group received information about the importance of early mathematics development and strategies for incorporating numeracy into their children's daily routines and parents in the active comparison condition received information on general development in preschool. Before and after the intervention, parents completed a questionnaire on their numeracy beliefs and practices, and children were assessed on their early numeracy skills. Findings indicate that, compared to parents in the comparison condition, parents who participated in the intervention reported more frequent direct HNE activities and their children showed greater improvement on numeracy skills. There were no group differences on beliefs of importance of math, self-efficacy for teaching math, or engagement in indirect HNE practices. The study provides initial evidence that a brief HNE intervention is feasible for parents to implement and is effective in improving preschool children's numeracy skills.

INTRODUCTION

Early numeracy skills are an important component of children's early development (Baroody, Lai, & Mix, 2006). Children develop early numeracy skills in two primary contexts: early childcare settings and the home (Clements & Sarama, 2009). Unfortunately, mathematics development is rarely a focus in preschool classrooms (Piasta, Pelatti, & Miller, 2014), making the home environment a critical context for the development of these skills. There was a critical gap in our understanding of home numeracy interventions, and particularly whether a broad, non-intensive home numeracy intervention can be effective in improving children's early numeracy skills. Thus, the purpose of this study was to develop a home numeracy environment intervention for parents of preschool-aged children and to evaluate it in the context of a randomized controlled trial (RCT).

Importance of Early Math

Mathematics skills are a foundational and critical component of early development (Baroody et al., 2006). Children's early mathematics skills are related to their later mathematics and reading skills (Duncan et al., 2007; Nguyen et al., 2016; Watts, Duncan, Siegler, & Davis-Kean, 2014). Children who enter formal schooling with foundational numeracy skills are more likely than their peers without these skills to succeed in kindergarten and in subsequent grades (Byrnes & Wasik, 2009) as early skills lay a foundation upon which to build more advanced skills. Further, these early skills predict greater educational attainment and socioeconomic status later in life (Ritchie & Bates, 2013).

The importance of a strong foundation in early mathematics skills makes it critical to identify potential avenues for supporting their development during the preschool years, especially because individual differences in children's abilities appear early in life (Dowker, 2008) and

persist (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004). For example, some children enter kindergarten with the ability to count to 100 or higher, while others are unable to count to 5 (Sarama & Clements, 2009b) and differences between children can also be observed in calculation abilities at kindergarten entry (Jordan, Kaplan, Nabors, Oláh, & Locuniak, 2006). Children are capable of developing an understanding of numerical ideas from a very young age and should be exposed to developmentally appropriate and engaging instruction early in life and in multiple contexts to better ensure that they have a strong foundation in mathematics (Clements & Sarama, 2009; Ginsburg, Lee, & Boyd, 2008; Jordan & Levine, 2009). Though a significant body of literature has focused on providing this instruction in preschools, less is known about the development and evaluation of interventions that can be effectively implemented in the home.

Theoretical Importance of Context

The context in which children are exposed to numeracy concepts is critical to consider, and though the school setting may be the obvious environment for this exposure, the home setting also plays a key role in this development (Aubrey, Bottle, & Godfrey, 2003; Lukie, Skwarchuk, LeFevre, & Sowinski, 2014). Proximal processes, such as the interactions between children and their parents, are thought to be the primary mechanism through which humans learn and develop (Bronfenbrenner & Morris, 2006). Bronfenbrenner and Ceci (1994) highlight, "For parents to further their children's learning and skill typically requires knowledge, know-how, and materials" (p. 576). However, this knowledge is not always innate and parents do not always have access to materials that facilitate children's development (Bradley & Corwyn, 2002). An intervention that provides information and basic materials may aid parents in supporting their children's numeracy development.

Research on the home numeracy environment is especially critical given that, compared to the preschool environment, less research has focused on developing and evaluating effective home numeracy programs. Mazzocco (2016) suggests that the home environment may be an under-examined and untapped component of children's early mathematics development because mathematics does not receive the same widespread public attention that literacy does (e.g., Council on Early Childhood, 2014). Additionally, and especially when compared to literacy activities, parents often exhibit reluctance to engage in mathematics activities with their children, perhaps due to math anxiety (Cannon & Ginsburg, 2008). Parents also tend to be less aware of the importance of early mathematics skills compared to other early skills, such as literacy and social skills (Musun-Miller & Blevins-Knabe, 1998). Encouraging parents to become involved and invested in their children's early mathematics development is a critical issue that must be addressed in order to narrow the school-entry gap in mathematics skills. Ultimately, there is a need to provide parents of preschool-aged children with strategies to appropriately integrate mathematics into their children's daily lives.

Early Mathematics Skills

Early mathematics skills are comprised of four factors that form the foundation for later mathematics learning: numeracy, measurement, geometry, and patterning (Clements & Sarama, 2009; Greenes, 1999; Milburn, Lonigan, DeFlorio, & Klein, 2018). Numeracy includes awareness of the use of numbers in counting, number relations, and arithmetic operations (Purpura & Lonigan, 2013). Measurement includes integrating and applying the other early mathematics skills in order to compare quantities, lengths, weights, and heights (Greenes, 1999). Geometry includes awareness of characteristics of shapes and ability to label, explain, characterize, and construct shapes (Clements & Sarama, 2009; Levenson, Tirosh, & Tsamir, 2011). Patterning involves

replicating, completing, predicting, extending, and describing predictable sequences (Clements & Sarama, 2009; Rittle-Johnson, Fyfe, McLean, & McEldoon, 2013). Although each of the early mathematics skills may be important for children's early mathematical understanding, numeracy skills appear to be an especially critical component (Nguyen et al., 2016; Rittle-Johnson, Fyfe, Hofer, & Farran, 2016), likely because children's understanding of number is central to more advanced math knowledge (Jordan et al., 2006). Thus, the current intervention is focused specifically on promoting numeracy skills.

Broad development of early numeracy skills

Mathematics skills are developed on a trajectory, meaning that basic skills must be learned before more complex skills can be mastered (Clements & Sarama, 2009). Broadly, early numeracy skills develop from informal knowledge to formal knowledge (Purpura, Baroody, & Lonigan, 2013). Informal knowledge is mathematical understanding that children gain through their everyday experiences (e.g., learning the meaning of the word "one" through interactions with adults), often outside of formal educational settings (Baroody & Wilkins, 1999; Ginsburg, 1977). Formal knowledge refers to the shift from concrete to symbolic understanding (e.g., using Arabic numerals) and includes skills that children often develop in formal school settings (e.g., learning that "1 + 1" represents adding two items together; Ginsburg, 1977). Researchers have observed the importance of numeral knowledge in the transition from informal to formal numeracy knowledge (Göbel, Watson, Lervåg, & Hulme, 2014; Purpura et al., 2013). Numeral knowledge refers to identifying, labeling, and connecting Arabic numerals to the quantities that they represent. The mediating role of numeral knowledge suggests that children must connect their informal knowledge to numeral knowledge before they are able to connect such knowledge to formal knowledge (Merkley & Ansari, 2016). Importantly, early numeracy skills are malleable and can

be promoted through formal instruction as well as through informal interactions (Baroody, Eiland, & Thompson, 2009; Clements & Sarama, 2007, 2008; Starkey, Klein, & Wakeley, 2004).

Informal numeracy skills

The key mathematical focus during the preschool years is informal numeracy knowledge (National Research Council [NRC], 2009). Developmentally appropriate informal numeracy instruction promotes the development of informal skills that lay the foundation for the formal skills that should be acquired during the elementary school years (Clements & Sarama, 2007). Three primary informal skills that are integral to the acquisition of later numeracy skills are numbering, number relations, and arithmetic operations (NRC, 2009; Purpura & Lonigan, 2013). Numbering skills relate to understanding of the counting sequence (e.g., verbal counting, counting from numbers other than one, one-to-one correspondence, cardinality), and these skills are individual components that children gradually develop over time (Wynn, 1992). Relations skills include understanding how numbers are related to each other and how they are associated on the mental number line (e.g., number comparisons; NRC, 2009). Arithmetic operations include understanding of composition and decomposition of groups (e.g., addition, subtraction, story problems; Baroody, 2006). Confirmatory factor analyses indicate that these three aspects of numeracy are distinct, but highly related, skills (Milburn et al., 2018; Purpura & Lonigan, 2013).

National standards emphasize informal numeracy skills as being important for children to develop during the preschool years (Common Core State Standards, 2011; National Council of Teachers of Mathematics, 2006). However, there is large variability in the individual skills that children have when they enter kindergarten, and many do not have the informal skills that are necessary to understand more advanced concepts that they will be exposed to in kindergarten (Sarama & Clements, 2009b). The home environment is strongly related to these differences in

children's skills at kindergarten entry (Anders et al., 2012; Bernstein, West, Newsham, & Reid, 2014; Mulligan, Hastedt, & McCarroll, 2012), thus making it a critical context for targeting and improving foundational mathematics skills.

Environments Where Preschool Children Learn Math

Childcare settings and the home are the two primary environments where most American children are exposed to early mathematics concepts during the early years (Anders et al., 2012; Starkey et al., 2004; Warren & Young, 2002). Teachers support children's early mathematics development by providing mathematics stimulation in the classroom and parents support this development by engaging with their children in mathematics-related activities in the home (Anders et al., 2012). However, perhaps due to the societal emphasis on literacy development (e.g., Council on Early Childhood, 2014), mathematics learning has generally not been a key focus of either environment until recently, and particularly when compared to literacy practices (Blevins-Knabe, Austin, Musun, Eddy, & Jones, 2000; Clements & Sarama, 2009).

Mathematics in the preschool environment

In a study examining how time is spent in preschool classrooms, Early and colleagues (2010) found that children were exposed to mathematics (via free choice time or teacher instruction) an average of 8% of the day, compared to 17% of the day that was spent on language and literacy related activities. Other researchers have also found that children are exposed to few direct or indirect mathematics experiences throughout the day (Farran, Lipsey, Watson, & Hurley, 2007; Graham, Nash, & Paul, 1997), and approximately 31% of preschool teachers do not spend any time at all on numeracy instruction (Piasta et al., 2014). Further, the time dedicated to mathematics in many preschool classrooms is focused primarily on spatial awareness, and

preschool teachers dedicate an average of less than six minutes of instructional time each day to numeracy (Piasta et al., 2014). The relatively low rate of mathematics instruction in preschools indicates that children may not be receiving adequate numeracy instruction in their daily lives, especially considering that a vast majority of parents believe that the school is primarily responsible for teaching early mathematics skills to their children (Evans, Fox, Cremaso, & McKinnon, 2004).

Despite evidence that little instructional time is afforded to mathematics in most preschool classrooms, intervention studies have demonstrated that quality preschool mathematics curricula may have positive impacts on young children's mathematics skills (Clements & Sarama, 2008; Starkey et al., 2004). Clements and Sarama (2008) demonstrated that the *Building Blocks* curriculum—implemented once per week for 10 to 15 minutes with accompanying 5 to 15 minute activities four times per week—can improve the classroom mathematics environment. *Building Blocks* focuses broadly on number skills, geometry, and patterning. Further, the curriculum emphasizes verbal interactions and exchanges between teachers and children, such as encouraging teachers to ask questions like "How did you know?" in order to prompt children to explain their strategies and thinking. The program has large effects on children's mathematics outcomes (e.g., effect sizes range from 0.44 to 1.25; Clements & Sarama, 2008) and children who are exposed to the *Building Blocks* curriculum may also show increases in their language and literacy skills (Sarama, Lange, Clements, & Wolfe, 2012).

Starkey et al. (2004) evaluated a preschool mathematics curriculum that included a home component and found it to be effective in improving preschool children's mathematics outcomes. The curriculum, *Pre-K Mathematics Curriculum,* targeted broad early mathematics skills (e.g., numeracy, patterning) through classroom lessons, and also invited parents to three classes over the

course of the school year. At the classes, parents received materials and learned how to conduct the curriculum activities at home with their children. Children who received the intervention performed significantly better on a broad assessment of informal mathematics at post-test than children who did not receive the intervention. Importantly, Starkey and colleagues (2004) did not assess the preschool and home components separately in this study (see Starkey & Klein, 2000). Other studies that have examined extensions of school-based interventions into the home environment have also been successful (as detailed below; Sonnenschein et al., 2016). Although developing an intervention that targets both the home and school environments is important, a better understanding of the feasibility and effects of a home environment intervention is necessary before developing a larger intervention that targets both environments.

Mathematics in the home environment

Similar to what teachers do in the preschool environment, parents generally report spending little time engaging their children in mathematics practices (Blevins-Knabe et al., 2000; Thompson, Napoli, & Purpura, 2017), despite the fact that parents are unique contributors to their children's development of early mathematical skills (Anders et al., 2012). Before an effective intervention for parents can be developed, it is necessary to understand the mathematics activities that parents do with their children and how frequently these activities occur. Parent-child engagement in mathematics-related activities is a critical factor in determining the richness of the mathematics environment that parents provide for children in the home.

A key component of the home mathematics environment is the home numeracy environment (HNE). The HNE is comprised of the many characteristics of the family and home setting that are thought to contribute to the development of numeracy skills (Street, Baker, & Tomlin, 2008). These characteristics include 1) parents' beliefs of the importance of mathematics,

2) parent-child engagement in numeracy activities, 3) parents' and children's attitudes regarding mathematics (e.g., self-efficacy), and 4) math-related physical resources found in the home. Parents' beliefs regarding mathematics relate to their understanding of the importance of early mathematics development and the extent to which they value mathematics learning (Musun-Miller & Blevins-Knabe, 1998). Parent-child engagement in numeracy activities consists of parents' intentional efforts to discuss and explain number concepts (Street et al., 2008). Although this engagement is intentional, it is important to note that mathematics may be incorporated into other activities; parent-child engagement does not necessarily mean that the parent engages the child in an activity for the sole purpose of teaching mathematics. For example, a parent can help his/her child practice counting while reading a picture book. Parents' and children's attitudes regarding mathematics include feelings about mathematics, such as math anxiety and parents' self-efficacy of teaching and engaging in mathematics-related activities and tasks (Gunderson, Ramirez, Levine, & Beilock, 2012). Finally, physical resources in the home include toys, books, and activity books that include number concepts, such as counting or printed numerals (Simpkins, Davis-Kean, & Eccles, 2005).

Parents' beliefs of the importance of math

Parents' beliefs about the importance of mathematics development are positively related to the frequency of their numeracy practices with their children (Musun-Miller & Blevins-Knabe, 1998). However, many parents report that they do not find math skills to be as important as other early skills, such as literacy development and social skills (Musun-Miller & Blevins-Knabe, 1998). Practitioners place a tremendous emphasis on the importance of reading development, and this is likely one reason why parents' understanding of the importance of language and literacy development and parent-child engagement in shared reading has increased (Bassok, Finch, Lee,

Reardon, & Waldfogel, 2016; Council on Early Childhood, 2014; Duursma, Augustyn, & Zuckerman, 2008). has increased over the last several decades (), likely due to the that). The knowledge gained from a brief intervention may encourage parents to consider mathematics an important aspect of their children's development. If parents have limited time with their children, they may focus their efforts on developing skills that they find to be important. Thus, it is critical to enhance parents' beliefs regarding the importance of numeracy skills. However, beliefs alone are not enough to promote positive change; parents must also have strategies for implementing practices (Maloney, Converse, Gibbs, Levine, & Beilock, 2015).

Parent-child engagement in numeracy practices

Parents' numeracy engagement with their children typically comes in the form of numeracy practices and math talk. Parent-child numeracy practices are categorized into two components: direct practices and indirect practices (Hart, Ganley, & Purpura, 2016; LeFevre et al., 2009; Skwarchuk, Sowinski, & LeFevre, 2014). Direct, or formal, practices are those that parents engage their child in with the explicit goal of mathematics instruction, such as printing numbers and counting objects. Indirect, or informal, practices are activities in which mathematics learning is incidental, such as playing board games or cooking. LeFevre et al. (2009) emphasize that the distinguishing factor between direct and indirect activities is that indirect activities take place in the context of a real-world task. However, it is important to note that "researchers have not developed a clear distinction between informal and formal activities" (Skwarchuk et al., 2014, p. 64).

Investigations into parent-child engagement in number activities in the home environment reveals that children display interest in numbers and often initiate mathematics-related interactions (Anderson, 1991), but that parents initiate mathematics-related interactions more often than their

children (Vandermaas-Peeler, Nelson, & Bumpass, 2007). Though children often initiate mathematics-based interactions on their own, parents may engage in these interactions and expand upon their children's observations and initiations. When parents engage and expand, mathematics-based activities are more complex than those that young children are cognitively able to construct on their own (Ginsburg, Cannon, Eisenband, & Pappas, 2008; Radziszewska & Rogoff, 1991; Saxe, Guberman, & Gearhart, 1987). For example, a young child might initiate an interaction while playing store where s/he pretends to buy a piece of fruit, but a parent can guide the child through the process of looking at the written numeral on the price tag to determine the cost and counting out the correct amount of money. Additionally, child-initiated interactions are encouraged and their meaning is deepened when parents expand upon their children's observations and connect number concepts to real-world situations (Anderson & Anderson, 1995). This contextualization and scaffolding allows children to gain a deeper understanding of concepts (Vygotsky, 1978).

Direct and indirect numeracy practices and children's outcomes

Young-Loveridge (1989) observed that there are wide variations in the frequency and content of number experiences that children are exposed to in the home environment before they enter formal schooling. Additionally, these number experiences were related to children's performance on a numeracy task. Children whose family members believed in the importance of and encouraged engagement in numeracy activities, who had a wider range of exposure to number experiences, and who observed their mothers using numbers in daily tasks, were more likely to perform well on the number task compared to children who did not have these experiences. Other researchers have also noted the variability in young children's exposure to numeracy at home, and some children who are observed over long periods of time are never seen engaging in mathematics activities (Tudge & Doucet, 2005).

Parents' direct numeracy practices with their children predict children's numeracy outcomes (Huang, Zhang, Liu, Yang, & Song, 2017; LeFevre, Clarke, & Stringer, 2002; Manolitsis, Georgiou, & Tziraki, 2013). Indirect numeracy practices, such as parent-child engagement in mathematical games (i.e., dice, counting, and calculation games), are also related to children's numeracy and addition fluency outcomes (LeFevre et al., 2009; Niklas & Schneider, 2013). Although evidence suggests that parent-child numeracy practices are related to children's numeracy skills, it is important to note that findings have been mixed; some studies have found positive relations and others have had negative or null findings (Blevins-Knabe & Musun-Miller, 1996; Blevins-Knabe et al., 2000; LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010; Pan, Gauvain, Liu, & Cheng, 2006; Skwarchuk, 2009). One potential explanation for mixed findings is that the activities parents engaged in with their children were not age-appropriate (Fluck, Linnell, & Holgate, 2005) or because parents practiced more basic skills with children who are struggling (Saxe et al., 1987). Further, some researchers have found that parents' direct approaches to teaching mathematics skills are more significantly related to children's mathematical outcomes than indirect approaches (Huntsinger, Jose, Larson, Krieg, & Shaligram, 2000; LeFevre et al., 2010).

It is likely that both direct and indirect engagement with mathematics concepts contribute to children's numeracy development, but in different ways. Skwarchuk and colleagues (2014) found that direct HNE activities (e.g., practicing addition) predicted children's symbolic number knowledge, whereas indirect activities (e.g., playing games) predicted non-symbolic skills. The usefulness of numeracy engagement is largely dependent both on parents' ability to facilitate their children's learning in a meaningful way and the frequency in which these activities are engaged. For example, board games may incidentally involve counting, but it cannot be assumed that all

parents count spaces out loud when moving pieces on the board. Further, Thompson et al. (2017) found that most home numeracy activities, and in particular indirect activities, occur, on average, only a few times per month for three- and four-year olds. Given that direct and indirect practices may relate differently to numeracy outcomes, both types of practices should be targeted in HNE interventions.

Parent math talk

In addition to activities, parents also provide children with verbal mathematical input (i.e., number talk and mathematical language; Durkin, Shire, Riem, Crowther, & Rutter, 1986). Number talk (e.g., verbal counting, labeling numbers) that children receive from parents early in life is related to children's ability to perform mathematics tasks at age three (Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010). Importantly, there is variation in the amount of number talk that children are exposed to (Vandermaas-Peeler, Boomgarden, Finn, and Pittard, 2012; Vandermaas-Peeler, Ferretti, & Loving, 2012) and this variation is positively related to children's mathematical knowledge (Gunderson & Levine, 2011; Ramani, Rowe, Eason, & Leech, 2015). Further, mathematical language terms that do not explicitly involve numbers (e.g., *more*, *few*, *least*) are also related to children's numeracy development (Purpura, Napoli, Wehrspann, & Gold, 2017). This mathematical language knowledge is an important classifier of low mathematics performance in preschool (Purpura, Day, Napoli, & Hart, 2017). Providing parents with opportunities and strategies for incorporating frequent and quality number talk and mathematical language into their interactions with their children may improve children's mathematics skills.

Specific strategies when incorporating math

In addition to specific situations in which parents can implement math-related activities (e.g., during routines, while reading), evidence-based strategies should be taken into consideration when discussing effective ways that parents can engage in mathematics with their children. Counting is one targeted skill that can be demonstrated for parents. Counting with objects present, rather than simply teaching rote counting, may be a more effective strategy for modeling one-to-one correspondence and the cardinal principle, and also for teaching children that counting has a specific purpose (Gelman & Gallistel, 1978; Gunderson & Levine, 2011). Additionally, labeling the cardinal value before counting the objects is the most effective way to help children learn the cardinal word principle (e.g., "Here are four cookies. One, two, three, four. How many cookies do we have?"; Mix, Sandhofer, Moore, & Russell, 2012). Another consideration is the size of the groups of objects that parents present to children. Working with and talking about larger sets (i.e., 4 to 10 objects) is more effective than working with smaller sets (i.e., sets of fewer than four objects) and working with larger sets may encourage children to practice skills such as counting rather than relying on subitizing (Feigenson, Dehaene, & Spelke, 2004; Gunderson & Levine, 2011). Finally, labeling sets with specific quantities (e.g., "here are two pennies") may help children to learn the cardinal principle (Casey et al., 2016). This type of labeling helps children to begin connecting number names to exact quantities.

Parents' and children's attitudes regarding mathematics

Children display a natural interest in mathematics (NRC, 2001), and this interest may be promoted by interventions that increase their exposure to math (Arnold, Fisher, Doctoroff, & Dobbs, 2002). However, children may also sense or even observe parents' negative feelings regarding math and lose their natural interest, as well as perform poorly in math (Maloney,

Ramirez, Gunderson, Levine, & Beilock, 2015). To effectively promote math engagement at home, interventions may need to promote parents' math-related self-efficacy and address their math anxiety in order to ameliorate parents' negative feelings (Cannon & Ginsburg, 2008). If parents are anxious about math or feel that they do not have the skills to teach math concepts to their children, they may not actively engage in a math-related intervention. Addressing these concerns directly may bolster parents' confidence in their abilities. Parental self-efficacy is related to parenting behaviors, and is both malleable and a mechanism for changes in parental behavior (Jones & Prinz, 2005). Thus, helping parents to feel more comfortable and confident with the subject, simply by providing them with strategies to engage their children with mathematics, may help them to feel more equipped for teaching their children mathematics at home.

Physical resources in the home

Physical math resources in the home include objects such as toys, books, and games that include or promote number concepts (e.g., counting or printed numerals). Children typically report that they enjoy engaging with math toys, and this enjoyment may be facilitated by interventions that increase children's exposure to math (Arnold et al., 2002). Further, with inexpensive and easily distributable tools—such as a bookmark with strategies for using mathematical language during shared reading—parents can be supported in using the resources that are already available to them or can be easily made available. It is important for a home numeracy intervention to guide parents in creative ways to use materials that are available as it is not realistic to expect parents to purchase costly mathematics-based toys or activities.

Methods of Enhancing the Home Numeracy Environment

In designing an intervention to enhance the HNE, it is critical to consider the range of numeracy-promoting activities that parents could engage in with their children. Though the HNE is related to the development of children's numeracy skills (Anders et al., 2012), parent-child engagement in numeracy activities is infrequent relative to other types of activities, such as shared reading (Blevins-Knabe et al., 2000; LeFevre et al., 2009). There are a variety of reasons why parents may not engage in numeracy activities, including not viewing numeracy skills as important, lack of time, or discomfort with mathematics in general. However, systematic observations of the HNE indicate that there are ample opportunities in children's daily lives at home to incorporate mathematics concepts, and specifically into practices that are likely already taking place in the home (Anderson, 1991). These methods can be systematically incorporated into an intervention program in order to enhance the HNE and, subsequently, children's numeracy performance. These opportunities emerge in activities such as shared reading, playing board games, parent-child play, and even in daily routines.

Incorporating numeracy into shared book reading

Evidence shows that shared book reading may be an effective way to improve children's mathematics skills (Hassinger-Das, Jordan, & Dyson, 2015; Jennings, Jennings, Richey, & Dixon-Krauss, 1992; Purpura, Napoli et al., 2017). Teachers are often encouraged to integrate subjects in order to cover more material in the limited time they have, and incorporating mathematics concepts into reading is one strategy that teachers use (Evans, Leija, & Falkner, 2001). Similarly, parents may be encouraged to incorporate numeracy concepts into shared reading with their children. Shared reading is one activity in which children may introduce mathematics ideas on their own as illustrations may facilitate such interactions (Anderson & Anderson, 1995; Anderson, Anderson,

& Shapiro, 2005). It is important to recognize that incorporating domain-specific content into reading may be a difficult task, even for teachers (Hojnoski, Polignano, & Columba, 2015). However, investigations into parent training have shown promise that parents are able to embed mathematics content into shared reading when given strategies for doing so (Hojnoski, Columba, & Polignano, 2014). In order for parents to effectively incorporate mathematical ideas into parent-child storybook reading, they should be introduced to developmentally appropriate mathematics vocabulary as well as strategies for seamlessly incorporating the terms and concepts into the story (Hojnoski et al., 2014).

Welchman-Tischler (1992) identified strategies that teachers can utilize to incorporate mathematics concepts into shared reading, and many of these strategies can also be used by parents in the home setting. Two strategies that were identified were providing children with a context and introducing manipulatives. Educators are encouraged to provide a context for stories by connecting the storyline to children's own lives. Parents can readily do this for their children by drawing comparisons between the plot and setting of the story to children's daily lives and environments. For example, many children's books focus on everyday activities such as cooking, shopping, or solving a problem (e.g., finding a missing object). Though all concepts found in children's books will not directly apply, parents can manipulate certain aspects of the story to make them relatable to their children's lives. Parents can also introduce manipulatives to help their children connect concepts. Although manipulatives are not necessary or appropriate in every mathematical context, they may be useful for parents to demonstrate mathematical concepts and scaffold their children's learning (e.g., removing manipulatives from a group to demonstrate subtraction; Sarama & Clements, 2009a). The manipulatives may directly align with stories (e.g., using actual cookies to talk about a story about baking cookies), or substitutions can be used (e.g., using stacks of pennies

to talk about a story about hats). Although providing a context and introducing manipulatives may not be intuitive to parents, they are strategies that require few resources and that parents can likely incorporate on their own with little training.

Incorporating numeracy into games

Mathematical games are a feasible way to supplement structured math learning when they are implemented in engaging ways (Dubé & Keenan, 2016). For example, board games are an effective way of promoting children's early numeracy development (Ramani & Siegler, 2008; Siegler & Ramani, 2008), and Sonnenschein and colleagues (2016) found that caregivers can be trained to effectively play board games at home with their children. Importantly, some strategies for promoting numeracy through games are more effective than others (Laski & Siegler, 2014; Whyte & Bull, 2008), but these strategies may not be intuitive. For example, it may be more beneficial for children to use a counting-on strategy (i.e., counting from the number they were on) rather than a counting-from-1 strategy when playing board games (Laski & Siegler, 2014). It is likely that receiving training on specific strategies (e.g., counting-on) would make board games a more useful tool for parents.

It is important to recognize that games do not have to be "math games" in order to incorporate elements of mathematics. For example, children can count spaces on any board game that requires the players to move forward or backward across squares. Providing parents with such tips may help them to promote mathematics concepts to their children during family time. Playing cards are another, and inexpensive, resource that can facilitate a wide range of numeracy activities (Skwarchuk, Vandermaas-Peeler, & LeFevre, 2016). Parents can help children compare the numbers on the cards (e.g., "You have a three and I have a five. Five is more than three") or draw

children's attention to the numerals and objects on the cards (e.g., "This is the number four. See the four hearts here? Let's count them together").

Incorporating numeracy into play

American parents often use play as a way to teach their children (Farver, 1993) and play has been identified as one context that affords opportunities for mathematical talk (Chan & Mazzocco, 2017). There is evidence that parents believe that play is a valuable way to build children's language abilities and support their school readiness (Manz & Bracaliello, 2016). Compared to structured tasks, parents engaging in free play with children provide more cognitive scaffolding and children are observed to be more engaged (Kwon, Bingham, Lewsader, Jeon, & Elicker, 2013). Numeracy-based play activities are an effective way of engaging children in mathematics in the classroom setting. For example, Cohrssen, Tayler, and Cloney (2015) found that the frequency that children engaged in play-based mathematics activities in their preschool classrooms was related to their mathematics outcomes. Further, teachers reported that children were interested in these activities and often requested them. Some of the play-based activities were playing number games with a puppet, playing a dice game that involved children counting objects, and a numeral card sequencing activity. Though the Cohrssen et al. study focused on preschool teachers, these structured activities are play-based and ones that parents could likely implement in the home.

Incorporating numeracy into routines

Children spend a large part of their day engaged in routines, such as grooming, dressing, eating, and helping with chores, and many of these routines are supervised by an adult. Kotsopoulos and Lee (2014) posit that these routines can provide young children with

opportunities to engage in mathematical learning, but recognize that caregivers often struggle with ways to incorporate mathematics into daily interactions with their children. Incorporating mathematics into these routines, such as encouraging children to count out how many plates are needed for dinner or how many shoes they need while getting dressed, may be an effective way for parents to talk to their young children about mathematics concepts without needing specific objects or to set aside extra time in the day for doing so. This may be especially true given that parents often report engaging in math with their children in unstructured ways (Cahoon, Cassidy, & Simms, 2017). Additionally, parents often report that the largest barrier preventing their participation in interventions or child engagement is time (Heinrichs, Bertram, Kuschel, & Hahlweg, 2005; Lamb-Parker et al., 2001; Mendez, Carpenter, LaForett, & Cohen, 2009; Spoth, Redmond, Hockaday, & Shin, 1996). Interventions that capitalize on times that parents are already engaging with their children may be successful in both recruiting and retaining parents.

Numeracy Interventions at Home

General HNE interventions

Though improving the HNE seems to be a promising avenue for increasing children's numeracy knowledge, little research has examined this approach. Starkey and Klein (2000) used random assignment to evaluate the effectiveness of a family mathematics curriculum with parents of Head Start preschoolers. Thirty-two parents were assigned to participate in either a four-month-long intervention or a business-as-usual comparison group; there were 28 dyads in the final sample. Parents who participated in the intervention attended eight biweekly classes where teachers demonstrated specific mathematics activities and provided individual feedback throughout the activity. Parents also had access to mathematics lending kits between classes. Children whose parents participated in the intervention significantly outperformed comparison children on

numeracy tasks at posttest. By learning HNE activities to engage their children with at home and having access to materials, parents were able to promote their children's mathematics knowledge. Although Starkey and Klein do not explain what was included in the math kits, they speculate that the availability of the kits was a primary reason that parents engaged children in mathematics activities at home.

Despite the effectiveness of the intervention, there are shortcomings that should be addressed in future research. Given that parents often report that time is the key variable that prevents them from engaging in interventions (Heinrichs et al., 2005), interventions that are months-long and involve multiple meetings are not feasible for many families. Additionally, it is important to determine whether parents are able to implement intervention activities and provide HNE support for their children without the use of intervention materials that must be returned (i.e., lending kits). It is important for researchers to determine if shorter (e.g., one month) HNE interventions that provide inexpensive, easily accessible materials and teach parents to utilize the resources they already have at home can be effective. Finally, the intervention was compared to a business-as-usual control condition which limits the ability to assert that a mathematics intervention specifically, and not a general parenting intervention, is effective in promoting mathematics skills.

In contrast to the intensive intervention implemented by Starkey and Klein (2000), Niklas, Cohrssen, and Tayler (2016) implemented a more feasible HNE intervention with parents of four year old children. The intervention group (37 parents) attended a 30-minute group information session on the importance of the HNE. They were also provided with an information sheet of suggestions for math activities that could be done at home with their child. Intervention group parents also attended a 30-minute individual session with their child where a member of the

research team coached the parent on supporting his/her child's mathematics skills while playing a dice game. Parents who did not participate served as the comparison group and did not receive any type of training or materials from the researchers. Children were assessed at pretest and posttest on counting and number value skills. Pretests were conducted during February and March and posttests were conducted beginning in July, but the authors do not specify if the intervention took place for the full time between pretest and posttest. The findings of the study indicate that there is some promise in HNE interventions. Parents in the intervention group increased their self-reported parent-child numeracy activities significantly more than parents in the comparison group. Further, children whose parents participated in the intervention showed significantly larger gains in counting and number values skills than children whose parents did not participate in the intervention. It may be that a non-intensive HNE intervention that provides parents with information on the importance of early mathematics, as well as general ideas for parent-child mathematics activities and a specific strategy (e.g., the dice game), may be effective in promoting mathematics in the home environment.

Though the findings of the intervention are promising, there are limitations of the study that should be noted. First, parents were not randomly assigned to the intervention. Rather, 113 parents were invited to participate in the intervention, and the 37 parents who attended the information session received the intervention and the remaining parents who did not were used as a comparison group. Random assignment is considered the "gold standard" for making causal assertions (Shadish, Cook, & Campbell, 2002). Because parents opted into the intervention group, selection bias is an issue. It is likely that motivation, as well as other unmeasured factors, played a part in the effectiveness of the intervention. In order to eliminate plausible confounds (e.g.,

motivation), researchers should randomly assign participants to intervention and comparison groups.

A second limitation of the study is that the only measure of the HNE (i.e., frequency of parent-child math activities) was retrospective parent report. Though this is a commonly accepted method of collecting HNE information that is utilized by many researchers (e.g., DeFlorio & Beliakoff, 2014; LeFevre et al., 2009; Skwarchuk et al., 2014), it is important to consider that not all of the parents in the intervention group completed the HNE surveys. Niklas et al. (2016) only reported that 70 parents returned the post-test survey and did not report how many parents were from the intervention and control groups. It may be that parents did not return their surveys because they did not increase the frequency of their HNE activities. Studies that utilize different forms of data collection (e.g., through text messaging) and do not rely on retrospective reports (e.g., collect information on a daily basis) are necessary in order to better understand mathematics interactions that occur between parents and children.

Targeted HNE interventions

There have also been a number of HNE interventions that target specific strategies for teaching numeracy skills, rather than generally promoting mathematics in the home. These targeted strategies include mechanisms through which mathematics can be learned, such as iPad apps, cooking, and games.

iPad apps

Berkowitz and colleagues (2015) assessed the effectiveness of delivering a mathematics intervention to parents of first grade children through the use of an iPad application. Participating parents (N = 587) were randomly assigned to a Bedtime Learning Together group where parents

used an iPad app to engage children in a math-based reading passage and follow up questions, or a non-math reading passage group (control) over the course of a school year. The intervention demonstrated that, although improvements in children's numeracy can be obtained by engaging in targeted mathematics practices as little as one time per week, more frequent use of the application was positively related to children's mathematics outcomes.

Cooking

Vandermaas-Peeler, Boomgarden et al. (2012) demonstrated that even brief (i.e., less than an hour long) interventions can increase parent-child numeracy exchanges. The researchers asked parents to engage in a cooking activity with their preschool-aged child and provided the intervention group with specific suggestions for incorporating numeracy into the activity. Parents then cooked with their children for approximately one hour. Parents in the intervention group provided more numeracy guidance to their children than did parents in the control group. Further, parents in the intervention group asked numeracy-related questions and provided guidance on content not included in the suggested activities. This study indicates that parents are able to provide specific numeracy guidance to their children during routine activities such as cooking. However, the intervention was brief and post-test assessments were conducted immediately after the cooking activity. The researchers did not follow up to determine if there was a sustained effect on parent-child engagement without having specific prompts and activities available.

Games

Researchers have evaluated the effectiveness of playing games to promote children's numeracy skills. Vandermaas-Peeler, Ferretti, and Loving (2012) implemented a two-week board game intervention with parents and their four year old children. Parents in the intervention group

were provided with specific strategies to incorporate while playing the game. Parents in the intervention group provided more guidance for their children in the areas of counting, number recognition, addition and subtraction, and number comparison. Parents reported high levels of enjoyment in engaging in the board game for both themselves and their children. Parents also reported noticing their children engaging in more spontaneous numeracy (e.g., counting and using numbers) since engaging in the board game sessions. Sonnenschein and colleagues (2016) also examined the efficacy of training parents to use specific counting strategies while playing a board game to improve their children's early numeracy skills. Children whose parents participated in the intervention improved on both numeral identification and number line estimation skills, potentially due to the strategies parents incorporated or the exposure to math-related concepts while playing the game.

Critical considerations

The interventions conducted by Sonnenschein et al. (2016) and Vandermaas-Peeler and colleagues (Vandermaas-Peeler, Boomgarden et al., 2012; Vandermaas-Peeler, Ferretti, & Loving, 2012) demonstrate that interventions may benefit parent-child numeracy engagement in specific activities (i.e., cooking and playing games). Such interventions are helpful in improving our understanding of parents' role in their children's numeracy development. However, it should be noted that interventions that target only one specific parent-child practice should not be generalized to the HNE as a whole. It is important to consider all aspects when trying to enact long-term benefits as it may be more feasible for parents to incorporate strategies into existing routines. Interventions that target specific math-related activities may give parents an additional task to do, whereas incorporating numeracy into existing routines capitalizes on time that parents and children

are already spending together. Additionally, the interventions may have been too brief to have lasting effects (Van Voorhis, Maier, Epstein, & Lloyd, 2013).

The study by Sonnenschein and colleagues (2016) highlights a few considerations when training parents on specific HNE practices. One consideration is the amount of training that parents receive. Parents in the study showed low adherence to specific game protocol. This may be due in part to the fact that parents attended only one training session at the beginning of the intervention and did not receive reminders during the intervention. Parents who receive "check ins" or reminders from project personnel may be more likely to adhere to protocol (Strandbygaard, Thomsen, & Backer, 2010). Another consideration is that a very small percentage of parents returned the log detailing the frequency and duration of their child's engagement with the board game. Parents who did not return the log may have been less likely to consistently engage their child in the game. Researchers should consider collecting this information in an alternative format (e.g., via text messaging) and more frequently than once at the conclusion of the intervention.

Conclusions from existing HNE interventions

Despite limitations to the interventions and study designs, existing HNE interventions demonstrate that the HNE is malleable and that there is promise for interventions targeting the HNE. Given appropriate support, parents are able to increase the amount of numeracy exposure their children receive in the home. However, each of the interventions mentioned is limited because none provides parents with information on all four aspects of the HNE (i.e., beliefs, engagement, attitudes, and resources). It is likely that, in order to provide the most supportive HNE, each aspect needs to be addressed. With only one aspect addressed, parents may, for example, understand that they should be engaging in more numeracy activities but their math anxiety may prevent them from being effective in this engagement. Further, parents may gain an understanding of the

importance of early mathematics skills, but be unsure of how to promote such skills in their own children. Addressing each of the four domains will help to ensure that parents understand the importance of early mathematics, feel efficacious in engaging their children in math-related activities, and engage their children in mathematics activities using the resources that they have available. Further, there is a need for an RCT to assess the effectiveness of a brief HNE intervention for parents of preschool-aged children (Niklas et al., 2016). Although the intervention study conducted by Starkey and Klein (2000) used random assignment, their intervention included eight sessions, which is not a feasible time commitment for many parents, and also used a business-as-usual control condition. The current study fills a critical gap in our understanding of methods to enhance the HNE of preschool-aged children and, ultimately, their early numeracy skills by: 1) addressing each component of the HNE, 2) using random assignment, 3) including only one in-person meeting and supplementing with text messaging, and 4) using an active control condition.

Developing an Effective Home Numeracy Intervention for Parents

Systematic analyses of literacy-based interventions support the notion that parents can be effective at implementing interventions and improving children's outcomes (Reese, Sparks, & Leyva, 2010; Sénéchal & Young, 2008; Sloat, Letourneau, Joschko, Schryer, & Colpitts, 2015). Although few studies have been conducted on the effectiveness of HNE interventions, evidence from correlational research and interventions targeting preschool development can be used to inform the development of a parenting intervention for the HNE. Existing interventions and studies of effective strategies for engaging in numeracy provide a foundation from which to build an intervention that broadly targets each aspect of the HNE (i.e., beliefs, engagement, attitudes, and resources) and provide evidence that brief interventions may be enough to promote positive change in the home learning environment. Further, studies utilizing text messaging provide evidence that

this may be an effective method for communicating ideas to parents (Hurwitz, Luricella, Hanson, Raden, & Wartella, 2015).

Practical considerations

In addition to aspects of an HNE intervention that are specific to numeracy practices, there are also practical considerations for developing a parenting intervention, such as duration and delivery of intervention components.

Duration of parenting interventions

Studies examining the home literacy environment have demonstrated that brief (e.g., one month) interventions can be successful in increasing the frequency of parent-child engagement as well as the quality of such engagement, ultimately leading to improvements in children's outcomes. Results from a meta-analysis on dialogic reading interventions with parents indicate that the effect sizes of month-long interventions do not differ from longer interventions (i.e., up to 28-week-long interventions; Mol, Bus, de Jong, & Smeets, 2008). Positive results of fewer intervention sessions have also been found for interventions targeting other parenting outcomes (e.g., parent-child attachment; Bakermans-Kranenburg, van IJzendoorn, & Juffer, 2003). Niklas and Schneider (2015) observed improvements in children's vocabulary when parents attended a brief meeting on the importance of the home literacy environment and a session to receive feedback on shared reading. Further, effects from brief interventions may be moderately sustained over time (i.e., over one year later; Niklas & Schneider, 2017).

Intervention components delivered via text messaging

Using text messages as a routine part of interventions appears to be an effective way to deliver information, such as literacy tips (Haagenson & Hahn, 2006; Kraft & Monti-Nussbaum,

2017), and improve mothers' self-efficacy (Evans, Wallace, & Snider, 2012). Recent evidence suggests that over 90% of American adults own cell phones and that over 80% of adults use cell phones to send and receive text messages (Duggan, 2013). Given the accessibility and ease of cell phones, they are becoming a commonly used form of communication in interventions, particularly for medical research (Anhøj, & Møldrup, 2004; Head, Noar, Iannarino, & Harrington, 2013; Kew, 2010). For example, cell phones have become a popular way of reaching parents to provide medical information, such as immunization reminders (Hofstetter, Vargas, Kennedy, Kitayama, & Stockwell, 2013).

Text messaging may also be an effective way to increase parents' activities with their children (Hurwitz et al., 2015). A recent meta-analysis found that a majority of interventions that utilized text messaging were successful in affecting positive behavioral changes (Fjeldsoe, Marshall, & Miller, 2009). Hurwitz and colleagues (2015) used text messages to provide parents of children enrolled in Head Start with suggestions for parent-child activities. Parents received three activity suggestions per week for six weeks. Parents who received the text messages engaged their children in significantly more activities than parents who did not receive the messages. Parents were also enthusiastic about the service and a majority indicated feeling positively about using text messages to deliver parenting information. Parents report that they prefer to receive study information via text messages to other methods of communication, and that daily text messaging is their preferred frequency of receiving information (Horowitz et al., 2006; Hurwitz et al., 2015). Studies have also found that a majority of participants open and read text messages that they receive (Gazmararian, Elon, Yang, Graham, & Parker, 2013). Text messaging is also an effective way to retain participants and engage with them for extended periods of time (Bigelow, Carta, & Lefever, 2008). Additionally, real-time data collection techniques such as text messaging

may ameliorate low return rates of physical intervention materials, which are a challenge of parenting interventions (e.g., Niklas et al., 2015; Sonnenschien et al., 2016).

Need for a holistic home numeracy intervention

Taken together, the current literature points to a need for a holistic, non-intensive HNE intervention that is evaluated through random assignment and compared to an active control condition. Though each of the previously mentioned intervention studies provides evidence of both the importance and the malleability of the HNE, each is missing at least one critical component to demonstrate that non-intensive, broad HNE interventions are an effective way of promoting preschool children's early numeracy skills.

The Current Study

Drawing from research on the HNE, as well as research on literacy interventions with parents, the current intervention was intended to improve children's early numeracy skills by improving their numeracy environments at home. Parents were randomly assigned to either an HNE training group (intervention) or a general parenting information group (control).

The intervention was expected to increase parent-child numeracy practices by providing parents with the tools, knowledge, and training to integrate mathematics into their daily routines. It was expected that increasing the frequency of parent-child numeracy practices would improve children's numeracy outcomes. Specifically, the study was guided by four hypotheses:

Hypothesis 1: Parents who participated in the intervention would rate numeracy development as more important compared to parents who did not participate in the intervention.

Hypothesis 2: Parents who participated in the intervention would report higher levels of self-efficacy for engaging their children in math-related activities compared to parents who did not participate in the intervention.

Hypothesis 3: Parents who participated in the intervention would engage their child in both direct and indirect numeracy practices more frequently compared to parents who did not participate in the intervention.

Hypothesis 4: Children whose parents participated in the intervention would outperform children in the active control condition on an assessment of numeracy, but not literacy, skills at posttest.

METHOD

Procedures

Preschools and childcare facilities were contacted regarding the study. If centers agreed to participate, informational letters (see Appendix A) and consent forms were sent home to parents. Additionally, parents were spoken to during common pickup and drop-off times and invited to participate in the study and some parents were recruited through emails sent to local "moms clubs." In order to participate, parents had to have a cell phone capable of receiving text messages and accessing the internet. Parents were randomly assigned to either an HNE intervention group or an active control condition. Parents in both groups attended an informational meeting where they received information on parent-child engagement (math-specific engagement for the intervention group and general engagement for the control group) and completed a background questionnaire. Beginning the day after the informational meeting, parents in both conditions also received daily text messages for four weeks with suggestions for activities that they could do with their child, as

well as a daily fidelity survey to monitor engagement. After the four-week intervention, parents completed the background questionnaire and children were posttested.

Children were pre- and posttested on measures of numeracy and literacy by undergraduate research assistants, graduate students, and postdoctoral researchers. If parents were recruited through their child's preschool, the child was assessed at the center. If children were not enrolled in a childcare program, they were assessed at the time of the informational meeting. Informational meetings took place at the research lab or another quiet location that was convenient for the parent (e.g., the library). When children were assessed during the informational meeting, most often they were in a separate room. However, in three cases children were assessed in the same room because the child did not want to be separated from the parent.

Participants

Parents

Of parents who were invited to participate, 42 parents (39 mothers and 3 fathers) consented to participate in the study. Twenty participants responded to letters that were sent home through childcare centers (5% response rate) and the remaining 22 learned about the study through a mom's club email. Parents' highest level of education ranged from some college to obtainment of a postgraduate degree, with the median educational level being obtainment of a Master's degree. Parents' age ranged from 27 to 47 years (M = 34.63, SD = 4.85). A majority (n = 34; 82.9%) of parents were married, two were unmarried but living with a partner, and five were divorced or separated from their partner. Most parents (n = 31; 75.6%) reported speaking only English at home and another 10 reported speaking another language (either entirely or in combination with English). Parent education, marital status, and primary language were not available for one family because the parent did not complete the background questionnaire.

Preschoolers

Children were eligible to participate as long as they were 3 or 4 years old and did not have any identified and untreated visual, speech, or hearing impairments. Of the 42 children who participated, 25 (59.5%) were male. Further, 70.7% were White, 19.5% were Asian, 4.9% were Black/African American, and 4.9% were biracial. Children ranged in age from 3.08 to 4.89 years (M = 3.90, SD = 0.55). All children spoke English, and English was identified as the primary language of 35 (85.4%) of the children.

Measures

Preschool Early Numeracy Skills Screener – Brief Version (PENS-B)

The PENS-B (Purpura, Reid, Eiland, & Baroody, 2015) was used to evaluate children's numeracy abilities. The PENS-B is utilized to assess the broad, general numeracy skills that children should be exposed to in preschool and kindergarten. The measure is 24 items and takes approximately five minutes to administer. The PENS-B is correlated with the Test of Early Mathematics Ability – 3rd Edition (TEMA-3; r = .73) and has high internal consistency (α = .93). The assessment booklet and scoring sheet are the only items necessary to administer the PENS-B.

Get Ready to Read! (GRTR)

The GRTR (Phillips, Lonigan, & Wyatt, 2009) was used to assess children's emergent literacy skills. The GRTR is a brief emergent literacy screener that includes 25 items assessing children's knowledge of letter-name and letter-sound, phonological awareness, print concepts, and emergent writing. The GRTR has adequate internal consistency (α = .79) and predictive validity (Phillips et al., 2009). Children were assessed on the GRTR in order to determine whether the

intervention discriminates to numeracy skills (i.e., assess whether the intervention improves only the targeted skill).

Background questionnaire

Participating parents completed a questionnaire twice: at the informational meeting and again at the conclusion of the intervention. The questionnaire took approximately 10 to 20 minutes to complete. The initial questionnaire was used to determine baseline equivalence of HNE practices across the intervention and control groups, as well as parents' beliefs of the importance of numeracy development and self-efficacy for engaging their child in numeracy activities. Although the main purpose of the questionnaire was to collect information on the HNE, questions on various topics (e.g., literacy practices, importance of learning various skills, family mealtime routines) were included in an attempt to prevent parents in the control group from learning the focus of the study.

Parent-child math activities

Parents reported the frequency of specific mathematics activities that they did at home with their child in the past month on a scale ranging from *never* (0) to *multiple times a day* (5). Questions were developed from previous research (LeFevre et al., 2010). Fourteen questions were used to calculate a direct parent-child activities composite ($\alpha = .90$): counting objects, printing numbers, reading number storybooks, using number activity books, comparing quantities, counting down, learning simple sums, identifying names of written numbers, playing with number fridge magnets, asking math-related questions, asking about quantities, comparing the size of numbers, reciting numbers in order, and using number flashcards.

Twelve questions were used to calculate an indirect activities composite (α = .86): measuring ingredients while cooking, playing board games, playing card games, sorting things by size/color/shape, talking about money while shopping, noting numbers on signs when walking/driving, playing games that involve counting/adding/subtracting, playing with calculators, playing games in the car that involve numbers, learning/singing math songs/rhymes, comparing sizes, and playing dominos.

Parent beliefs regarding math

Parents reported how important they believe it is for their child to reach certain milestones by kindergarten entry on a scale from *not very important* (0) to *very important* (4). Nine researcher-developed questions regarding parents' beliefs of the importance of math development were used to calculate a composite (α = .91): calculating simple sums, using the terms "more than" and "less than," identifying numbers, solving basic word problems, verbally counting to 40, accurately counting 1 to 15 objects in a row, printing numbers, counting out 1 to 5 objects from a group, and reading numerals 1 to 10.

Parent math-related self-efficacy

A self-efficacy score was created using four items (α = .84). Parents were asked three researcher-developed questions regarding their self-efficacy of teaching their child math-related concepts and engaging their child in math activities at home: I feel comfortable teaching my child about numbers, I feel comfortable integrating math activities into my child's daily routines, and I have the skills that are necessary to teach my child about numbers and math. They also responded to one question addressing their comfort of teaching their child during daily interactions: I can

teach my child in our daily interactions. For each item, parents were asked to report on a range from *strongly disagree* (1) to *strongly agree* (5).

Intervention

Random assignment

Parents were randomly assigned to either the intervention group or the control group. Random assignment occurred on a rolling basis. As often as possible, random assignment occurred in blocks of four parents as they enrolled as this has been identified as a more stringent way to randomly assign participants on a rolling basis than assigning each parent as s/he enrolls (St. Pierre, 2004). However, due to gaps in enrollment, parents were sometimes randomly assigned on their own or in pairs (i.e., not in a block of four).

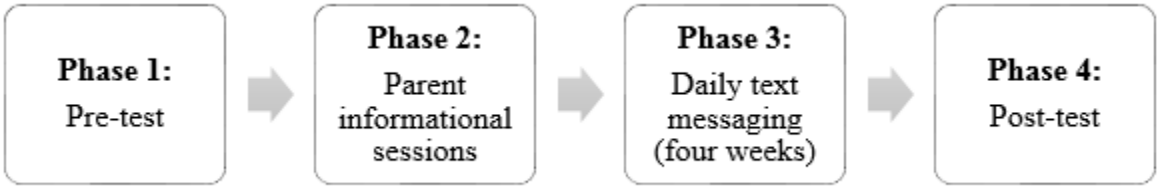

Figure 1 Intervention process.

HNE intervention

The intervention process is presented in Figure 1. There were two main intervention components: an informational meeting and daily short message service (SMS) tips (i.e., text messaging). Parents were invited to attend an informational meeting and then received daily tips delivered through SMS for four weeks (i.e., 28 total text message tips). The informational meeting was held at the research lab or another quiet location (i.e., at the child's school during pick up or drop off time, the library, or a community center). All informational meetings were conducted by the same person. Several dates and times were offered in order to accommodate parents' schedules.

Most parents were unable to attend a group meeting, so an individual meeting was scheduled at his/her convenience. Four parents attended a meeting with another parent rather than having an individual meeting (two parents in the intervention group attended a meeting together and two parents in the comparison group attended a meeting together). The information and strategies that parents received were designed to provide them with general tools for incorporating math in the home environment, and not to assign specific activities to do each day. Information was presented in a slideshow and parents were given copies of the slides and presenter notes to take home. See Appendix B for the slides and presenter notes that were presented to parents in the intervention condition.

Beliefs of the importance of math

Parents received information on the importance of early mathematics, including the relation between early math skills and later outcomes (Nguyen et al., 2016). They also received information on young children's ability to understand mathematical concepts and to perform mathematical tasks. It was explained that children learn mathematics skills on a trajectory, and that the more children know when they enter school, the more prepared they will be to learn more advanced concepts. Further, parents were briefly introduced to national standards for kindergarten math so they could begin making connections between what children will learn in school and what skills they should begin working on at home.

Engagement

Parents were encouraged to incorporate mathematics and mathematical language into their child's daily routines. Examples were included for mealtime, bath time, and bedtime. Parents were also given strategies to incorporate mathematical content into storybook reading. Because a

majority of parents, regardless of socioeconomic status, report reading to their children almost every day (Bracken & Fischel, 2008; Phillips & Lonigan, 2009), this is an opportunity to capitalize on an existing routine using methods that have been shown to be effective in other situations (Purpura, Napoli et al., 2017) and may also be effective for parents. A picture book was used to demonstrate specific examples and parents received a bookmark with mathematical language terms and examples (see Appendix C). Parents watched brief videos demonstrating adult-child interactions with math activities. Finally, similar to the *Building Blocks* intervention (Clements & Sarama, 2008), parents were encouraged to question their children's strategies and thinking with questions like "Why?" and "How do you know?" in order to promote discussion about mathematics concepts.

Attitudes

Math anxiety and self-efficacy were explicitly discussed with parents. They were given information about adults' math anxiety and how it relates to children's own math anxiety and mathematics performance (e.g., Beilock, Gunderson, Ramirez, & Levine, 2010; Maloney, Ramirez et al., 2015). Parents' self-efficacy regarding their ability to teach their children about mathematics concepts was addressed by discussing that only basic mathematics skills (e.g., counting, naming numbers) are necessary to engage young children with math and emphasizing that any parent who can communicate with their children can teach them about math. Further, parents were encouraged to see themselves as valuable players in their child's math development by emphasizing the important role that the home environment plays in this development. Parents also received information about how early attitudes about math relate to children's later academic and career choices.

Resources

In addition to receiving the bookmark, a math activity kit was provided to parents. The kit included four dice, two sets of number cards, links to math resources on the internet, and a print out of a math game. Demonstrations were made to show parents how to use the materials to engage with their child. Parents were also provided with suggestions for using resources that may already be present in their homes. Demonstrations were made of how to incorporate number talk into card and board games and best practices for doing so. Further, parents were encouraged to think of toys or items that they have in their home that their child particularly enjoys (e.g., blocks, dolls) and to brainstorm ways of incorporating numeracy into exchanges with those items.

SMS tips

In addition to the tips provided at the informational session, the SMS program Remind™ was used to send parents daily text messages. Text messages were sent in the afternoon (approximately 4:30 p.m.) during the week and in the morning (approximately 11:00 a.m.) on weekends. The messages included a reminder of the importance of early mathematics skills or an encouraging reminder that parents have the necessary skills to teach their child math, as well as a strategy for incorporating mathematics and/or using resources in the home to incorporate mathematics into daily routines and activities. As with the strategies provided during the session, these tips were designed to be general examples and not specific tasks for parents to complete. The SMS tips are in Appendix D.

Control group

Parents assigned to the comparison condition did not receive the HNE intervention. In an attempt to reduce the potential that attention—rather than the intervention—produces effects, an

attention placebo condition was utilized (Powell, 2013). The control group received the same amount and variety of attention as the intervention group. Parents assigned to the control condition were asked to participate in an informational meeting on general child development and parent-child engagement (see Appendix E for slides that were presented). They also received daily SMS texts with tips for engaging with their child and supporting general development (e.g., literacy). The SMS tips can be found in Appendix F. Parents in the control group received an activity kit with items similar to the math kit received by intervention group parents, but with a broader parent-child engagement focus. Items included a print out of a letter game, print outs of songs and rhymes, and a picture-matching rhyming game. As such, intervention effects can be assumed to be due to the intervention itself, and not a result of time, attention, or items given to parents. The control group was provided with information from the HNE intervention meeting (i.e., slides, a list of the text messages, and games) after children were posttested.

Fidelity and Feasibility

Remind™ was also used to collect daily implementation information. Collecting fidelity data on a daily basis may be more appropriate than relying on retrospective parent report as parents may not remember the activities they did over the entire course of the intervention, and provide insight into the feasibility of the intervention (Powell & Carey, 2012). Parents in both groups received a link to a Qualtrics survey through Remind™ each evening after their child's typical bedtime (parents provided this information on the first questionnaire). Parents who did not submit the fidelity survey two nights in a row received a reminder text message. If parents did not complete the survey three nights in a row, they received a phone call. The survey was designed to be read and responded to quickly (i.e., less than one minute).

Intervention group

The intervention group received the following fidelity questions and response options:

1. Did you incorporate any math language terms into storybook reading today? *YES or NO*
2. Did you incorporate any of the math practices discussed in our informational meeting today? *YES or NO*
3. Did you use any of the activities/suggestions sent to your phone? *YES or NO*
4. Did you engage your child in other math activities today? *YES or NO*
5. Please SPECIFY the math activities you and your child did today. *Note: This question was only displayed if parents replied "Yes" to Question 4.*

Control group

The control group received the following fidelity questions and response options:

1. Did you read with your child today? *YES or NO*
2. Did you engage your child in any of the activities discussed in our informational meeting? *YES or NO*
3. Did you use any of the activities/suggestions sent to your phone? *YES or NO*
4. Did you engage your child in any other quality time activities today? *YES or NO*
5. Please SPECIFY the activities you and your child did today. *Note: This question was only displayed if parents replied "Yes" to Question 4*

Feasibility of implementation

In addition to the five daily fidelity questions, parents in both groups received additional questions regarding feasibility of implementation at the end of each week:

6. How many of the strategies that were sent this week were realistic for you to do with your child? *ALL or MOST or SOME or FEW or NONE*
7. How often did you feel that you had adequate knowledge/ability to implement the strategies? *ALWAYS or MOST OF THE TIME or SOMETIMES or RARELY or NEVER*
8. What information would have helped you implement the strategies?
9. Were any of the strategies that were sent this week particularly difficult to implement? Please explain.
10. Were any of the strategies that were sent this week particularly useful or effective? Please explain.

At the end of the intervention, parents were be asked to complete an intervention feedback survey. The purpose of the survey was to collect parents' opinions regarding the feasibility of the intervention. The feedback survey for the intervention group can be found in Appendix G and the feedback survey for the control group can be found in Appendix H.

Analytic procedure

Preliminary analyses

All analyses were conducted using IBM SPSS Statistics 24.First, analyses were conducted to determine whether children in the intervention and control groups differed from each other at pre-test in a systematic way. Specific variables analyzed for pre-test differences were parent education, children's age, and outcome variables (i.e., parent views of importance, parent self-efficacy, direct HNE activities, indirect HNE activities, PENS-B scores, and GRTR scores). Bivariate correlation analyses were conducted to determine associations between all pretest and posttest variables. Additionally, analyses were conducted to determine if there were differences

between parents who attritted and those who did not to assess for threats of internal validity (Murnane & Willett, 2011). Differences in rates of participation (i.e., fidelity) were also examined. Intent-to-treat, as opposed to per-protocol, analyses were conducted as rates of participation in the intervention were not related to any outcomes (see Table 3) and intent-to-treat analyses are more stringent and are less biased than per-protocol analyses (Shadish et al., 2002; Szalacha, 2012).

Primary analyses

Six analyses of covariance (ANCOVAs) were conducted to test the four main hypotheses. Children's age and sex, parent education, and the associated pretest score were included as covariates in the ANCOVAs. Adjusted Hedge's g for each of the outcomes were calculated and interpreted using the What Works Clearinghouse guidelines, which defines effect sizes of 0.25 standard deviations or larger to be "substantively important" (Institute of Education Sciences [IES], 2014).

In order to test whether the intervention had positive effects on parents' beliefs of the importance of numeracy (Hypothesis 1), one ANCOVA was conducted. In order to test whether the intervention had positive effects on parents' self-efficacy for teaching math (Hypothesis 2), one ANCOVA was conducted. In order to test the hypothesis that the intervention would have positive effects on parent-child engagement (Hypothesis 3), one ANCOVA was conducted for each outcome (i.e., frequency of direct and indirect HNE activities). Finally, to test whether the intervention had positive effects on children's numeracy, but not literacy, outcomes (Hypothesis 4), one ANCOVA was conducted for each outcome (i.e., PENS-B and GRTR).

Exploratory analyses

In addition to the primary analyses, post hoc ANCOVAs were conducted on each of the individual importance, self-efficacy, direct HNE, and indirect HNE items. All analyses controlled for children's age and sex, parent education, and the associated pretest item.

Missing data

Forty-two parents consented to participate in the study. One parent assigned to the comparison group did not respond to requests to schedule an informational meeting. Thus, background information and pretest HNE reports were collected for 41 parents. Additionally, four children (one in the comparison group, three in the intervention group) did not assent to the pretest GRTR assessment. All 42 children completed pretest PENS-B. As for attrition, one parent in the comparison group could not be reached for a posttest visit. As a result, posttest HNE reports were collected for 40 parents and posttest GRTR and PENS-B scores were collected for 41 children.

RESULTS

Preliminary analyses

Means for parent and child characteristics are presented in Table 1. On average, at pretest, parents rated numeracy development to be moderately important to important (M = 2.81, SD = 0.88, Range = 0.78 to 4.00). Additionally, at pretest, most parents agreed to feeling comfortable engaging their children in numeracy activities (M = 4.28, SD = 0.63, Range = 2.75 to 5.00). At pretest, parents reported engaging their children in direct HNE activities a few times per month (M = 1.96, SD = 0.88, Range = 0.21 to 3.71). Parents also reported engaging their children in indirect HNE activities a few times per month (M = 1.66, SD = 0.85, Range = 0.33 to 3.25).

Table 1 *Descriptive Statistics of Participant Characteristics, Covariates, and Key Outcome Variables.*

	Intervention Group				Control Group			
Variable	*M*	*SD*	Min.	Max.	*M*	*SD*	Min.	Max.
Child age	3.76	0.53	3.12	4.89	4.09	0.55	3.08	4.85
Parent age	34.71	5.43	27.00	47.00	34.39	4.46	27.00	46.00
Parent education	8.00	1.10	5.00	9.00	7.74	1.05	5.00	9.00
Fidelity surveys completed	22.71	5.68	6.00	28.00	20.71	8.68	0.00	28.00

N = 40 for parent age and parent education. *N* = 42 for child age and fidelity surveys completed.

Correlations between covariates, child outcomes, and parent outcomes can be found in Table 2. Children's age was correlated with PENS-B and GRTR scores. Neither children's sex nor parent education were related to any of the outcome variables. Parents' beliefs of the importance of numeracy at pretest was not related to the frequency of direct or indirect HNE activities. Parents' self-efficacy for teaching math at pretest was related to the frequency of both direct and indirect HNE activities. Direct and indirect HNE activities were strongly related at both pretest and posttest. Direct, but not indirect, HNE activities at pretest were related to children's PENS-B scores.

Pretest differences

Children in the intervention and comparison conditions did not significantly differ from each other based on parent education, $t(39) = -1.03$, $p = .312$ (Hedge's $g = 0.31$) or child's age $t(40) = 1.73$, $p = .091$ (Hedge's $g = -0.52$). Additionally, the intervention and comparison conditions did not significantly differ from each other on key outcome variables: parents' beliefs of the importance of math $t(39) = 0.45$, $p = .653$, Hedge's $g = -0.14$; parents' self-efficacy for teaching math $t(40) = 1.73$, $p = .948$, Hedge's $g = 0.02$; direct HNE activities $t(39) = 0.65$, $p =$

.518, Hedge's g = -0.20; indirect HNE activities $t(39) = 0.92$, $p = .364$, Hedge's g = -0.28; GRTR scores $t(36) = -0.39$, $p = .700$, Hedge's $g = 0.12$; or PENS-B scores $t(40) = 1.16$, $p = .255$, Hedge's g = -0.35. Although there were not statistically significant pretest differences, it is important to note that there were substantive differences on pretest for parents' education, children's age, indirect HNE activities, and PENS-B scores. Compared to children in the control group, children in the intervention group had more highly education parents, were younger, were exposed to fewer indirect HNE activities, and performed lower on the PENS-B.

Fidelity of implementation

Intervention group fidelity

Parents in the intervention condition completed from 6 to 28 daily fidelity surveys (M = 22.71, SD = 5.68). One parent completed only 6 surveys, another parent completed 13 surveys, and the remaining 90.5% of parents in the intervention group completed more than half of the surveys. Parents in the intervention condition reported engaging in an average of 48.29 numeracy activities throughout the course of the intervention (SD = 17.90). This indicates that, on average, parents engaged in one or two numeracy activities each day. Parents reported most frequently engaging their child in an activity that they learned about from the informational meeting (M = 15.29, SD = 6.84). Parents also reported incorporating math language terms into storybook reading about half of the days (M = 13.76, SD = 6.60) and trying an activity received through a text message slightly less frequently (M = 11.71, SD = 7.02). Parents reported engaging in "other" math activities less frequently than any other activity (M = 7.52, SD = 5.10). Fidelity of implementation was not significantly related to any of the outcome variables (see Table 3).

Table 2 *Correlations between Covariates, Home Numeracy Environment, and Assessment Scores.*

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	–													
2. Child Sex	.30	–												
3. Parent Education	-.01	.08	–											
4. T1 Importance	.00	-.13	-.07	–										
5. T1 Self-efficacy	.31*	-.02	.04	.04	–									
6. T1 Direct HNE	.19	.02	-.11	.31	.39*	–								
7. T1 Indirect HNE	.17	.00	-.04	.26	.46*	.87**	–							
8. T1 PENS-B	.67**	.13	.18	-.14	.30	.39*	.28	–						
9. T1 GRTR	.64**	.05	.09	-.06	.24	.40*	.33*	.77**	–					
10. T2 Importance	-.04	-.08	-.07	.88**	.01	.31*	.25	-.11	-.07	–				
11. T2 Self-efficacy	.33*	-.18	.12	.01	.73**	.41*	.47**	.34*	.42*	.03	–			
12. T2 Direct HNE	.09	-.10	-.10	.30	.28	.76**	.63**	.28	.41*	.35*	.35*	–		
13. T2 Indirect HNE	.23	.01	-.14	.25	.34*	.76**	.76**	.26	.37*	.25	.43**	.88**	–	
14. T2 PENS-B	.74**	.23	.05	-.05	.35*	.35*	.28	.87**	.81**	-.05	.43**	.31	.33*	–
15. T2 GRTR	.64**	.17	.07	-.31	.27	.14	.13	.75**	.88**	-.29	.34*	.02	.12	.80**

N = 38-42.

Note. T1 = Time 1, T2 = Time 2, PENS-B = Preschool Early Numeracy Screener – Brief Version, GRTR = Get Ready to Read!, HNE = Home Numeracy Environment

*$p \leq .05$, **$p \leq .01$

Table 3 *Correlations between Fidelity Measures, Covariates, and Outcomes for the Intervention Condition.*

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	–													
2. Child Sex	.10	–												
3. Parent Education	.13	.18	–											
4. T2 Importance	-.21	.09	.20	–										
5. T2 Self-efficacy	.34	-.24	.04	-.06	–									
6. T2 Direct HNE	-.08	-.18	-.09	.45*	.23	–								
7. T2 Indirect HNE	.00	-.10	-.05	.36	.32	.90**	–							
8. T2 PENS-B	.77**	-.01	-.01	.13	.39	.24	.18	–						
9. T2 GRTR	.75**	-.21	.12	-.26	.57**	.05	.09	.77**	–					
10. Fidelity: Number of surveys completed	-.07	.04	-.04	-.25	-.37	-.32	-.42	-.13	-.29	–				
11. Fidelity: Math language	-.04	-.08	-.05	-.24	-.30	.22	.09	-.15	-.15	.43	–			
12. Fidelity: Meeting activity	-.04	.00	.01	.07	-.26	.14	.14	-.15	-.30	.34	.60**	–		
13. Fidelity: Text message activity	-.01	.19	.01	.18	-.28	.31	.28	-.15	-.30	.37	.70**	.68**	–	
14. Fidelity: Other math activity	.09	.00	.05	.33	.35	.07	-.01	.35	.21	.11	-.08	-.32	-.02	–
15. Fidelity: Total of all math activities	-.01	.04	.00	.10	-.22	.27	.19	-.07	-.23	.46*	.85**	.78**	.90**	.13

N = 21.

Note. T2 = Time 2, PENS-B = Preschool Early Numeracy Screener – Brief Version, GRTR = Get Ready to Read!, HNE = Home Numeracy Environment

*$p \leq .05$, **$p \leq .01$

Comparison group fidelity

Parents in the comparison condition completed from 0 to 28 daily fidelity surveys (M = 20.71, SD = 8.68). Two parents did not complete any surveys, one parent completed 10 surveys, another parent completed 13, and the remaining 81% of parents in the comparison group completed at least half of the surveys. Parents in the fidelity condition reported engaging in an average of 60.90 activities throughout the course of the intervention (SD = 30.28). This indicates that, on average, parents engaged in 2.18 activities each day. Parents reported most frequently reading with their child (M = 16.90, SD = 9.35). They also reported engaging in another quality time activity (M = 16.05, SD = 8.75). Parents also reported engaging in activities that they learned about in the meeting (M = 14.76, SD = 9.32) and from the text messages (M = 13.19, SD = 7.21).

Primary analyses

Intent-to-treat analyses were conducted including all 42 participants who enrolled in the study. Adjusted pretest means, adjusted posttest means, standard deviations, and adjusted effect sizes are presented in the results and in Table 4. Unadjusted values are presented in Table 5.

Parents' beliefs of the importance of mathematics

Contrary to hypotheses, at posttest, controlling for children's age and sex, parent education, and pretest beliefs of importance, there were not statistically significant differences of parents' beliefs of the importance of mathematics between the intervention and comparison groups, $F(1, 33) = 0.12$, $p = .729$, Hedge's $g = 0.07$.

Table 4 *Adjusted Pretest and Adjusted Posttest Mean Scores, Standard Deviations, and Effect Sizes for Key Measures.*

	Intervention Group n = 21				Control Group n = 19				
	Adjusted Pretest		Adjusted Posttest		Adjusted Pretest		Adjusted Posttest		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Hedge's *g*
Importance of numeracy	2.75	0.86	2.91	0.85	2.86	0.93	2.84	1.05	0.07
Self-efficacy	4.54	0.65	4.56	0.61	4.45	0.61	4.51	0.50	0.08
Direct HNE practices	1.93	0.98	2.62	0.92	1.99	0.77	2.40	0.80	0.25
Indirect HNE practices	1.58	0.79	2.13	0.83	1.75	0.91	1.99	0.75	0.17
PENS-B	9.77	6.62	12.84	5.60	10.44	5.61	10.49	6.54	0.38*
Get Ready to Read!	16.37	6.08	16.23	5.13	13.96	4.95	16.83	6.17	-0.10

Note. Pretest means are adjusted for child age and sex and parent education. Posttest means are adjusted for child age and sex, parent education, and pretest score of the variable of interest;
PENS-B = Preschool Early Numeracy Screener – Brief Version, HNE = Home Numeracy Environment
*$p \leq .05$

Table 5 *Raw Pretest and Posttest Mean Scores, Standard Deviations, and Effect Sizes for Key Measures.*

	Intervention Group *n* = 21				Control Group *n* = 19				
	Pretest		Posttest		Pretest		Posttest		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Hedge's *g*
Importance of numeracy	2.77	0.86	2.87	0.85	2.85	0.93	2.88	1.05	-0.01
Self-efficacy	4.51	0.65	4.56	0.61	4.45	0.61	4.51	0.50	0.09
Direct HNE practices	1.87	0.98	2.55	0.92	2.05	0.77	2.48	0.80	0.08
Indirect HNE practices	1.54	0.79	2.00	0.83	1.78	0.91	2.14	0.75	-0.17
PENS-B	8.81	6.62	11.29	5.60	11.10	5.61	11.95	6.54	-0.11
Get Ready to Read!	15.06	6.08	15.19	5.13	15.10	4.95	16.00	6.17	-0.14

Note. PENS-B = Preschool Early Numeracy Screener – Brief Version, HNE = Home Numeracy Environment
*$p \leq .05$

Parental self-efficacy

Contrary to hypotheses, at posttest, controlling for children's age and sex, parent education, and pretest self-efficacy, there were not statistically significant differences of parents' self-efficacy for teaching math between the intervention and comparison groups, $F(1, 33) = 0.22$, $p = .640$, Hedge's $g = 0.08$.

Frequency of HNE activities

Direct HNE activities

At posttest, controlling for children's age and sex, parent education, and pretest direct HNE activities, there were not statistically significant differences of parents' reports of the frequency of direct HNE activities between the intervention and comparison groups, $F(1, 33) = 1.32$, $p = .258$, Hedge's $g = 0.25$. However, What Works Clearinghouse guidelines indicate that this effect is "substantively important" (IES, 2014), supporting hypotheses.

Indirect HNE activities

Contrary to hypotheses, at posttest, controlling for children's age and sex, parent education, and pretest indirect HNE activities, there were not statistically significant differences of parents' reports of the frequency of indirect HNE activities between the intervention and comparison groups, $F(1, 33) = 0.69$, $p = .414$, Hedge's $g = 0.17$.

Child outcomes

Numeracy skills

As hypothesized, at posttest, controlling for children's age and sex, parent education, and PENS-B pretest score, children in the intervention condition significantly outperformed children

in the comparison condition on the PENS-B, $F(1, 33) = 6.86$, $p = .012$, Hedge's $g = 0.38$. What Works Clearinghouse guidelines indicate that this effect is "substantively important" (IES, 2014).

Pre-literacy skills

As hypothesized, at posttest, controlling for parents' education and children's age, sex and, GRTR pretest score, children whose parents participated in the intervention did not score significantly higher on the GRTR assessment compared to children in the comparison condition, $F(1, 33) = 0.39$, $p = .536$, Hedge's $g = -0.10$.

Exploratory analyses

Pretest means, adjusted posttest means, standard deviations, and adjusted effect sizes for post hoc analyses are presented in Tables 6 to 9.

Parents' beliefs of the importance of mathematics

See Table 6 for all individual beliefs of importance items. At posttest, parents in the intervention group reported greater beliefs in the importance of solving basic word problems compared to parents in the comparison group, ($F[1, 34] = 1.95$, $p = .172$, Hedge's $g = 0.35$. Parents in the comparison group rated accurately counting 1 to 15 objects in a row to be more important than parents in the intervention group ($F[1, 34] = 1.20$, $p = .281$, Hedge's $g = -0.26$.

Parents' self-efficacy

See Table 7 for all individual self-efficacy items. At posttest, compared to parents in the comparison group, parents in the intervention group reported greater self-efficacy on "I feel comfortable integrating math activities into my child's daily routines" ($F[1, 34] = 3.86$, $p = .058$, Hedge's $g = 0.49$).

Frequency of HNE activities

See Table 8 for all individual direct HNE items. At posttest, parents in the intervention group reported engaging their children more frequently in five individual direct HNE practices: counting objects (F[1, 34] = 5.82, p = .021, Hedge's g = 0.53), learning simple sums (F[1, 34] = 4.52, p = .041, Hedge's g = 0.65), asking math related questions (F[1, 34] = 5.18, p = .029, Hedge's g = 0.71), comparing quantities (F[1, 34] = 4.76, p = .036, Hedge's g = 0.63), and comparing sizes of numbers (F[1, 34] = 5.30, p = .028, Hedge's g = 0.72). The comparison group reported more frequent engagement in reading number storybooks (F[1, 34] = 1.49, p = .231, Hedge's g = -0.29), identifying names of written numbers (F[1, 34] = 1.61, p = .214, Hedge's g = -0.34), and counting down (F[1, 34] = 1.20, p = .281, Hedge's g = -0.30).

See Table 9 for all individual indirect HNE items. At posttest, parents in the intervention group reported engaging their children more frequently in three individual indirect HNE practices: comparing sizes (F[1, 34] = 3.82, p = .059, Hedge's g = 0.54), playing with calculators (F[1, 34] = 5.22, p = .029, Hedge's g = 0.54), and sorting things by size/color/shape (F[1, 34] = 1.87, p = .180, Hedge's g = 0.33).

Table 6 *Pretest and Adjusted Posttest Mean Scores, Standard Deviations, and Effect Sizes for Individual Importance of Numeracy Items.*

	Intervention Group *n* = 21				Control Group *n* = 19				
	Pretest		Adjusted Posttest		Pretest		Adjusted Posttest		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Hedge's *g*
Calculating simple sums	1.81	1.17	1.94	1.26	1.95	1.36	2.01	1.35	-0.05
Using terms more than/less than	2.71	1.19	2.91	1.00	2.70	1.38	2.62	1.34	0.24
Identifying numbers	3.48	0.75	3.42	0.87	3.50	0.83	3.53	0.84	-0.13
Solving basic word problems	1.86	1.28	2.36	1.38	1.95	1.36	1.87	1.40	0.35
Verbally counting to 40	2.24	1.45	2.73	1.29	2.80	1.36	2.45	1.38	0.21
Accurately counting 1 to 15 objects in a row	3.29	0.85	3.23	0.90	3.35	0.93	3.48	1.02	-0.26
Printing numbers	2.76	1.18	2.88	1.12	3.05	1.32	2.92	1.29	-0.03
Counting out 1 to 5 objects from group	3.38	0.87	3.41	0.60	3.15	0.99	3.34	1.10	0.08
Reading numbers 1 to 10	3.19	1.03	3.20	1.17	3.40	1.14	3.41	1.03	-0.19

Table 7 *Pretest and Adjusted Posttest Mean Scores, Standard Deviations, and Effect Sizes for Individual Self-Efficacy Items.*

	Intervention Group *n* = 21				Control Group *n* = 19				
	Pretest		Adjusted Posttest		Pretest		Adjusted Posttest		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Hedge's *g*
I feel comfortable teaching my child about numbers	4.57	0.75	4.50	0.87	4.55	0.76	4.66	0.58	-0.21
I feel comfortable integrating math activities into my child's daily routines	4.33	0.80	4.53	0.68	4.30	0.87	4.15	0.83	0.49
I have the skills necessary to teach my child about numbers and math	4.38	0.97	4.58	0.68	4.35	0.88	4.41	0.69	0.24
I can teach my child in our daily interactions	4.67	0.58	4.67	0.58	4.70	0.47	4.79	0.42	-0.23

Table 8 *Pretest and Adjusted Posttest Mean Scores, Standard Deviations, and Effect Sizes for Individual Direct HNE Items.*

	Intervention Group n = 21				Control Group n = 19				
	Pretest		Adjusted Posttest		Pretest		Adjusted Posttest		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Hedge's *g*
Counting objects	3.57	1.08	4.20	0.83	3.65	1.18	3.62	0.99	0.53*
Reading number storybooks	2.48	1.50	2.81	1.45	2.60	1.14	3.21	1.20	-0.29
Using number activity books	1.76	1.48	1.83	1.49	1.58	1.22	2.15	1.57	-0.21
Identifying names of written numbers	2.62	1.50	3.02	1.40	2.68	1.49	3.48	1.26	-0.34
Learning simple sums	0.76	1.22	2.38	1.19	1.00	1.12	1.48	1.50	0.65*
Counting down	1.48	1.60	1.92	1.49	1.80	1.36	2.35	1.35	-0.30
Playing with number fridge magnets	1.05	1.47	1.05	1.30	1.20	1.77	0.82	1.76	0.15
Printing numbers	1.52	1.63	2.11	1.69	1.65	1.34	2.09	1.34	0.01
Asking math-related questions	1.43	1.29	3.17	1.34	2.00	1.38	2.29	1.07	0.71*
Comparing quantities	1.90	1.48	3.36	0.89	2.00	1.41	2.61	1.41	0.63*
Reciting numbers in order	2.76	1.64	3.52	1.11	3.45	1.00	3.74	0.91	-0.21
Comparing sizes of numbers	1.52	1.44	2.94	1.26	1.65	1.42	1.97	1.37	0.72*
Asking about quantities	2.71	1.62	3.31	1.25	2.75	1.21	3.02	1.17	0.23
Using number/arithmetic flashcards	0.67	1.02	1.09	1.42	0.70	1.22	0.69	1.07	0.31

Table 9 *Pretest and Adjusted Posttest Mean Scores, Standard Deviations, and Effect Sizes for Individual Indirect HNE Items.*

	Intervention Group *n* = 21				Control Group *n* = 19				
	Pretest		Adjusted Posttest		Pretest		Adjusted Posttest		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Hedge's *g*
Measuring ingredients while cooking	1.71	1.06	2.11	1.07	1.65	1.23	1.88	1.39	0.18
Playing board games with die or spinner	1.62	1.56	1.99	1.35	2.00	1.49	1.80	1.35	0.14
Playing card games	1.71	1.62	1.82	1.47	1.55	1.00	1.67	1.25	0.11
Sorting things by size, color, or shape	2.05	1.50	2.83	1.12	2.50	1.36	2.45	1.15	0.33
Talking about money while shopping	0.67	0.86	1.70	0.98	1.65	1.31	1.81	1.29	-0.09
Noting numbers on signs	1.90	1.76	3.05	1.42	3.00	1.71	3.05	1.43	0.00
Playing games that involve counting/adding/subtracting	2.14	1.62	2.39	1.25	1.75	1.45	2.68	1.39	-0.22
Playing with calculators	0.48	0.75	1.00	1.22	0.53	0.91	0.39	0.96	0.54*
Playing games in the car that involve math	1.48	1.47	2.46	1.68	1.75	1.59	2.60	1.37	-0.09
Learning/singing math songs or rhymes	1.62	1.63	1.60	1.36	1.85	1.60	1.75	1.44	-0.11
Comparing sizes	2.57	1.47	3.67	0.97	2.50	1.24	3.11	1.07	0.54
Playing dominoes	0.52	0.75	0.70	0.97	0.60	1.14	0.81	1.15	-0.10

Parent Views of Intervention Components

General study feedback

All parents who participated in the study, regardless of group assignment, were asked about the frequency of text messages. A majority of parents (*n* = 29; 72.5%) felt that the frequency was "about right." The remaining 11 parents felt that the text messages were received too frequently. Of those parents, most indicated that they would prefer to receive text message tips one to three times per week. Additionally, all parents who participated in the study agreed or strongly agreed that the informational meeting was easy to understand, and all but one parent agreed or strongly agreed that the text messages were easy to understand.

HNE Intervention-specific feedback

Of the 21 parents assigned to the intervention condition, 18 reported that they referred to the PowerPoint slides and/or notes from the slides at some point during the intervention. Of the 18 parents who reported referring to the slides and/or notes, most (*n* = 10; 47.6%) reported referring to them throughout the project. All parents who participated in the intervention agreed or strongly agreed that they noticed benefits for their children's math skills due to their participation. All parents who participated in the intervention agreed or strongly agreed that their participation increased their knowledge about how to engage their child in math at home. Further, at the conclusion of the intervention, all but one of the parents agreed or strongly agreed that they felt confident about their abilities to engage their child in math at home.

DISCUSSION

The purpose of this study was to examine the feasibility of a non-intensive four-week intervention to promote parent-child engagement in numeracy activities. The development of the

intervention was guided by the expectation that, in order to increase the frequency of HNE activities, it is necessary to provide parents with practical strategies that can be incorporated into existing routines. Additionally, it was believed that parents' self-efficacy and beliefs in the importance of math development would be important components to target. This study fills an important gap in the literature, as it is the first RCT assessing the effectiveness of an intervention targeting the broad HNE by providing parents with specific numeracy engagement strategies delivered through a brief informational meeting and daily text messages. Additionally, it expands on previous intervention studies by targeting only the home environment (i.e., not including schools; Starkey et al., 2004) and targeting all four aspects of the HNE (i.e., beliefs, engagement, attitudes, and resources).

The hypotheses were partially supported and the findings generally align with and expand upon previous HNE intervention research (Niklas et al., 2016; Starkey & Klein, 2000). At posttest, compared to parents in the control condition, parents in the intervention group reported more frequent direct HNE activities and their children showed greater improvement on a measure of early numeracy skills. Effect sizes were similar to those found in previous HNE intervention studies (Starkey & Klein, 2000). Children's numeracy skills improved despite that, at posttest, there were not substantive differences between the intervention and control group on beliefs of the importance of numeracy, self-efficacy for teaching math, or engagement in indirect HNE activities. Although further examination is necessary, it seems that increasing the frequency of direct HNE activities—and specifically counting objects, learning simple sums, asking math-related questions, comparing quantities, and comparing the sizes of numbers—is sufficient for generating substantive change in children's early numeracy skills. It is also important to note that, although not all results were significant or substantive, effects for all composite numeracy outcomes were positive.

Intervention Components

The HNE intervention was developed to target four components of the HNE that have been theorized to contribute to children's development of numeracy skills: parents' beliefs of the importance of math, engagement in numeracy activities, attitudes (i.e., parents' self-efficacy), and resources. It is critical to consider each of these outcomes in order to determine which are necessary for the intervention to be successful.

Beliefs of the importance of math

Parents' beliefs of the importance of math development have been demonstrated to be positively related to the frequency of their engagement in numeracy activities with their children (Musun-Miller & Blevins-Knabe, 1998). Thus, it was expected that it would be important to target parents' beliefs of the importance of numeracy in order to encourage parent-child engagement in HNE activities. At the end of the study, parents in the intervention condition were no more likely to report believing math development to be important for their child than parents in the comparison condition. One likely reason for this null finding is the duration of the intervention. It may not be feasible to meaningfully change parents' feelings about math in one month. Public opinion about the importance of literacy development changed over decades of research and public outreach (e.g., Zuckerman & Khandekar, 2010), and the same amount of time and effort may be required for parents to value math development to the same extent. It may be necessary to provide boosters or follow-up with parents in order to see sustained improvement in children's skills. Relatedly, it is also possible that the intervention did not provide enough support for parents in terms of increasing their beliefs of the importance. It may be necessary to provide more information on the importance of early math development, or to build in natural reinforcements such as midterm

assessments and reports where parents can see the positive impact that their involvement in the intervention has on their children's development.

Another potential explanation is misalignment between the survey items measuring importance and the information that parents received regarding the importance of math. In general, parents who participated in the intervention may find math development to be more important compared to parents in the comparison group, but this may not have been tapped into with the questions that were provided. For example, parents may think math skills are important in preschool, but not specifically think that learning to solve word problems is an important skill for preschool children. Parents received only broad messages regarding the importance of early math development (e.g., "Early math is important"), and not specific messages such as, "Solving word problems is important." It will be important for future research to delineate parents' beliefs of the importance of math and determine if those beliefs are more nuanced than the information collected in the present study.

It is important to note that, although parents' opinions of the importance of numeracy did not change, parents in the intervention still reported more frequent direct HNE practices. Additional research is necessary in order to understand this relation. It may be that the measures of importance did not accurately tap into parents' beliefs, or that parents' beliefs regarding math are not important in determining their numeracy practices. It may also be that parents in the study met a certain necessary threshold of beliefs of importance to engage in practices. Understanding this relation will be important in future development of the intervention to determine if targeting parents' beliefs is necessary, or if the intervention could be equally successful without that component.

Engagement

Parent-child engagement in HNE activities is positively related to children's numeracy development (Anders et al., 2012; Huang et al., 2017). However, there is limited evidence demonstrating whether an intervention targeting the HNE can be effective in promoting this engagement. Thus, a primary intent of the current intervention was to increase the frequency of both direct and indirect HNE activities. Compared to parents in the counterfactual condition, although the effect was not statistically significant, parents who participated in the intervention reported engaging their child in substantively more direct HNE activities. Additionally, although the effect was not statistically significant or substantive, positive increases were demonstrated for indirect activities as well. Similar to the findings of Niklas et al. (2016), parents who participated in a brief HNE intervention reported increased HNE activities.

Parents in the intervention condition may have learned ways to integrate numeracy into daily activities that their children were already doing. Many of the direct HNE activities that were assessed are those that can easily be incorporated into other activities. For example, counting or asking a child a math-related question can be done while playing at the park, and there were substantive intervention effects on those individual items. This type of engagement is less time consuming and involves fewer specific materials than many of the indirect HNE activities that were measured. Parents may have also learned new math-focused activities through the resources that were provided (e.g., the math printout game), but did not consider those activities when reporting on the indirect HNE items as they were not directly asked about.

It is important to note that parents in the counterfactual condition reported substantive increases in the frequency of engaging in a few specific HNE activities. It may be that parents were prompted by the HNE questionnaire to engage in these activities more often. For example,

parents were asked to report numerals that their children could name. Parents in the counterfactual condition reported engaging their children more in identifying names of written numbers. Further, parents in the counterfactual group reported reading more number storybooks with their children. Parents who participated in the intervention learned strategies for incorporating numeracy into storybook reading, and they may have focused on integrating math into typical storybooks rather than focusing on math-specific books.

Importantly, parents most frequently reported engaging their children in activities learned during the informational meeting, through the text-messaged tips, or by incorporating math language terms into shared storybook reading. Parents only reported engaging their children in other numeracy activities about a quarter of the days. This indicates that providing parents with specific strategies for engaging their children in numeracy—rather than simply asking them to increase their numeracy activities—may be a necessary component for the intervention to be effective. Further, parents reported incorporating math language into reading about half of the days. Teaching parents to incorporate numeracy into activities that they are doing already is another likely reason for positive effects of the intervention. Given that parents report that time is the largest barrier that prevents engagement in interventions (Heinrichs et al., 2005; Mendez et al., 2009), capitalizing on activities that they are already doing with their children may be the most effective strategy for increasing engagement with numeracy concepts.

Parents who participated in the intervention were not significantly more likely to report engaging their children in indirect HNE activities than parents in the comparison group. Some parents reported that the suggested indirect activities (e.g., cooking together) involved too much preparation. Other activities, like playing board games or card games, required parents to engage in a specific activity, rather than incorporating questions or activities into something they were

already doing together. Further, many of the indirect activities required specific materials, like a board game or a deck of cards, that may have required extra effort to set up. Despite the effect of indirect HNE engagement being non-significant and non-substantive, it is important to note that the effect was positive. Additionally, parents in the intervention group did show substantive increases in the frequency of some indirect HNE activities (i.e., comparing sizes, playing with calculators, and sorting items by size, color, or shape). Importantly, like the direct HNE activities, these are practices that parents and children can engage in while doing other activities together (e.g., sorting toys while playing).

The factor that distinguishes direct practices from indirect practices is that indirect activities occur in the context of a real-world task (LeFevre et al., 2009). Direct HNE activities involve intentional teaching of numeracy skills, whereas indirect HNE activities are more incidental. It may be that the intervention caused parents to be more aware of math in everyday contexts, and to intentionally promote numeracy development in those contexts. When intentional teaching takes place in real-world contexts, it becomes difficult to distinguish activities as either direct or indirect (Skwarchuk et al., 2014). Additionally, although an important factor of indirect HNE activities is that they occur in real-world contexts (LeFevre et al., 2009), parents may not be doing activities that provide the real-world context regularly (e.g., cooking together, shopping, playing board games). Many parents report engaging children with numeracy in an unstructured way (Cahoon et al., 2017), and it may be more realistic for HNE interventions to focus on how parents can incorporate intentional teaching of numeracy into preexisting routines rather than asking parents to allot time to numeracy-specific activities.

Attitudes

Previous research reports that parents generally do not feel efficacious teaching their children math (Cannon & Ginsburg, 2008). However, research on early numeracy often compares parents' feelings of math and literacy (e.g., Blevins-Knabe et al., 2000; Cannon & Ginsburg, 2008), which may explain why most findings indicate that parents are not comfortable engaging in math. It may not be that parents are uncomfortable with math, but that they are less comfortable with math than reading. Other research focuses on parents' self-efficacy for their own math performance rather than self-efficacy for teaching math (Vasilyeva, Laski, Veraksa, Weber, & Bukhalenkova, 2018). It may be that parents do not feel confident with their own ability to perform math tasks, and not that parents do not feel comfortable with numeracy activities in general.

The results of the current study are aligned with findings from other countries that indicate that parents feel comfortable with their ability to teach their children math (e.g., Cheung, Yang, Dulay, & McBride, 2018). On average, parents in both conditions reported feeling efficacious teaching their children about math concepts and engaging in math activities, both before and after participation in the study. Likely due to high initial reports of self-efficacy, parents who participated in the intervention were not more likely to report greater feelings of self-efficacy for teaching math than parents in the comparison group. In future validation of the intervention, it will be important to determine whether the intervention is effective for parents who are less efficacious. The intervention may only be effective for parents who feel comfortable engaging their children in math activities. There is not enough variability in the current sample to determine if there are differences in participation or outcomes if parents do not feel efficacious. Further, parents' high levels of self-efficacy at the beginning of the intervention prevent conclusions regarding the effectiveness of the intervention in improving self-efficacy. Components were built into the

informational meeting and the text messages to promote self-efficacy, but it is impossible to conclude whether these components are effective or if they are necessary for the intervention to be successful.

Although parents' overall self-efficacy did not improve as a result of the intervention, parents who participated in the intervention demonstrated a substantive increase in their comfort with integrating math activities into their children's routines. Teaching parents ways to incorporate numeracy into activities and routines that they were already engaging in with their children was a primary goal of the intervention. It may be that parents practiced this more during the four-week intervention and became more confident in their abilities. In future evaluations of HNE interventions, it will be important to ask additional self-efficacy questions in order to determine if there are certain aspects of self-efficacy that are more important than others in promoting parents' comfort with engaging their children in numeracy activities.

It must be acknowledged that, on average, parents who participated in this study were well educated. All parents completed high school and many parents held a graduate degree. Parents with higher levels of education may feel more efficacious teaching and engaging with their children compared to parents with lower levels of education (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Thus, a more diverse sample will be necessary before determining whether self-efficacy is an important component of the intervention, and whether the intervention is effective at increasing parents' self-efficacy for engaging their children in math activities.

Resources

Starkey and Klein (2001) speculated that making math materials accessible to parents was a key factor in the success of their HNE intervention. Thus, providing parents with activities to engage in with their children was expected to be an important component of the present

intervention. The intervention also involved showing parents how they could use materials that they already had in their homes to engage their children with numeracy concepts. Parents in both the intervention and counterfactual conditions received materials to engage in with their children. Although many parents in the intervention condition commented on using materials, either in the final questionnaire or in the daily surveys, few parents in the comparison condition did. The activity kits for the intervention group included copies of the slides and presenter notes, a bookmark to encourage the use of math language during reading, dice, number cards, and a number game. The resources provided to parents were inexpensive or free and most could be easily accessed on the internet.

Providing materials may be important for short-term impacts, but perhaps more important is providing parents with strategies for using resources that are already present in their homes. The current intervention demonstrated for parents how children's books, snacks, toys, and other objects that many families have in their homes could be used to engage children with numeracy concepts. Additionally, because these items are readily available, parents did not have to have transportation or allot time to retrieving activities kits as they did in Starkey and Klein's (2000) intervention. Although conclusions cannot be drawn from the current study, it is likely that providing parents with ways to engage using materials that they already have is a more useful, cost-effective strategy than only providing access to materials.

Child Outcomes

Numeracy

Results indicate that a brief, non-intensive intervention may be effective in improving children's early numeracy skills. The findings are similar to Starkey and Klein's (2000) intervention, which also concluded that encouraging parents to engage with math activities with

their children at home is an effective way to improve children's early numeracy performance. However, the present study expands on previous intervention work by demonstrating that the HNE intervention does not have to be intensive to be effective. The intervention in the present study was only four weeks long and required only one meeting with parents, whereas Starkey and Klein's intervention was four months long and consisted of eight meetings. Using text messages as a method of delivering information is likely more feasible for parents than attending several meetings. Further, text messages can be read at a time that is convenient for parents, and the messages can be stored to review later. This is more convenient than attending meetings, particularly for families who struggle with transportation, childcare, and nontraditional working hours.

The findings of the study also provide initial evidence of a causal relation between the HNE and children's numeracy outcomes. This is aligned with correlational research (Anders et al., 2012; Napoli & Purpura, 2018), as well as preliminary evidence from intervention research (Niklas et al., 2016; Starkey & Klein, 2001). Children of parents who received the intervention, which promoted numeracy engagement at home, demonstrated improved numeracy skills from pretest to posttest. Future evaluations of the intervention should conduct mediation analyses to determine the mechanisms for this relation and to evaluate the theory of change, that participating in the HNE intervention leads to increased HNE activities which promote children's numeracy skills.

Emergent literacy

The intervention group and comparison group did not significantly differ at posttest on the GRTR emergent literacy screener. Thus, because the intervention group did not outperform the control group, it can be surmised that the intervention was not functioning to increase broader

parent-child engagement, but that it is domain specific. This finding is also important because it indicates that the intervention did not negatively affect children's literacy development.

Parent Views and Future Considerations

Parents' opinions of the intervention are important to consider when determining next steps. Specifically, parents' views of the text messaging component (i.e., frequency of messages and the program used to deliver them) will be a critical consideration as this is a fairly new method for delivering intervention components. Additionally, it will be important to collect information on parents' views of the resources (i.e., activity kits) that were provided in order to determine if they are a necessary and enjoyed component of the intervention.

Parents' general opinions and fidelity

Parents' views of the intervention, as well as their reports of fidelity of implementation, indicate that a four-week parenting intervention targeting children's numeracy development is feasible. Parents responded positively to the intervention and most parents engaged regularly by completing daily fidelity surveys. However, information on parents' enjoyment of participating was not collected. In future evaluations of the intervention, data should be collected regarding parents' enjoyment of participating in the intervention, as well as enjoyment of participating in specific HNE activities. Parents' enjoyment may be an important factor of the intervention, but that cannot be determined from the present study.

On average, parents in the intervention group completed about 80% of the daily fidelity surveys. Further, through the surveys they reported engaging their children in an average of one to two numeracy activities each day. Taken together, the composite direct and indirect HNE variables indicate that parents in the intervention group reported engaging in some kind of math activity a

few times per week. Although this is slightly less often than responses to the fidelity surveys, it is likely that some of the activities parents engaged in were not captured on the HNE questionnaire. Further, parents may have over-reported on fidelity surveys as they could have perceived the questions to be asking about the same thing. Specifically, parents received a text message asking if they incorporated math language into reading, and this activity was discussed during the informational meeting. As such, parents may have responded "yes" to fidelity questions asking about engaging in an activity from the meeting, as well as the question about incorporating math language into storybook reading. This would have been reflected in the fidelity survey as two activities, though there may have only been engagement in one activity.

The results indicate that it is feasible to encourage parents to engage in daily numeracy activities. Parents reported engaging their children most frequently in activities that they learned about during the intervention. This is supported by responses to the HNE questionnaire and the specific items that showed substantive growth (e.g., asking math-related questions, comparing numbers and quantities). Thus, it is critical that future HNE interventions provide parents with specific strategies for engaging in numeracy activities with their children. This is likely a more feasible way to promote HNE engagement compared to generally encouraging parents to engage in math without providing examples and strategies for doing so. Parents may be aware that they should engage their child in numeracy activities, but may not know specific strategies for promoting numeracy competence (e.g., counting objects rather than verbal counting). Additionally, parents may not have ideas about how to incorporate numeracy into activities that they are already doing (e.g., incorporating math language terms into storybook reading). Providing specific activities and strategies gives parents concrete, attainable goals to aim for rather than the broad, potentially overwhelming task to just "do more."

Frequency of text messaging

Text messaging was included in the intervention because it is a way of engaging parents in regular communication without requiring them to travel or be available at a specific time. Text messaging is a cost-effective way to share simple engagement strategies with parents. It is important to ensure that the frequency of text messaging is appropriate for parents because receiving text messages too frequently or not frequently enough may cause parents to disengage from the study (Cortes, Fricke, Loeb, & Song, 2018). A majority of parents indicated that the frequency of text messaging was about right. However, about one-fourth of the parents thought that text messages were sent too often. Previous research indicates that three text messages per week can be effective in increasing parent-child engagement (Hurwitz et al., 2015). In further development of the intervention, it will be important to determine the right balance for the frequency of sending tips. Decreasing the frequency of text messages over the course of an intervention has been shown to be an effective strategy, perhaps because reminders and suggestions are less necessary as participants begin to change their behaviors (Head et al., 2013).

It may be that parents who thought the text messaging was too frequent were also considering the daily fidelity surveys, and believed that receiving two separate messages and responding to a survey each day was burdensome. In further development and assessment of this intervention, parents' opinions about the frequency of text-messaged numeracy suggestions should be assessed separately from text-messaged fidelity surveys. Additionally, it will be important to consider other methods of collecting fidelity data in order to reduce the burden of completing a daily survey.

An additional consideration is that text messages were sent at the same time for all participants (i.e., around 4:30 p.m. on weekdays and 11:00 a.m. on weekends). Head et al. (2013)

suggest that the time of day that messages are receiving may influence how participants feel about the frequency of text messages. Allowing participants to select the time that they receive text messages may ameliorate feeling that text messaging is too frequent. For example, if parents are driving home from work or cooking dinner at the time messages are received, they may feel that the messages are a distraction or interfere with their routines, or they may simply ignore the messages. On the other hand, if parents select the best time for messages to be sent, they can receive them at a time that does not disrupt their daily activities.

Use of Remind™ software

Remind™ was a convenient, free way to schedule text messages in advance. Although the program was convenient to schedule and deliver the messages, it may not have been the best option for receiving the messages. Some parents indicated that Remind™ was being used by their children's school. In these instances, parents sometimes missed or did not see text messages until after they were sent because parents were receiving other messages through the same program. In further development of this intervention, it will be important to use a text-messaging program that is not commonly used by schools or other organizations with which parents frequently interact.

Another consideration is that Remind™ can be downloaded as a phone app and parents may have downloaded the app to their phone and received notifications from the app rather than text messages. Using a different text messaging program will be necessary in determining if text messages specifically, and not notifications from an app, are an effective way of delivering intervention information. Additionally, Remind™ messages have a character limit, and many of the daily tips had to be sent as two text messages. Parents who felt that text messages were sent too frequently may have been thinking of the inconvenience of receiving two messages rather than one. Finally, tailoring text messages to individual participants is difficult with Remind™. Using a

program that easily customizes text messages (e.g., uses parent and child names, allows participants to select the time messages are received) may be an ideal way to engage and retain participants (Fjeldsoe et al., 2009; Head et al., 2013).

Resources

Specific data were not collected regarding parents' use of the activity kits. Future assessment of the intervention should include specific questions regarding whether parents used the materials that were provided to them and, if so, how frequently. Further, parents' opinions about the materials that were provided are important to evaluate. Many of the materials provided would be classified as indirect activities (e.g., card games, dice), and parent-child engagement in indirect HNE activities did not substantively increase as a result of the intervention. It is possible that parents used the materials in ways that would be categorized under direct HNE activities (e.g., using the die to practice counting rather than as a game). Without asking specific questions regarding materials, it is impossible to deduce if and how parents engaged with them, and how they reported the use in the HNE questions that were asked.

Study Limitations and Future Directions

There are limitations of the present study that should be noted, and each indicates a direction for future research. The first limitation is that the sample size is small. As such, results should be interpreted with caution as the study was underpowered and effect sizes may be inflated. Though this is a pilot study and the feedback from parents will help to build a larger program, the small sample size limits the generalizability of the results. The small sample size also limits ability to conduct additional analyses such as moderation (e.g., determining if parents' self-efficacy, math anxiety, or beliefs in the importance of math moderate the effects of the intervention). It will be

important for researchers to conduct moderation analyses on future HNE interventions to evaluate the theory of change. As such, future research on HNE interventions should use a larger sample.

A second limitation is that the sample is relatively homogenous. Parents who participated in this study were generally well educated, English speaking, and married. Future research should evaluate the intervention in a more diverse sample. Specifically, it will be important to determine if the intervention is feasible in single-parent households or for parents with lower levels of education attainment. Additionally, future research should examine the effectiveness of the intervention for dual language learners.

A third limitation is that a business-as-usual comparison condition was not included. Although comparing the intervention condition to an active comparison group has many strengths, there may have been aspects of the information that the comparison group received that affected outcomes. This is unlikely as many of the parents in the comparison condition expressed that the activities provided were things that they were already engaging in with their child. However, some parents expressed that receiving and responding to the text messages helped them to be more mindful of their engagement with their children. Future research should include both active and business-as-usual counterfactuals to better understand effects that are HNE-specific and those that are general effects of promoting parent-child engagement.

A fourth limitation of the current study is that the informational meetings were held with individual parents or in pairs, rather than in groups, and informational meetings were all conducted by the same person. These are not feasible delivery methods for scale-up. Due to parents' individual differences and questions that parents asked during the informational meeting, each parent may have had a unique experience with the intervention. Further, the relationship between the interventionist and the parent may be an important component, and one that is unlikely to

develop if the intervention is delivered to a much larger group. An important next step for this intervention is to assess its effectiveness when the informational meeting is delivered to larger groups and by different interventionists.

A fifth limitation is that HNE information was collected via parent report. Although self-report is a common data collection method, it allows for reporter bias. Parents in the intervention condition may have over-reported HNE activities on the fidelity surveys or at posttest due to social desirability. Further, the intervention may have made parents more aware of numeracy activities that they had already been doing. Future research should use additional data collection methods that reduce the potential for bias, such as directly observing or asking parents to audio record interactions. Although these techniques may cause parents to alter their interactions, they may provide more accurate information on the frequency of HNE activities. Additionally, only one parent—usually a mother—was involved in the intervention and reported about engagement. It will be important for future studies to involve both parents when possible, and to actively solicit the involvement of fathers.

A sixth limitation is that some children attended the informational meeting with their parents, rather than being assessed at their preschool. Although we attempted to keep parents and children in separate rooms, children were sometimes not comfortable when their parent left the room. As a result, in three instances parents were in the room while their child was being assessed. These parents, all of whom were assigned to the comparison condition, may have heard the assessments that were being conducted and altered their behaviors accordingly (e.g., overhearing their child being asked to count and practicing this skill with their child). Child assessments may also have been affected by the presence of the parent. Future research should ensure that children

are assessed without the parent present in order to prevent the potential that the assessments affect parent behaviors or that children perform differently due to their parents' presence.

A seventh limitation is that the study does not include parents' reports of math anxiety, and items addressing self-efficacy were limited. Parents' math anxiety is significantly and negatively associated with their self-reported mathematics engagement with their children, meaning that parents who are anxious about math are less likely to engage in parent-child mathematics activities (del Rio, Susperreguy, Strasser, & Salinas, 2017). Math-based interventions that are easy to implement may be particularly salient for parents with math anxiety (Berkowitz et al.,2015). It may be that providing parents who have math anxiety with specific tools to engage their children mitigates their anxiety by giving them a concrete strategy for teaching math and removing some of the pressure of thinking of activities on their own. Additionally, being able to support their children's math development may bolster parents' self-efficacy regarding teaching and engaging in math activities. Additionally, the present study included only four questions on parents' self-efficacy. Future evaluations should include additional, more specific self-efficacy items in order to ensure that parents do not report inaccurately high levels of self-efficacy.

Conclusion

Despite its limitations, the present study demonstrates the feasibility of an HNE intervention for parents of preschool children. In general, parents were engaged in the intervention, reported finding the activities to be easy to integrate into their daily routines, and completed the intervention. As a result of their parents' participation in the intervention, children's numeracy scores were improved. The study provides initial evidence of a causal relation between the HNE and children's numeracy outcomes. Although the intervention was designed with scale-up in mind,

this was a pilot efficacy trial and an important next step is determining whether the intervention is effective when delivered under less ideal circumstances.

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APPENDIX A. PARENT RECRUITMENT LETTER

[Date]

Dear Parent or Guardian:

We are conducting a study to help us better understand caregivers' activities with their preschool child (3-4 years old) and how these activities relate to children's early academic and behavioral skills. This information will help us to develop programs for parents and caregivers. We would like to request your help with this project. If you are interested, please contact Amy Napoli at anapoli@purdue.edu or [phone].

Participation will include:

1. Attending an informational meeting (about 1 hour)
2. Completing a questionnaire on caregiver-child activities and background information
3. Your child completing brief academic and behavioral assessments
4. Receiving and replying to brief daily text messages over the course of 4 weeks

Your appointment will be at your child's school or on the Purdue campus. The total appointment time will be about one hour. Child assessments take approximately 20 minutes and will be conducted at your child's school or on the Purdue campus.

Participation is this study is voluntary. All information will be kept strictly confidential.

Thank you for your interest!

Sincerely,

Amy Napoli, M.S.

Research Assistant

Human Development and Family Studies

Purdue University

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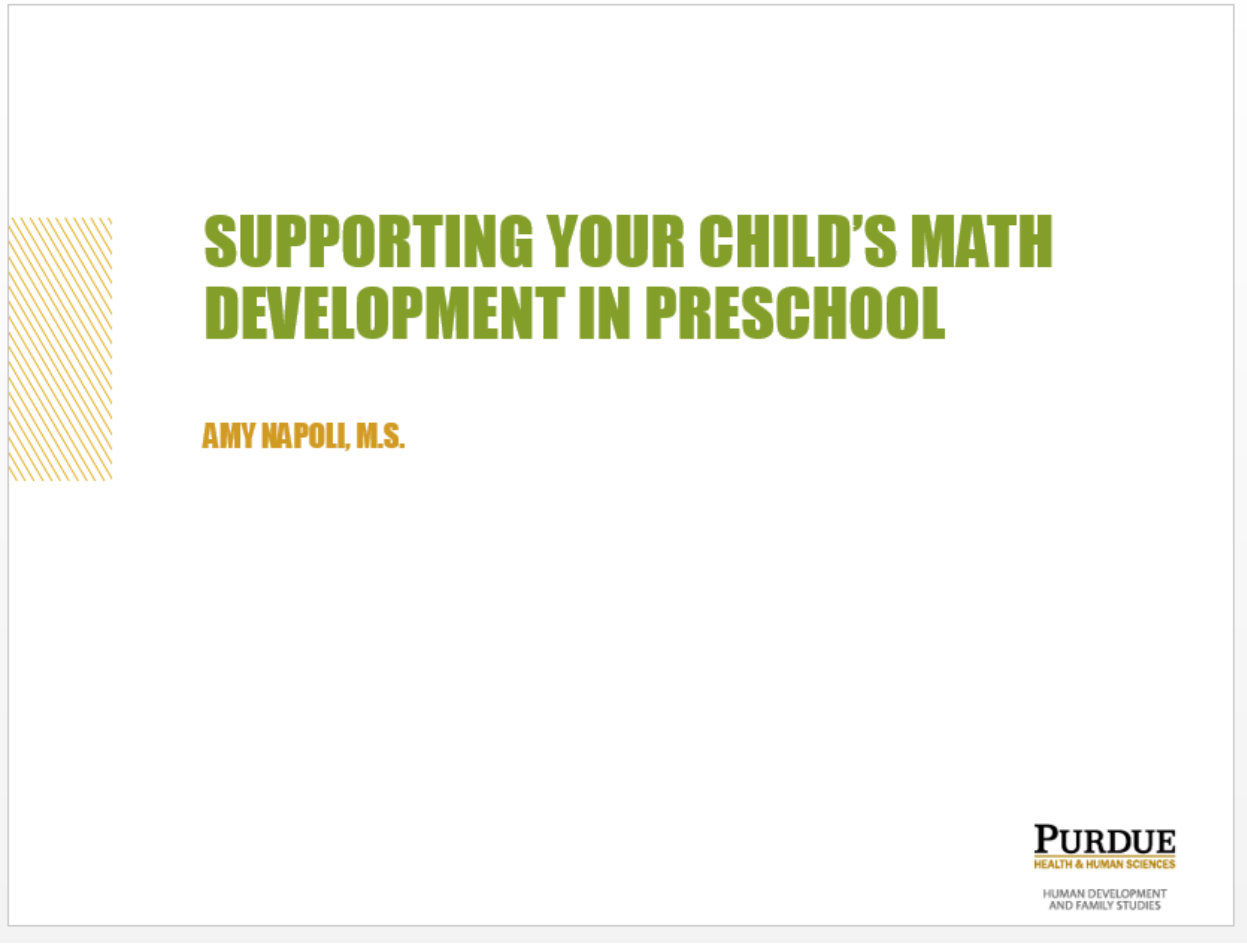
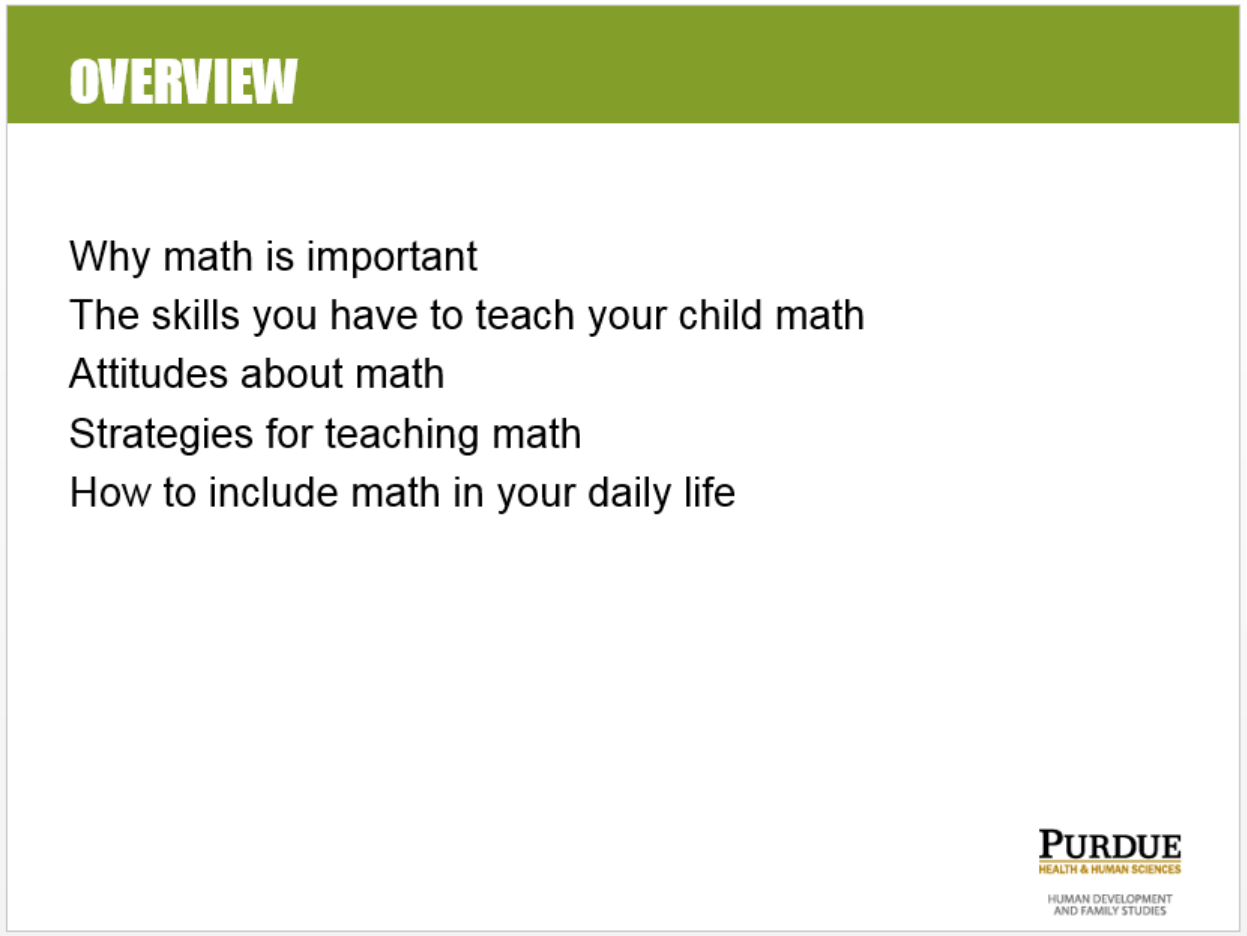
APPENDIX B. INTERVENTION GROUP INFORMATIONAL SLIDES



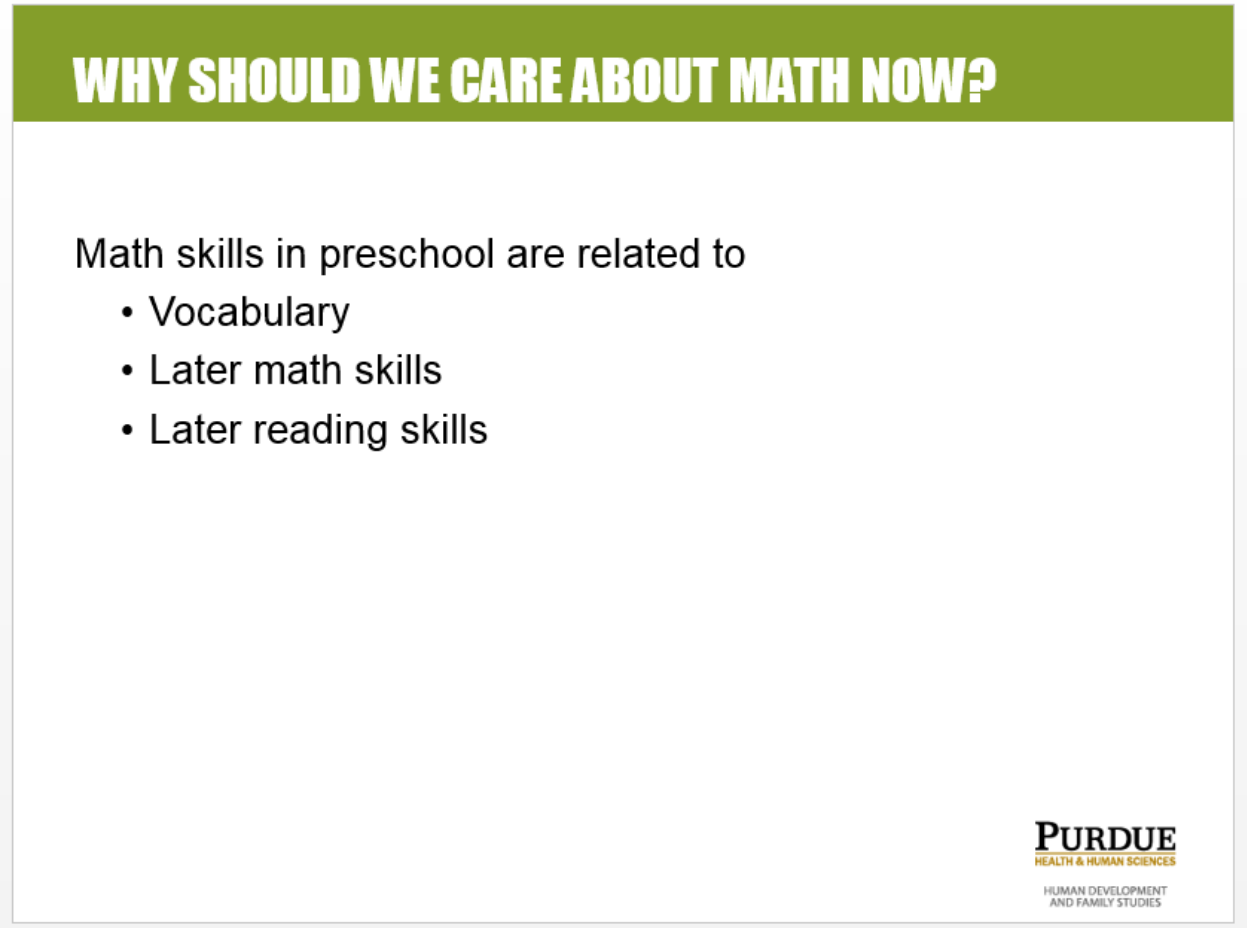
Presenter: Thank you all so much for coming.

I'd like to talk to you today about how you can support your child's math development at home.



Presenter: Today we're going to focus on 4 main points:

Why math is important, why math is important specifically at this age, what skills you need to have to teach your child math, and some strategies for talking about and teaching math to preschoolers and how you can incorporate these strategies into your child's daily routines.



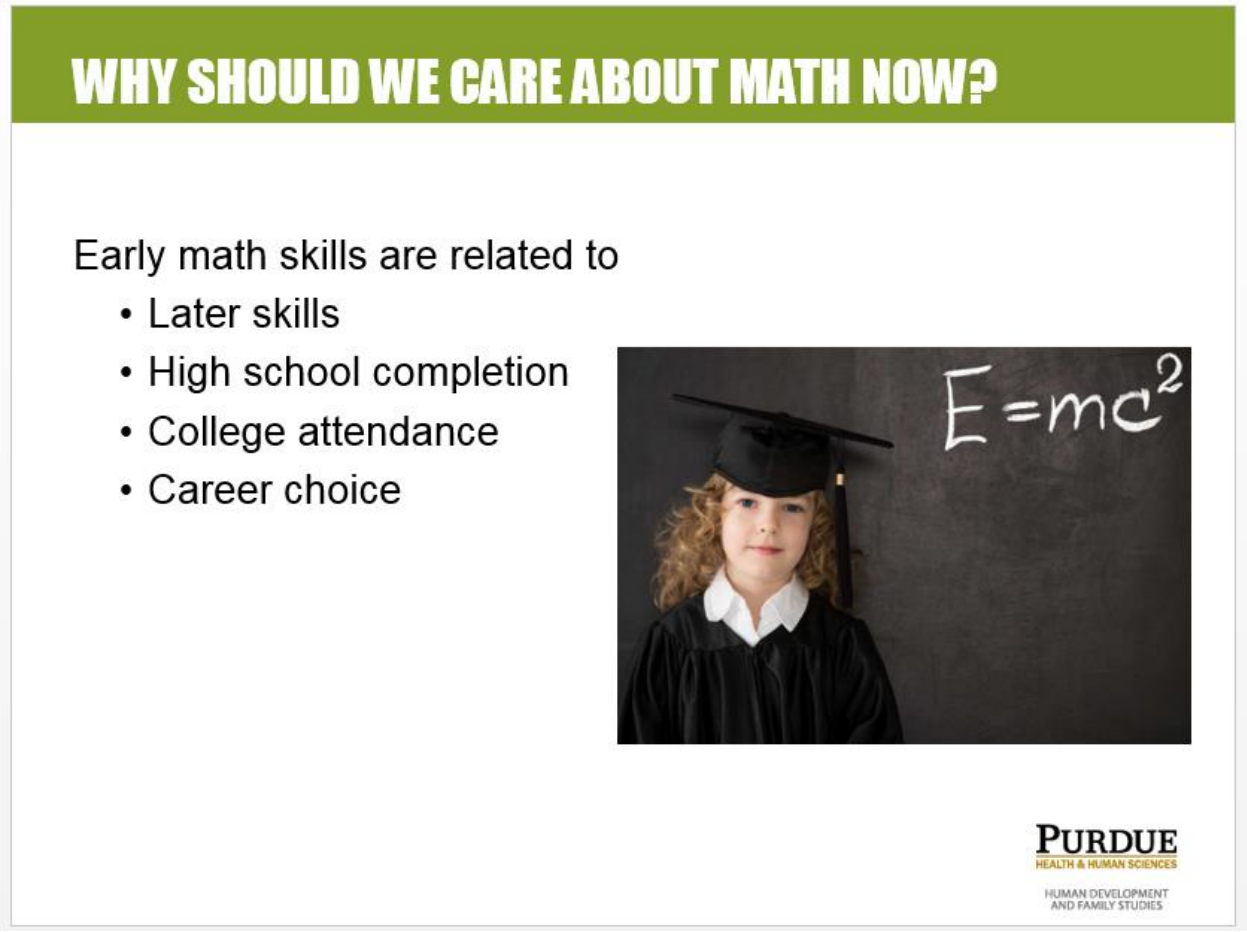
Presenter: So why should you care about math and want to do math with your child?

Early math skills are related to many other types of skills.

Children who practice math more tend to have better vocabulary skills,

They tend to have better math skills later, and to have better reading skills later.

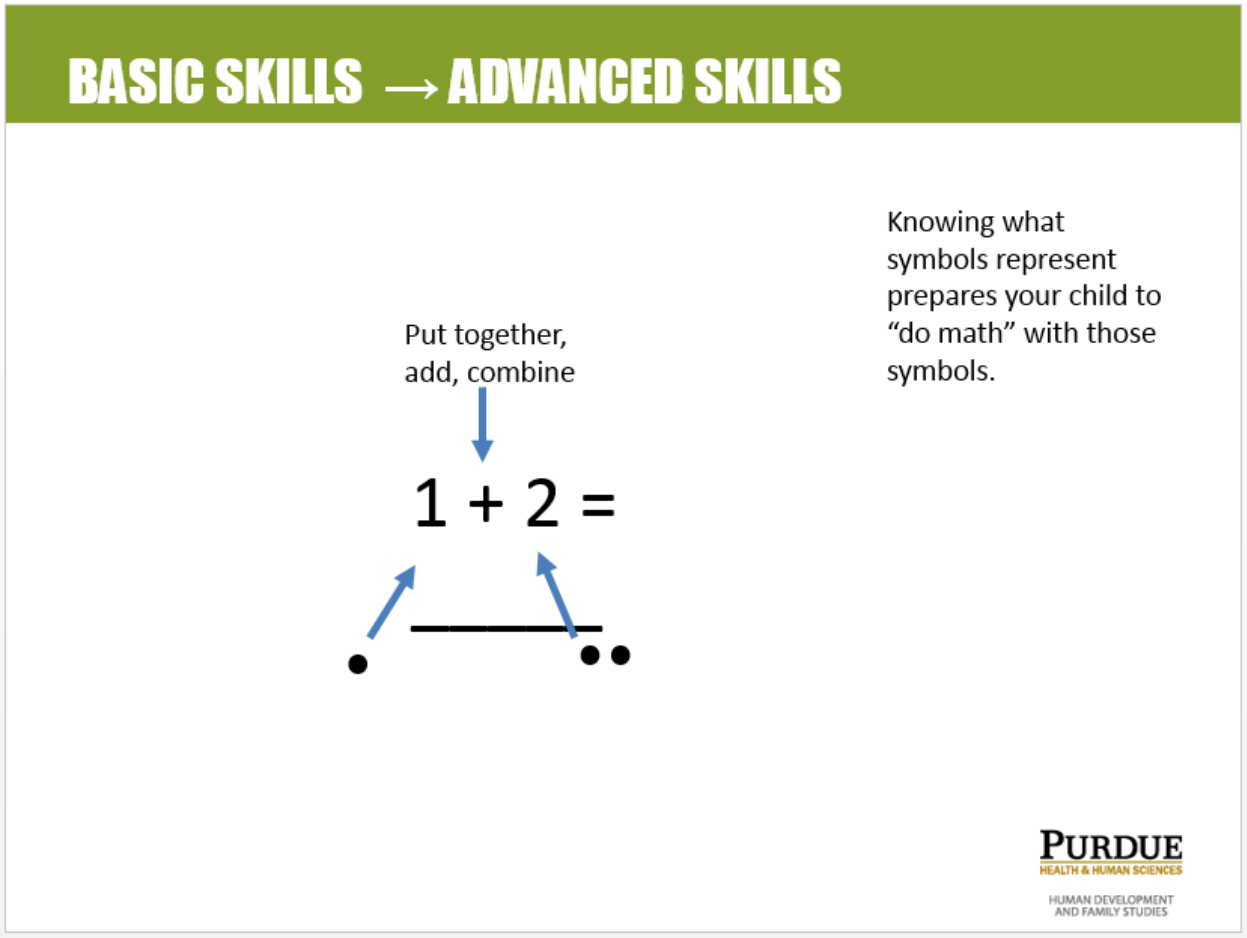
This relationship goes at least through high school, and probably later.



Presenter: Early math skills are the single best predictor of later skills – even more so than early reading skills.

They also predict other important outcomes, like graduation and career choice. Children who are not comfortable with math now might avoid jobs later that they think involve math.

Many preschool teachers do not specifically teach math, so it is especially important that you try to bolster these skills at home.

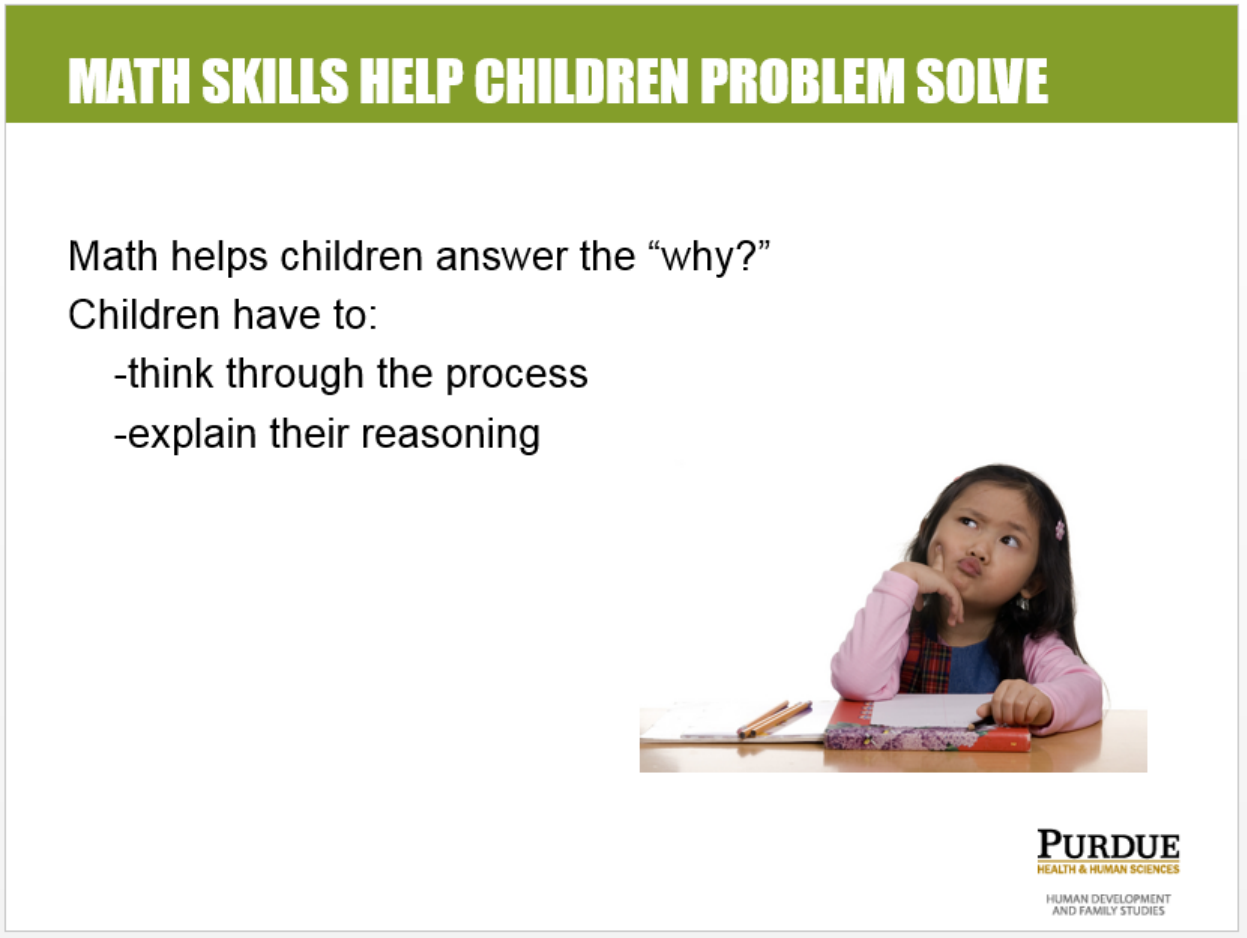


Presenter: Early math skills also set the foundation for later skills.

If your child goes into kindergarten knowing that the written number 1 represents just 1 item, he or she will be prepared to learn more advanced skills like counting.

Similarly, your child will need to recognize math symbols and know what they mean in order to do written math in school.

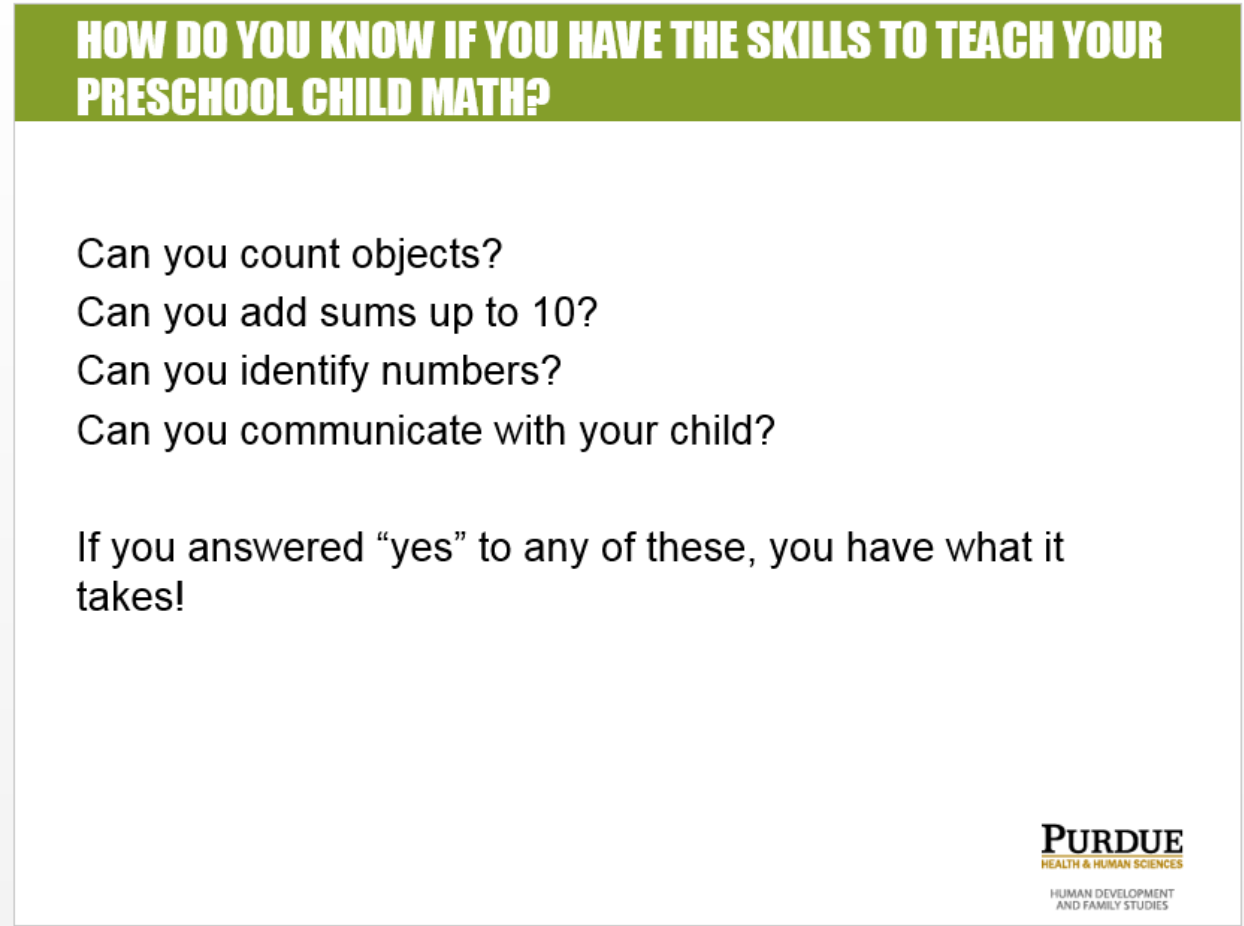
So for example, in order to know the answer to "1 plus 2" your child needs to be able to recognize that the written number 1 means one item, and the written number 2 means two items, and the plus symbol means that you need to add those things together. If your child goes into school with a basic understanding of these concepts, he or she will be better prepared to learn about adding.



Presenter: How many of your children ask “why?” a lot?

Children are curious and math promotes some of the skills that help children answer some of those “why” questions.

Math helps children problem solve and build the skills to find things out on their own. Math helps children thinking through the process of solving a problem and explain their reasoning or how they got the answer



Presenter: Now let’s talk about some of the things that you need to know to teach your child about math.

If I handed you five books, raise your hand if you would be able to count out two from the group.

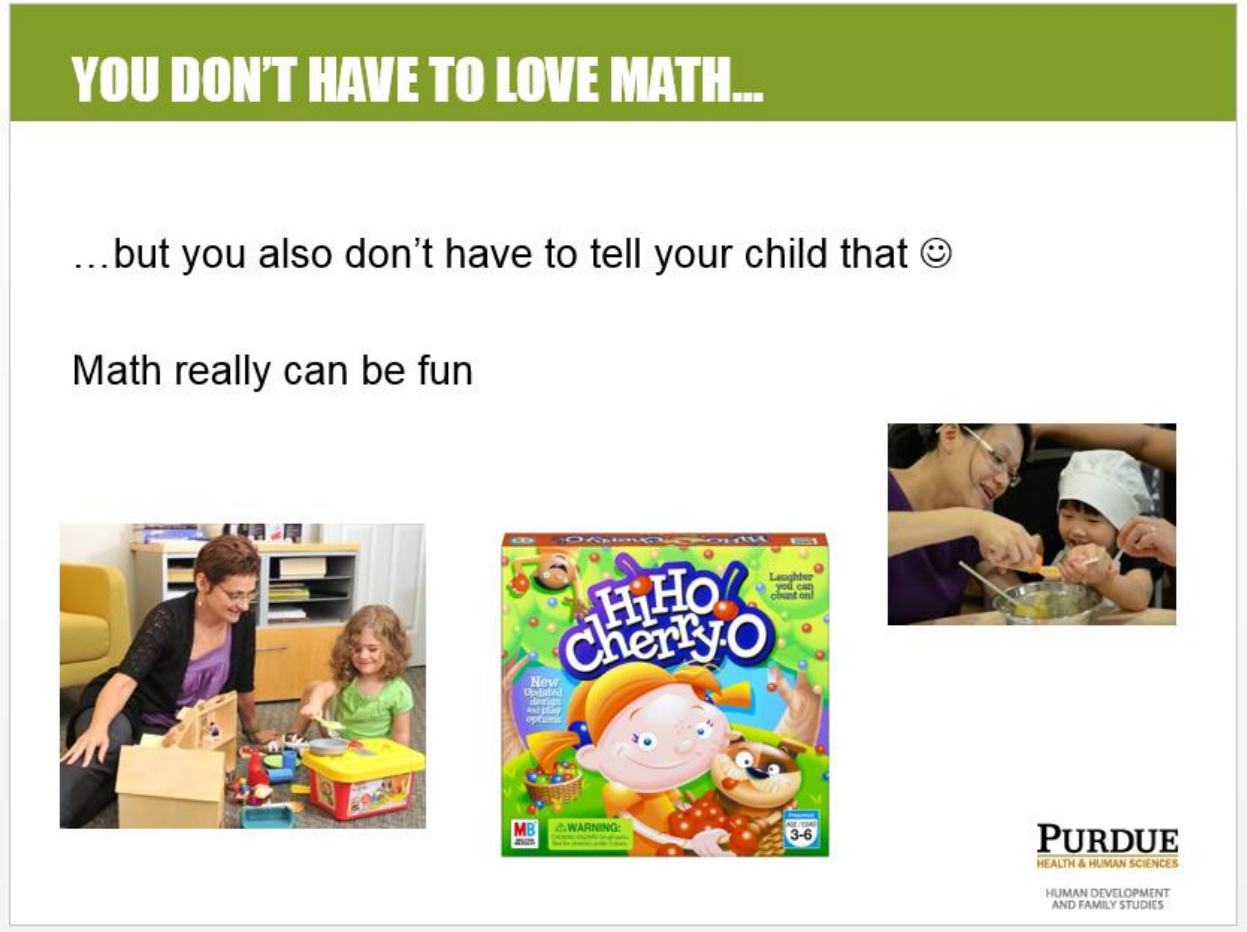
Raise your hand if you can add two plus two. How about three plus four.

Raise your hand if you can name all of the numbers up to twenty.

Now raise your hand if you are able to talk to your child.

Great! Everyone in this room has what it takes to help a preschooler learn about math!

You don’t need to be great at geometry or algebra or even know what those things are in order to help your preschooler think about math ideas.



Presenter: Children begin developing attitudes about math from a very young age.

If your child picks up that you have negative feelings about math, s/he is more likely to develop negative feelings and not be as successful in math.

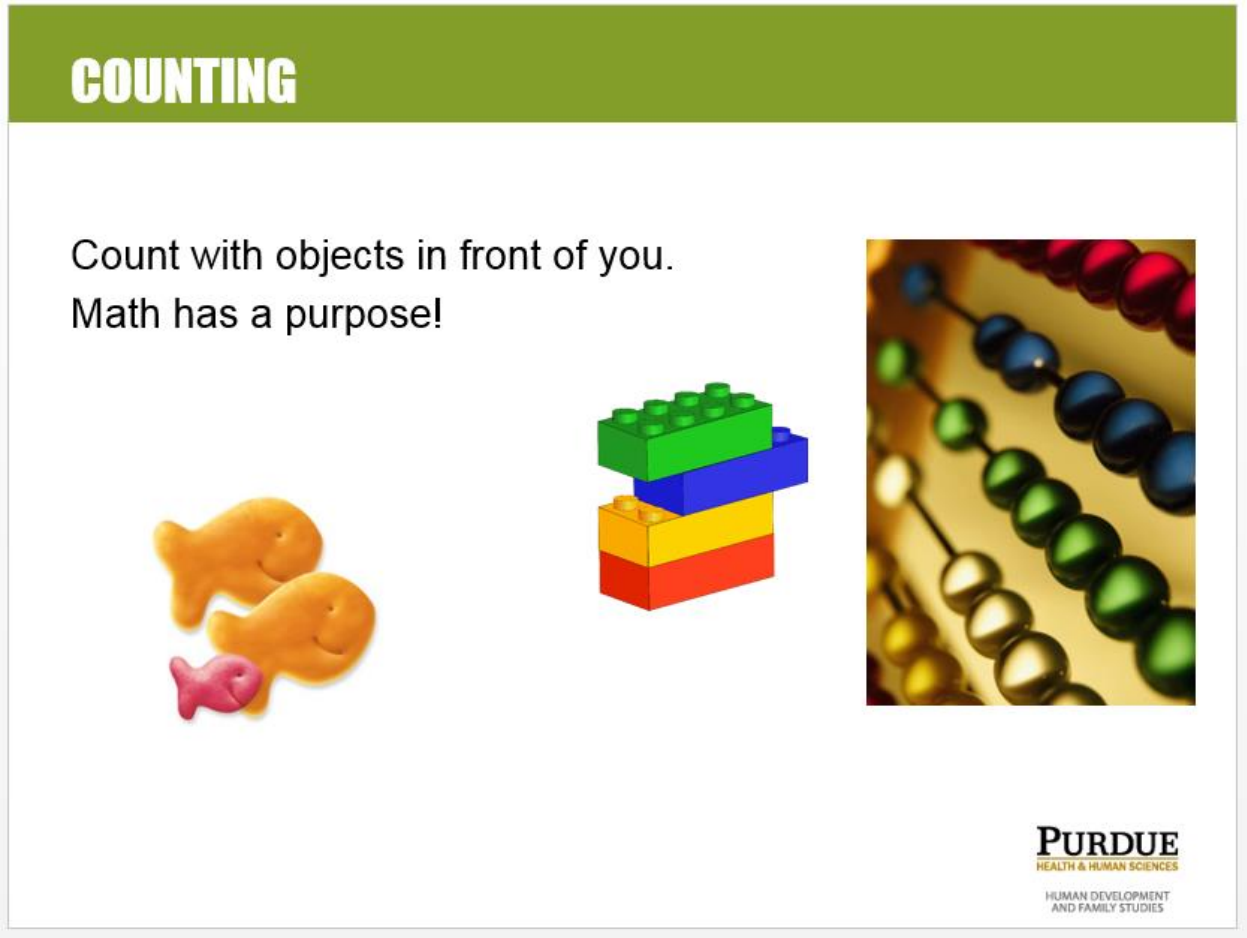
Negative feelings about math often lead to math avoidance such as taking less challenging math classes in school and, ultimately, choosing a career that is not math heavy.

On the other hand, if you show your child that you think math is fun and you enjoy thinking about numbers, s/he is more likely to enjoy it, too.

It's ok if you're pretending – the goal is to model positive attitudes about math.

Try not to say things like "I've always hated math" or "Math is too hard for me" or "I've never been good at math."

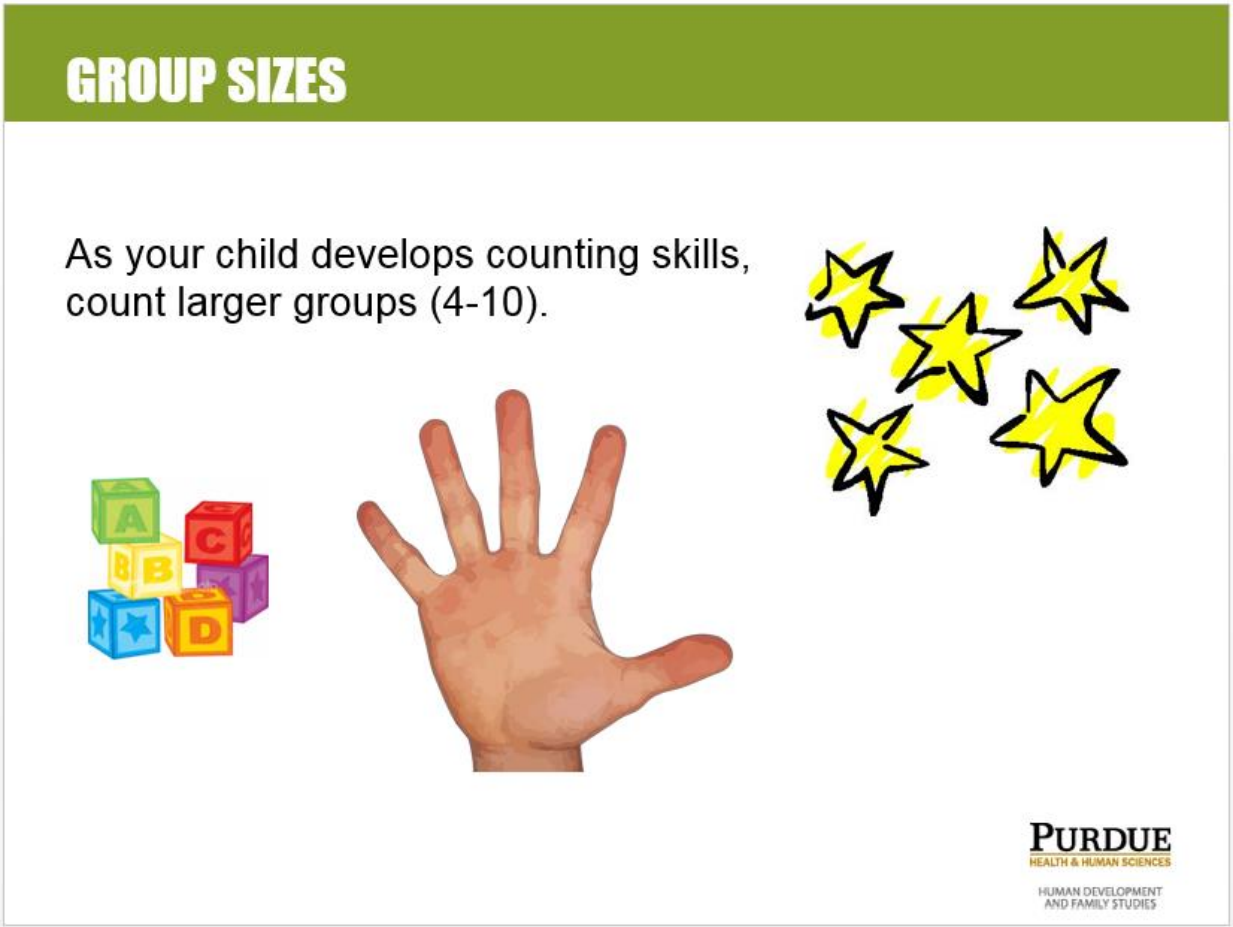
Presenter: Now I'd like to talk about some specific strategies that have been shown to help children learn early math concepts.



Presenter: Counting with objects in front of you is more helpful to children than simply counting out loud.

This can be done throughout the day, such as at meal time (how many plates are on the table?), bath time (how many bottles are there?), snack time (how many crackers do you have?), or while playing (how many blocks can we stack?).

Counting objects, rather than simply reciting numbers, shows children that counting has a purpose.



Presenter: It's almost important to pay attention to the skills that your child is building.

When children develop skills for counting to three – accurately *and* consistently – it's time to start challenging them.

Don't immediately throw 20 times at your kid and expect them to figure it out,

But build on skills as your child learns them.

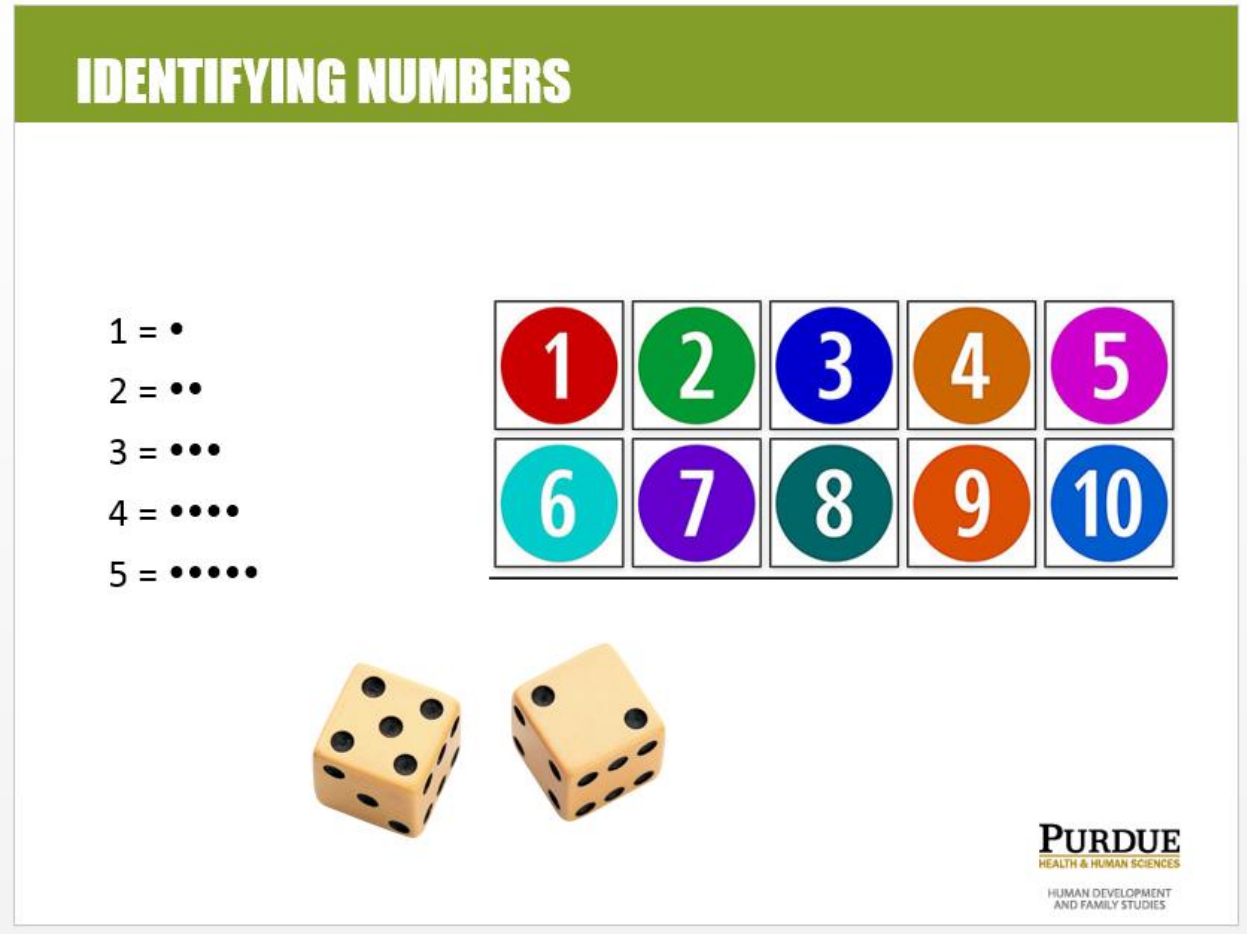
Work on counting larger groups of items, like 4 or 5, then build on that with groups of 6 or 7.

Presenter: Even simple things like labeling the quantity of sets helps children connect number words to specific quantities.

So saying things like “Look! There are 5 birds in the tree!” instead of “look at the birds in the tree” helps your child build those skills.

There are also specific strategies for labeling sets before counting objects that can help your child learn about counting.

When you count, say how many there are, count together, then repeat how many or ask how many. “Here are three socks. One, two, three, four. Four socks.” or “Here are two pennies. One, two. How many pennies are there? Can you count them?”



Presenter: It's important that children begin learning about written numbers just like they learn about letters.

Similar to the way we learn that each letter has it's own sound, we learn that each number has its own amount.

You can teach your child about this by writing the number and showing that many of an item.

You can also make a number book together where you write each number on a piece of paper and have your child put that many stickers or draw that many objects on the page.

Presenter: Learning math language terms helps children learn math.

Using words like those listed and helping your child learn what they mean helps give them a language to talk about math concepts.

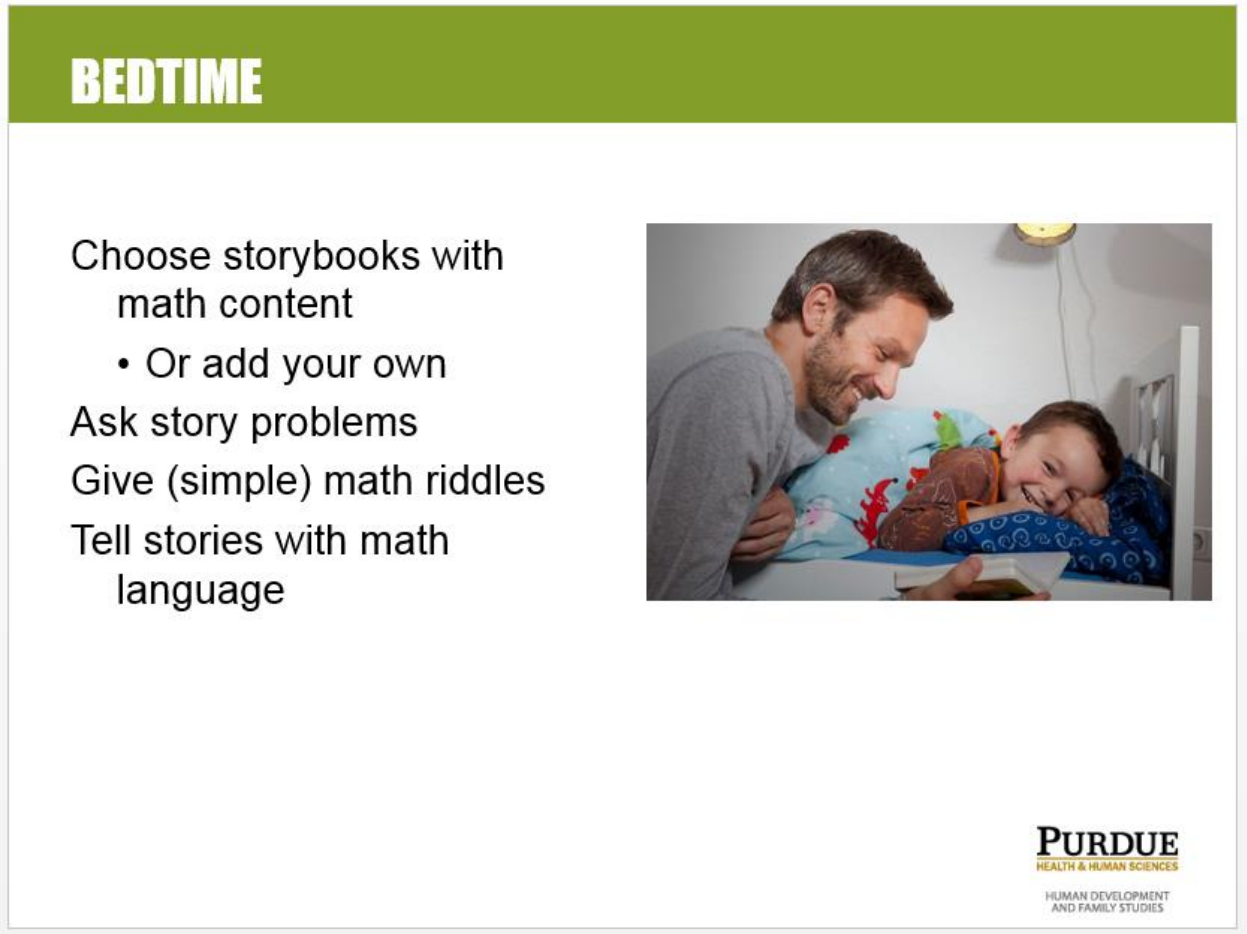
So when your child knows what “more” means, they can begin to learn to identify that some numbers are “more” than others.

They can’t talk about those concepts until they have an understanding of the word.

Presenter: So when can you do math with your child?

The short answer is all the time and everywhere!

But let’s talk about some specific times that you can do math together.

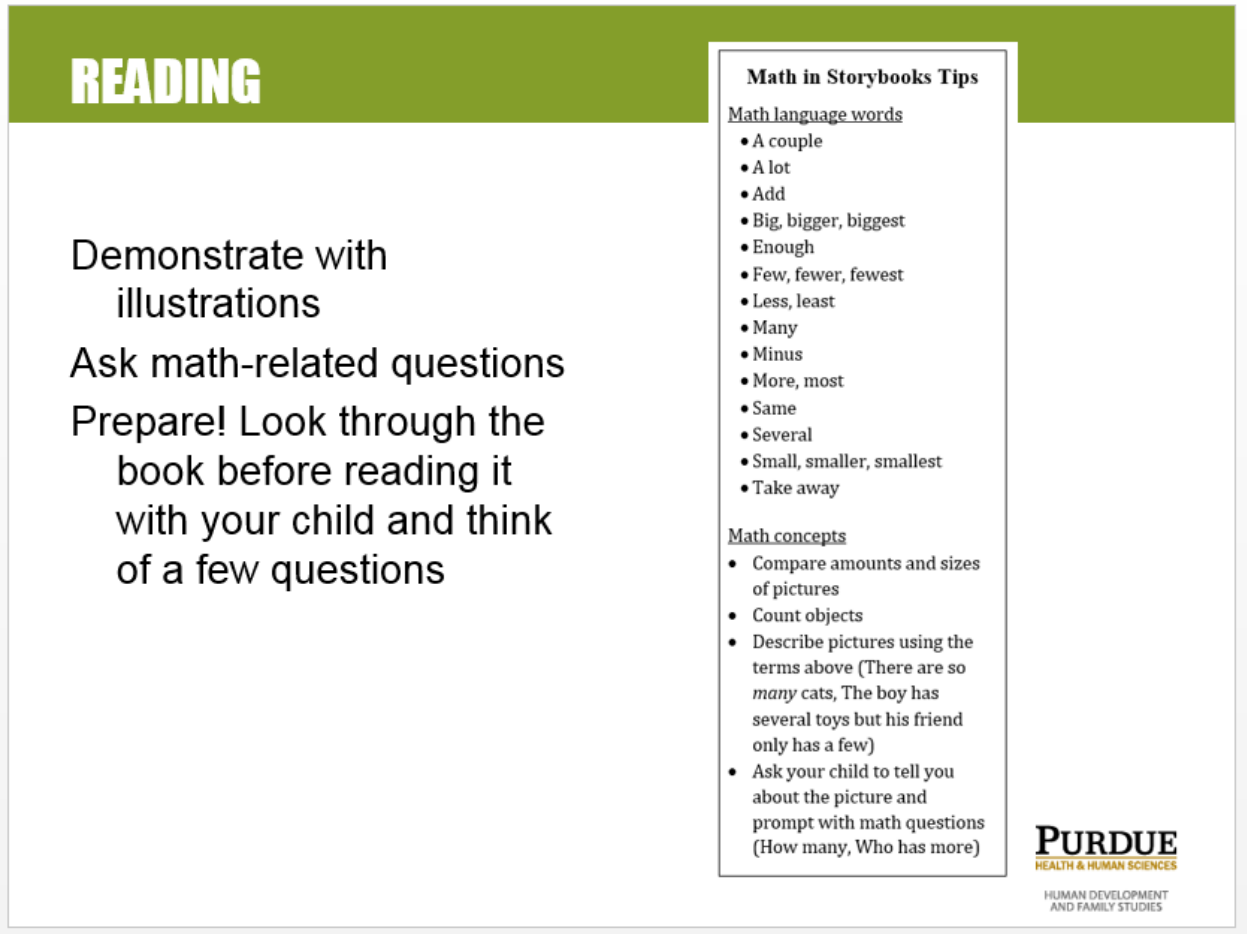


Presenter: How many people read to their child before bed? At least sometimes?

You can find books that incorporate math, or add you own math content to the stories you already like reading together.

You can do story problems together, or simple math riddles.

You can also tell stories using math language terms that we talked about.



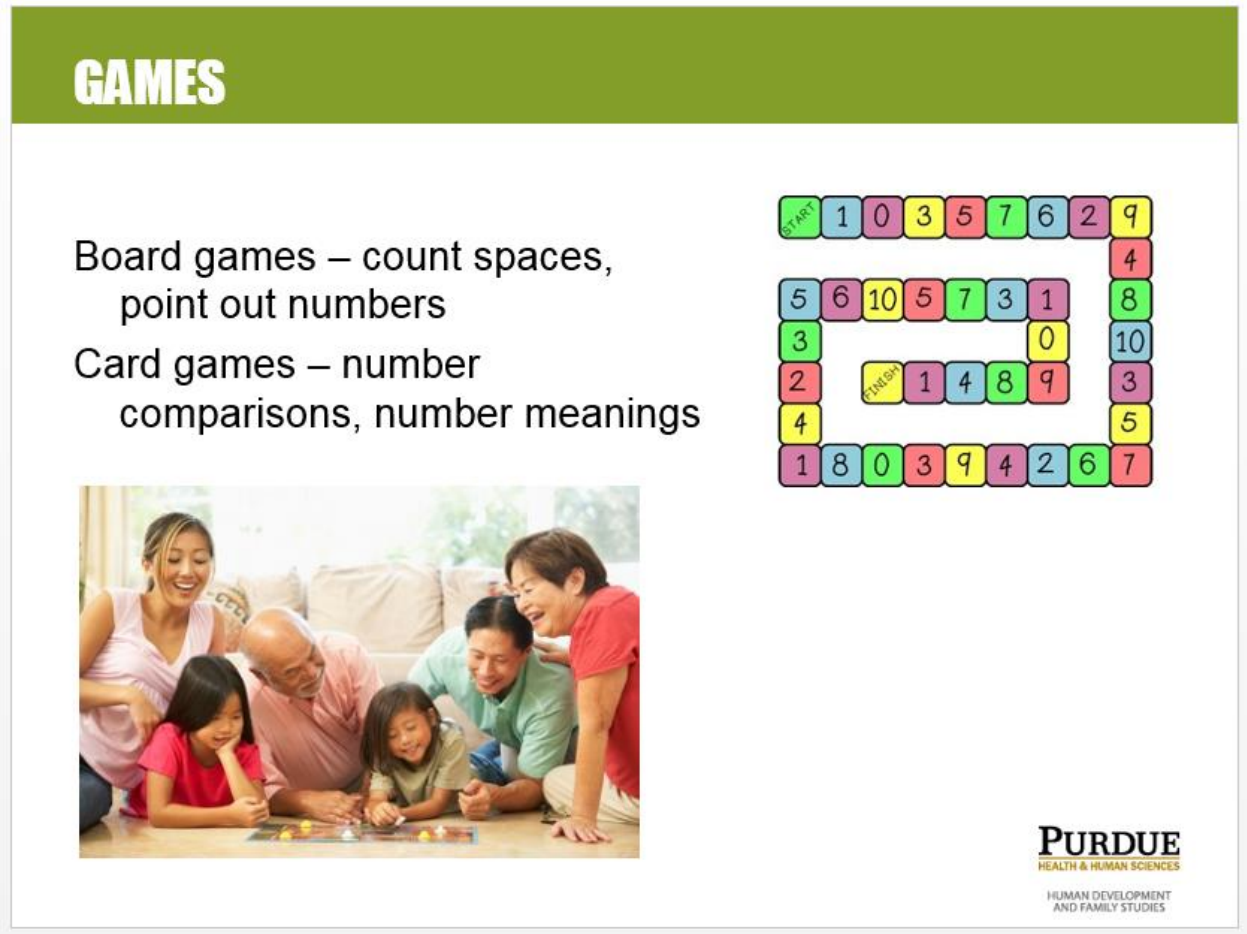
Presenter: You can incorporate math into reading by describing the illustrations using math language or specific numbers.

[Demonstrate example with a few pages from storybooks.]

You can also ask questions that encourage your child to use math language or count.

It also helps to take a few minutes to go through books on your own and think about some ways you can incorporate math. This might take off some of the pressure of trying to think of things in the moment. I've even seen people jot down notes on paper and stick them in the book to remember things.

You will receive a book mark that can help to remind you of the math terms and give you some ideas of how to build math in.



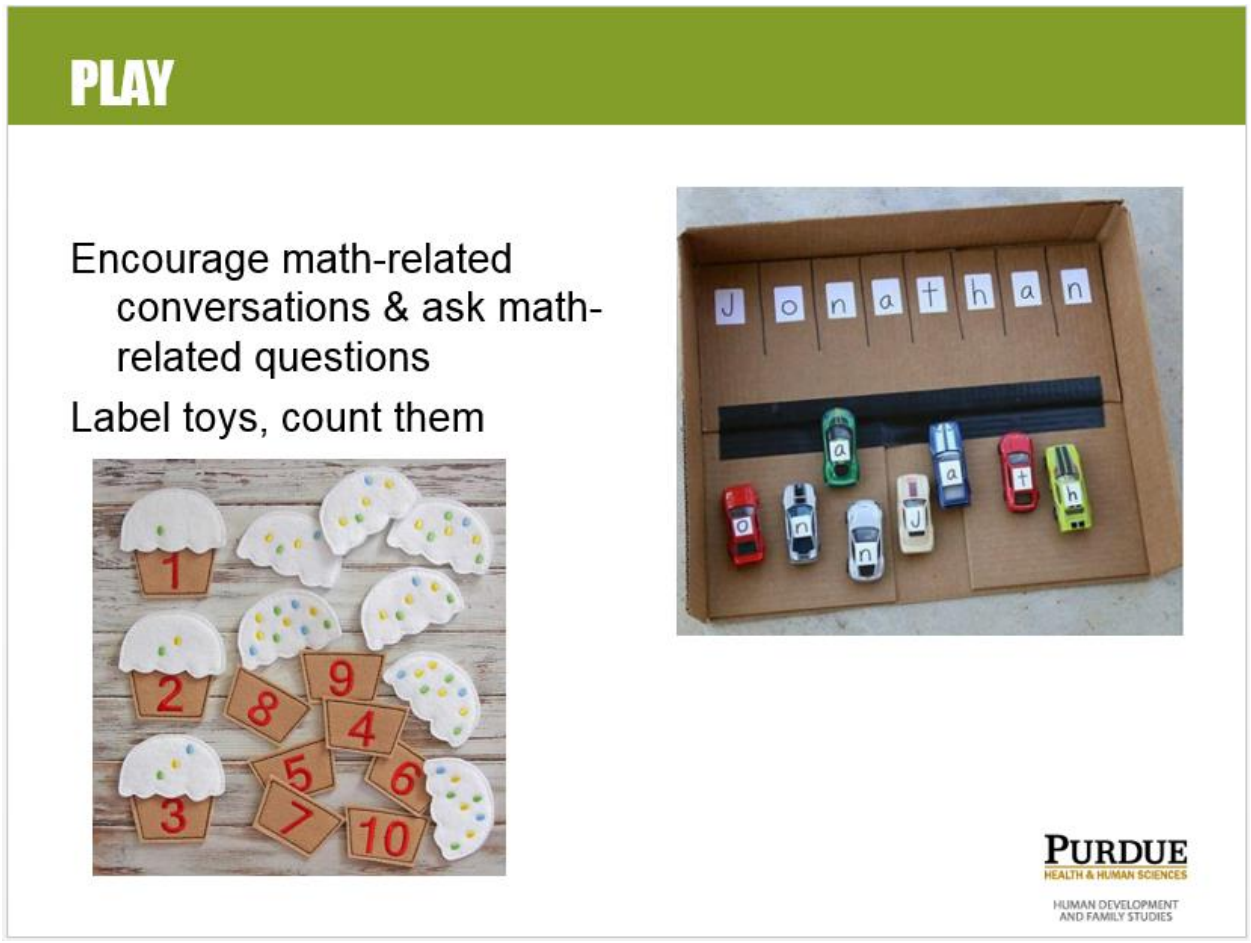
Presenter: You can use board games that you already have or print ones off the internet for free. You can count the dots on the dice or the spaces on the board.

If you are playing a game that has numbers on the spaces, encourage your child to count from the number they are on rather than from one.

[Show example with game]

Card games also help your child connect written numbers to quantities and you can play games like War to compare numbers.

You'll receive a copy of a game and some cards.

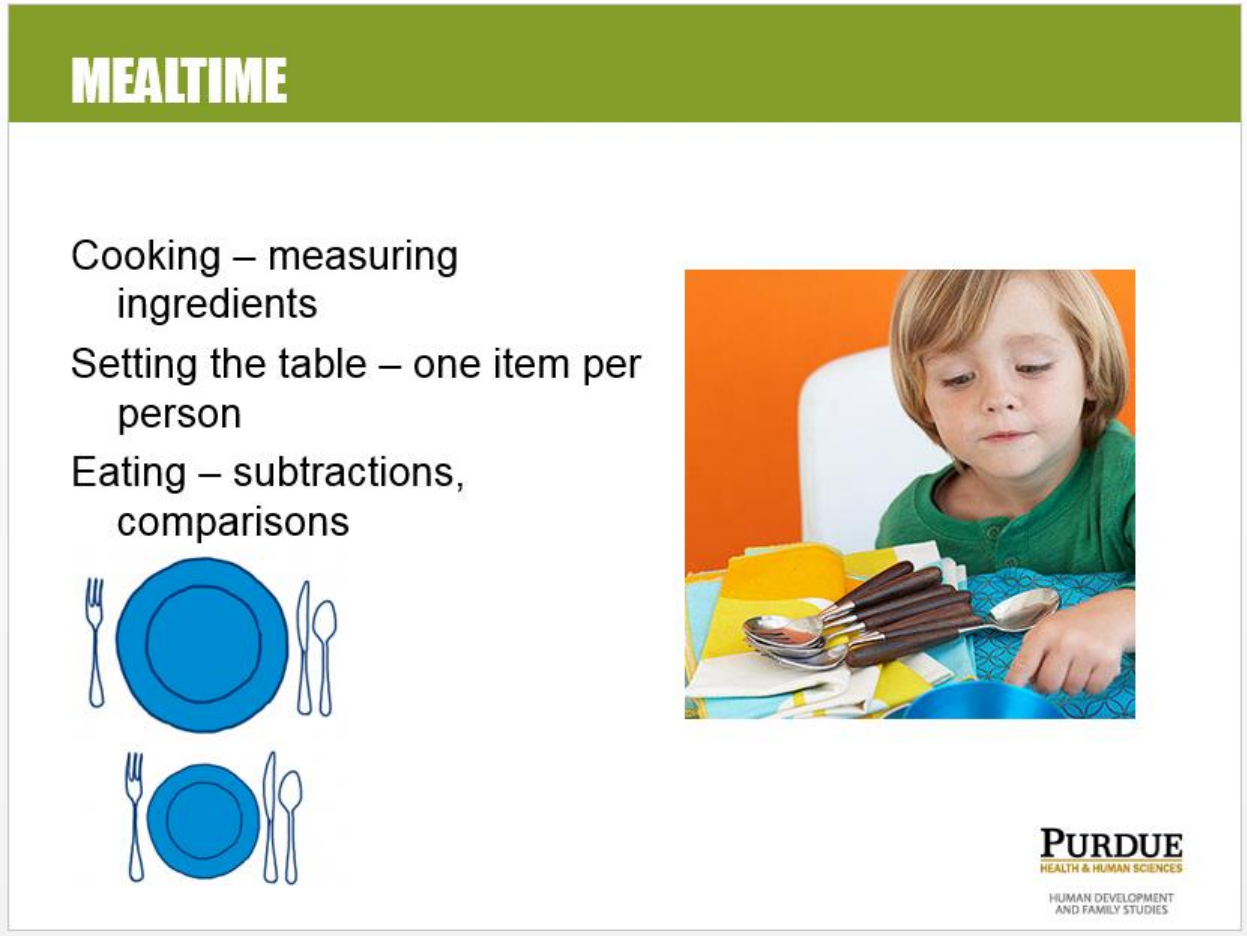


Presenter: You can incorporate math into play through the conversations you initiate and the questions you ask.

[Demonstrate example with toys.]

You can also create fun toys yourself that engage your child in math concepts.

For example, you can make a parking lot or garage for toy cars and label the spots with numbers and the cars with dots. Or you can label the cars with numbers to work on putting the numbers in order.



Presenter: You can use mealtime as a way to engage your child with math by asking them to help you set the table. They'll need to figure out how many people there are, how many items they need, and match one item to one person.

You can also involve your child in the cooking and have them help with measuring.

You can even talk about math while you eat by comparing the quantities of food everyone has and counting the items on your plates.

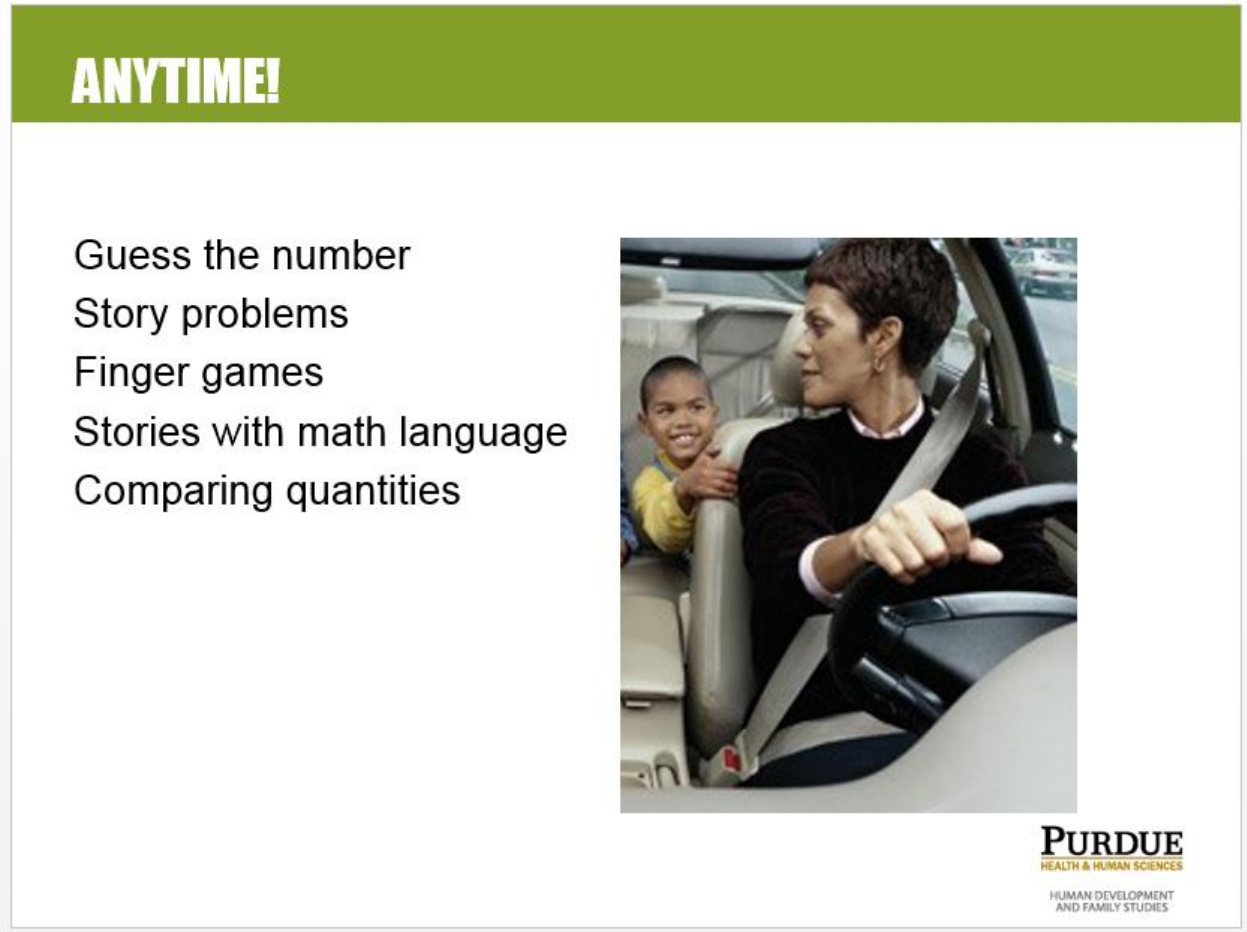
Presenter: You can build math into literally any time of day.

You can talk about the numbers on the clock when your child wakes up or goes to bed.

While getting dressed you can count buttons on clothes, match pairs of socks and shoes, and use words like bigger and smaller.

You can count each finger as you wash them.

You can make comparisons and talk about how full the bath is with math terms like “empty” and “full.” You can also line up and count toys.

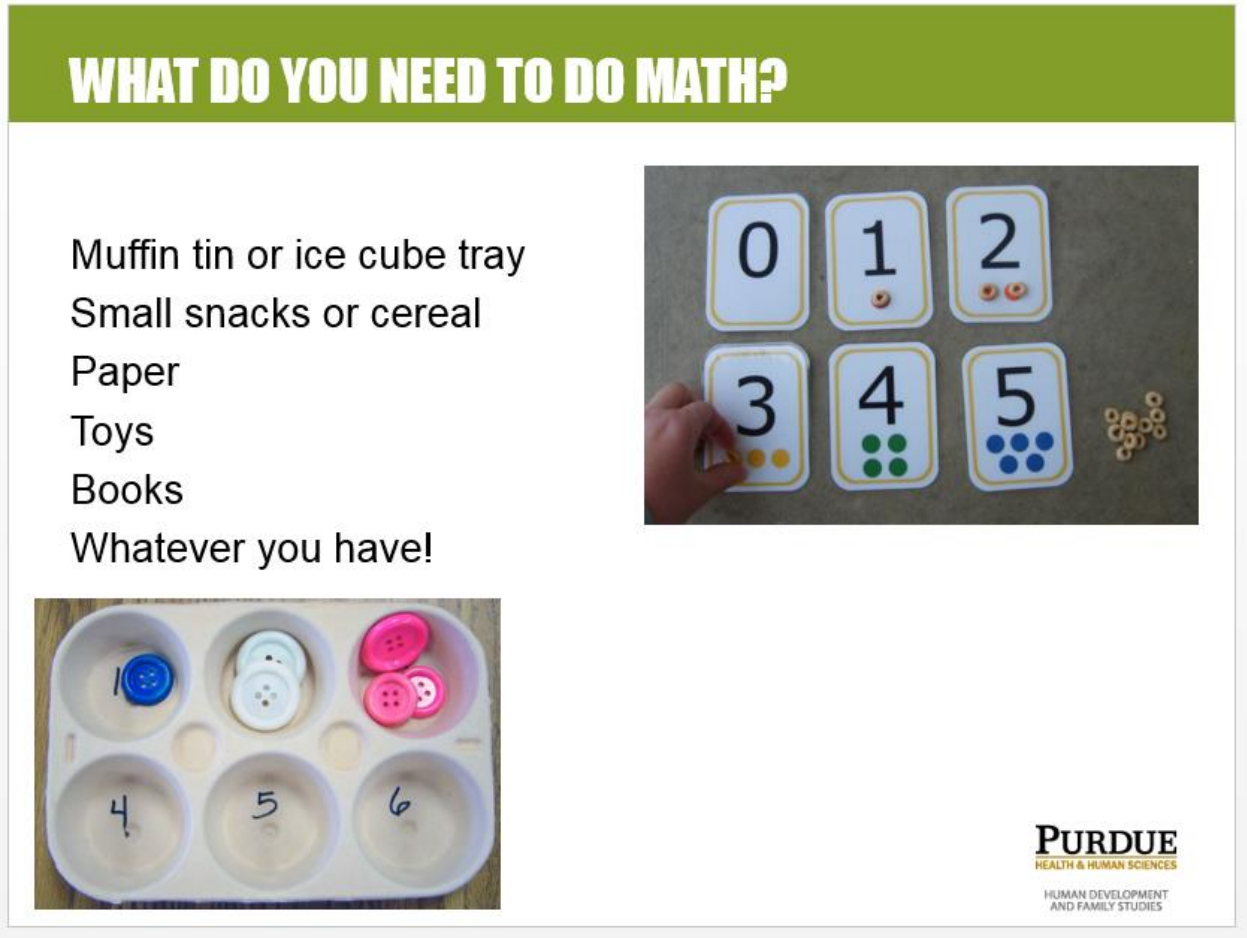


Presenter: You can talk about numbers and math anywhere! You don't always need to have objects. You can think through math ideas together.

You can play number guessing games like "I'm thinking of a number that's bigger than 2 and smaller than 4."

You can ask your child story problems like "Four children were on the playground and one child went home. How many are still playing?" and teach strategies for using their fingers if they have difficulty answering.

You can also tell stories using math language terms and compare quantities of things that you see.



Presenter: You have items around your home that you can use to do math.

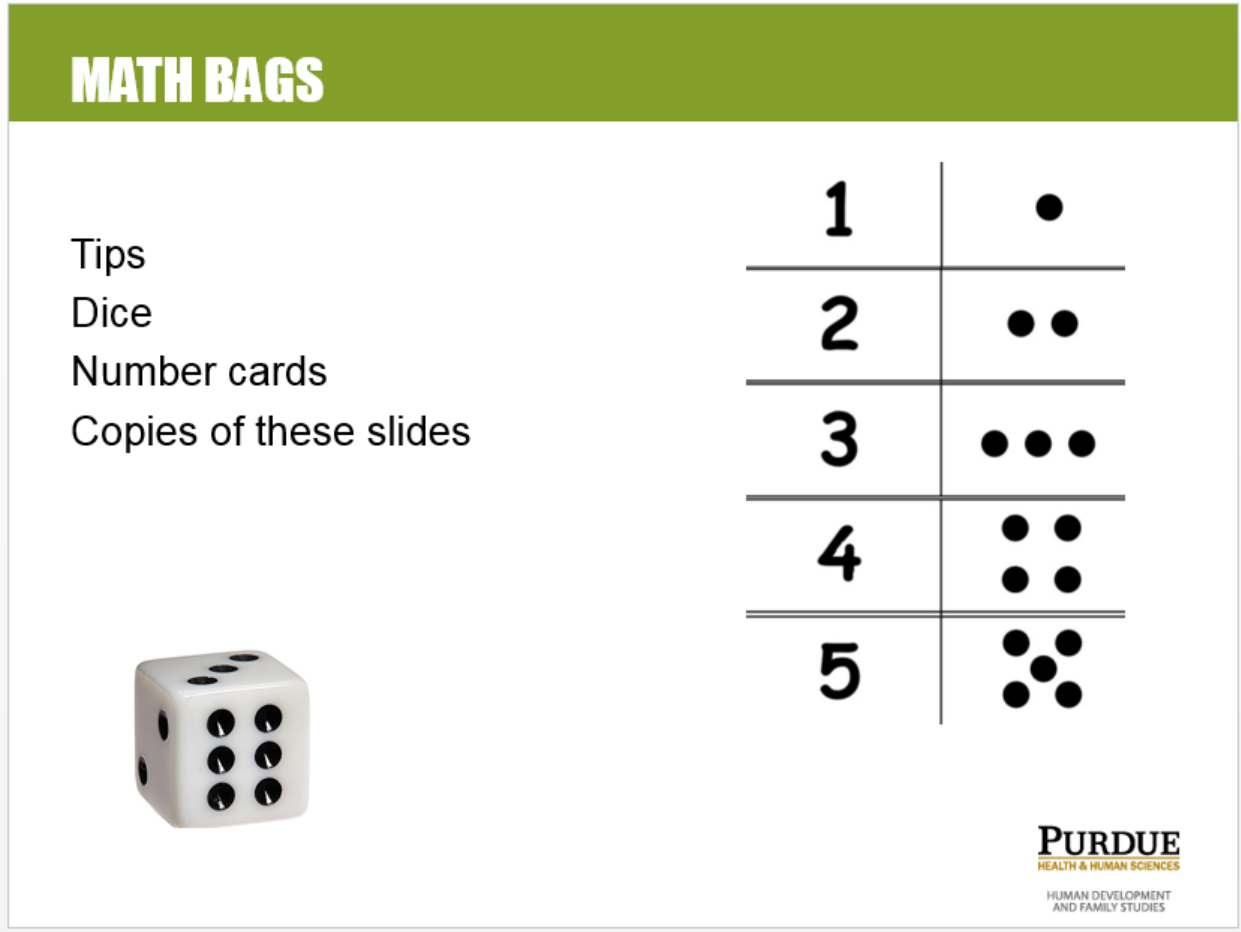
Muffin tins and ice cube trays can be used to sort and count items.

You can count and compare quantities while snacking. This is also a good opportunity to use math language, like subtracting/taking away when you eat some and comparing who has more/less.

You can draw objects and write numbers down together on paper. You can also make number books together by writing numbers on a sheet of paper and having your child draw or add stickers of that particular number then stapling all of the sheets together to make a number book. Then you can read the book together and talk about numbers.

You can create number story problems using the toys your child has. “This truck has 4 wheels and this motorcycle has 2 wheels. How many wheels do they have altogether?” “Let’s see who can build the taller block tower. What happens if you add one more? What happens if we take two away from my tower?”

Books, especially ones with detailed illustrations, are great for having conversations about numbers. You can ask how many of something is on the page. You can compare how many things different characters have.



Presenter: You will also receive math bags to take home.

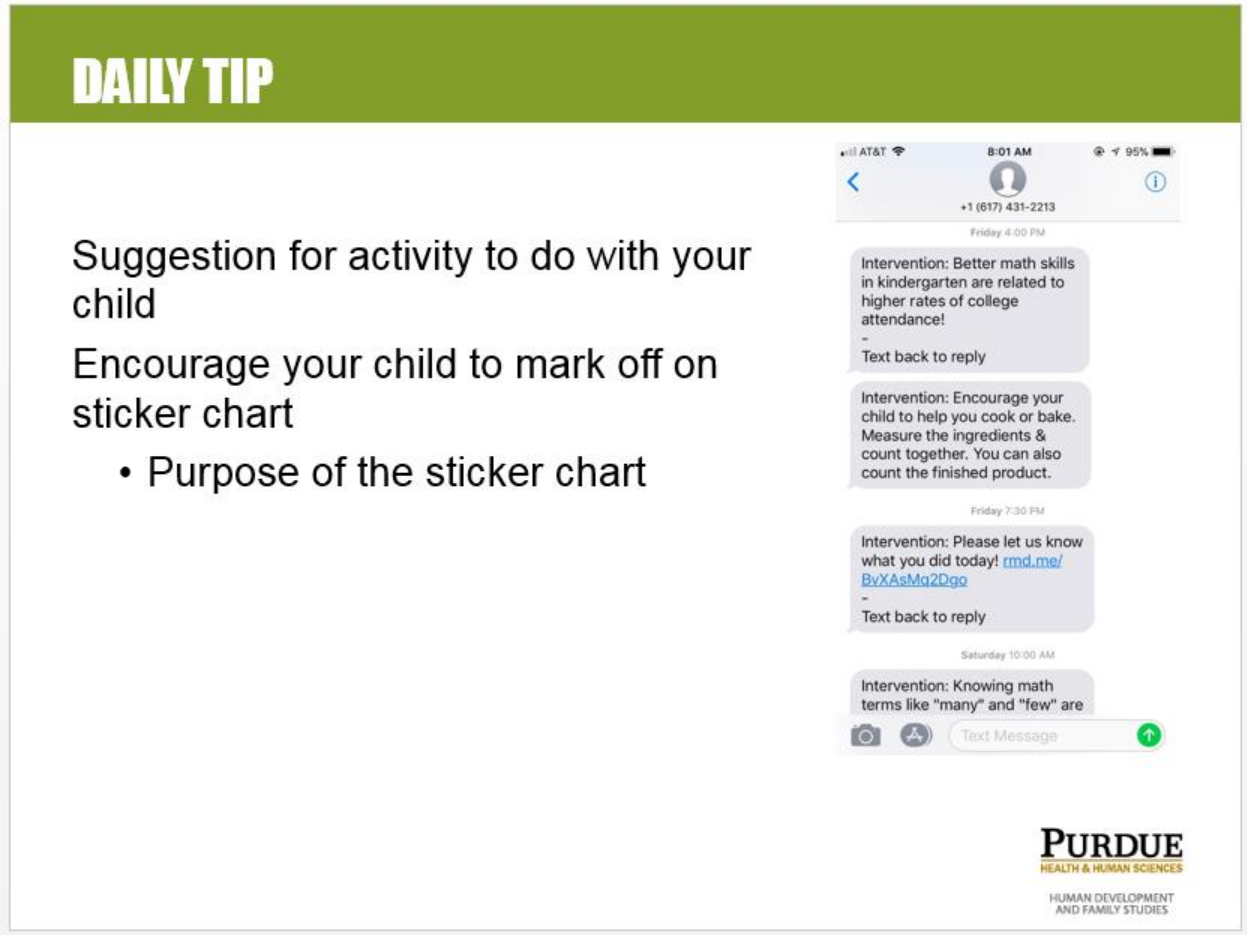
There are tips provided in the bags for how to use the items.

There are dice to practice counting and matching quantities.

There are cards to practice matching written numbers to quantities.

All of these things will hopefully be fun for both you and your child.

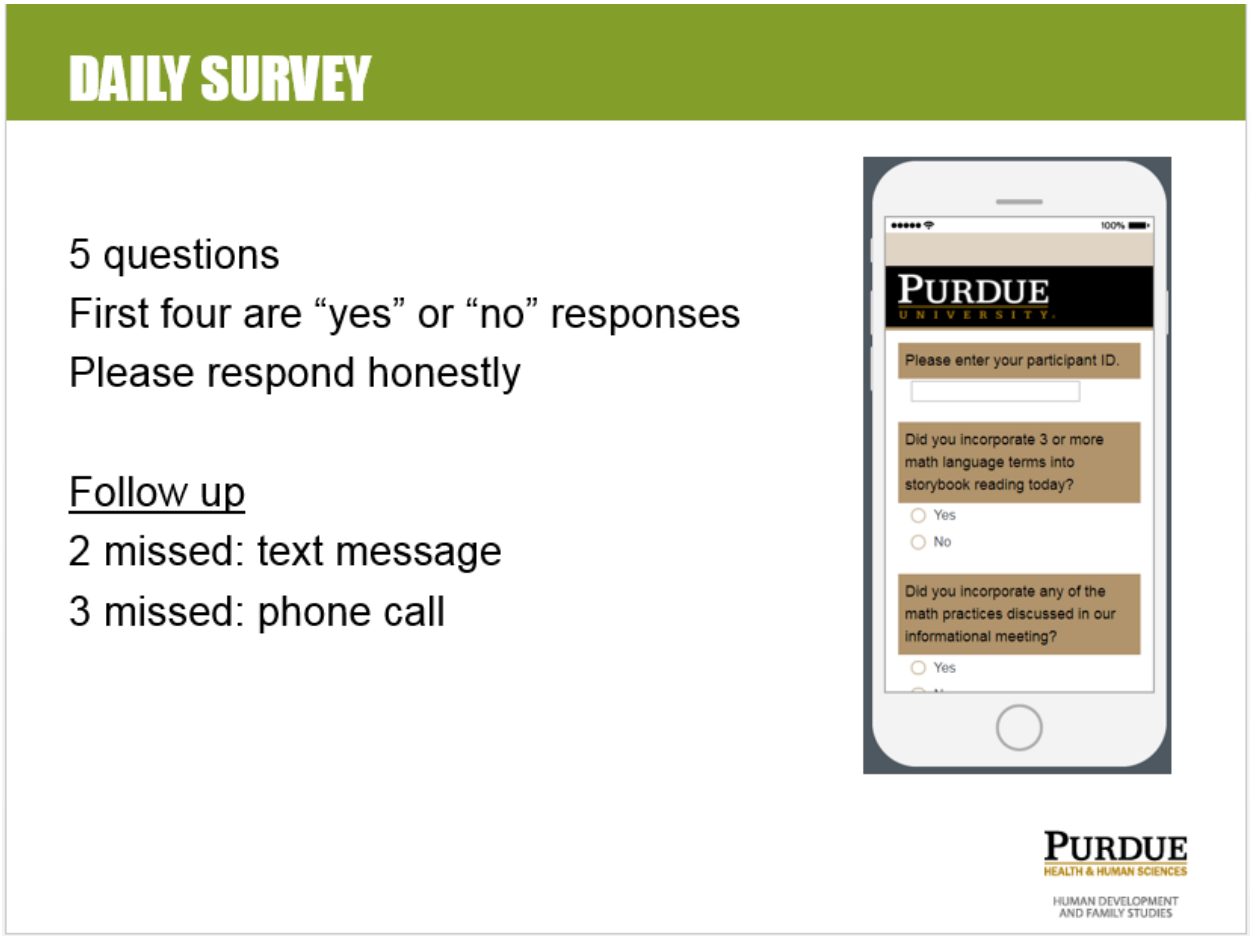
Remember the purpose isn't to do math drills but to show your child that it is fun to engage with numbers and think about math ides.



Presenter: Each day you'll receive a text message to your phone with a new tip or idea for incorporating math.

You may not be able to do the particular strategy on the day that you receive it, but please try to use all of the strategies at some point during the month.

If you can't do the tip that day, try to do something we talked about today or a tip that you received earlier.



Presenter: You’ll also receive a link each evening to a survey. The survey is very brief and shouldn’t take more than a minute or two.

The most important thing about the survey is that you respond honestly.

You are all busy and I know that you will not be able to do every single thing every single day.

The purpose of the survey is to find out how much you do,

And how much is realistic for most parents.

Please do not feel that you should report doing something because I will think poorly of you.

The most helpful thing you can do is be honest and report what you did that day.

Also, please try your best to respond to the survey each night. If you don’t submit a survey two nights in a row, I will follow up with a text message. If you miss 3 in a row, I’ll call to check in.

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APPENDIX C. MATHEMATICAL LANGUAGE BOOKMARK

Math in Storybooks Tips

Math language words

- A couple
- A lot
- Add
- Big, bigger, biggest
- Enough
- Few, fewer, fewest
- Less, least
- Many
- Minus
- More, most
- Same
- Several
- Small, smaller, smallest
- Take away

Math concepts

- Compare amounts and sizes of pictures
- Count objects
- Describe pictures using the terms above (There are so *many* cats, The boy has several toys but his friend only has a few)
- Ask your child to tell you about the picture and prompt with math questions (How many, Who has more)

APPENDIX D. INTERVENTION GROUP SMS TIPS

Note: B = beliefs; E = engagement; A = attitudes; R = resources

Week 1

Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
You have the skills that it takes to help your child learn math! Label the amounts of things while talking to your child ("Here are 2 books") to help him/her connect number names to specific quantities.	Daily exposure to math may help your child succeed in school. When getting dressed in the morning, compare your clothes to your child's. Whose shirt is bigger? Who has more buttons? Talk about similarities/ differences. Your clothes are bigger; you both need 1 shirt & 2 socks	You have what it takes to help your child learn math in fun ways! Go on a number "I-spy" adventure! This can be done with numbers (I spy the number 2) or quantities (I spy three tall trees). This helps your child identify math concepts in the everyday world.	Early math is important & your child can learn about math while helping! Encourage him/her to help you set the table. How many people? Everyone needs 1 of each item. While eating, encourage him/her to compare quantities of food on his/her plate. "Is there more bread or cheese?"	Using math language helps children learn math skills. Try using math terms while at the store. Compare fruit (which apple is bigger?) talk about prices (this costs more), or count the items in your cart (how many boxes do we have?).	Children with better math skills in kindergarten are more likely to succeed in high school. You have skills to help prepare your child Practice counting objects you have at home (blocks, pillows) & help your child connect one number name to one item as you count.	If you have a positive attitude about math, your child is more likely to enjoy math and have a positive attitude too. Check out a new math book from the library. Here are some of our favorites: http://www.mathsthroughstories.org/recommendations.html
E; A	B; E	E; A	B; E	B; E	B; E; A; R	E; A; R

Week 2

Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
The more you do math with your child, the more likely s/he is to succeed in school. Make a counting book with him/her. Write numbers 1 to 10 & have your child draw the correct number of items (e.g., draw 4 circles on the 4 page) or add stickers.	Talking about and explaining math helps children to learn concepts and math vocabulary. Encourage your child to explain his/her thinking. Ask follow up questions like "How do you know there are 2 apples?" or "How did you figure that out?"	Be positive about math. Many children love to sort things. This helps promote math skills. Sort toys into categories (color, size, shape) & compare the groups. "Are there more big dinosaurs or little dinosaurs?" "How many squares and how many triangles? Which is more?"	Early math skills are one of the best predictors of school success. Count out small groups of foods at snack time. "Here are 3 raisins. Let's count them together. 1, 2, 3. If you eat one of them, how many will be left? What if I give you 2 more?"	Even if math makes you nervous, you can still provide positive math experiences for your child. Use number cards 1-5 from your pack. Have your child identify the numbers and put them in the correct order. When your child has those numbers down, add cards 6-10.	The more math activities your child does with you, the better s/he'll understand math when s/he gets to school. Play Mother May I together. Give him/her a turn picking the number of steps that you take. Count out loud as you take them. [Document with Mother May I instructions attached to text]	Early positive experiences with math can lead to success in math-related careers. Using tape and a marker, label your child's favorite toys 1 through 5 (cars, dolls, dinosaurs). Then, label a corresponding item with dots. For example, if your child loves toy cars, label the cars with numbers and make a parking lot with a piece of paper. Label the spots with dots. Can your child park the cars in their right spots? Get creative! [Example picture included]
B; E; R	B; E	E; A; R	B; E; R	E; A; R	B; E	B; E; R

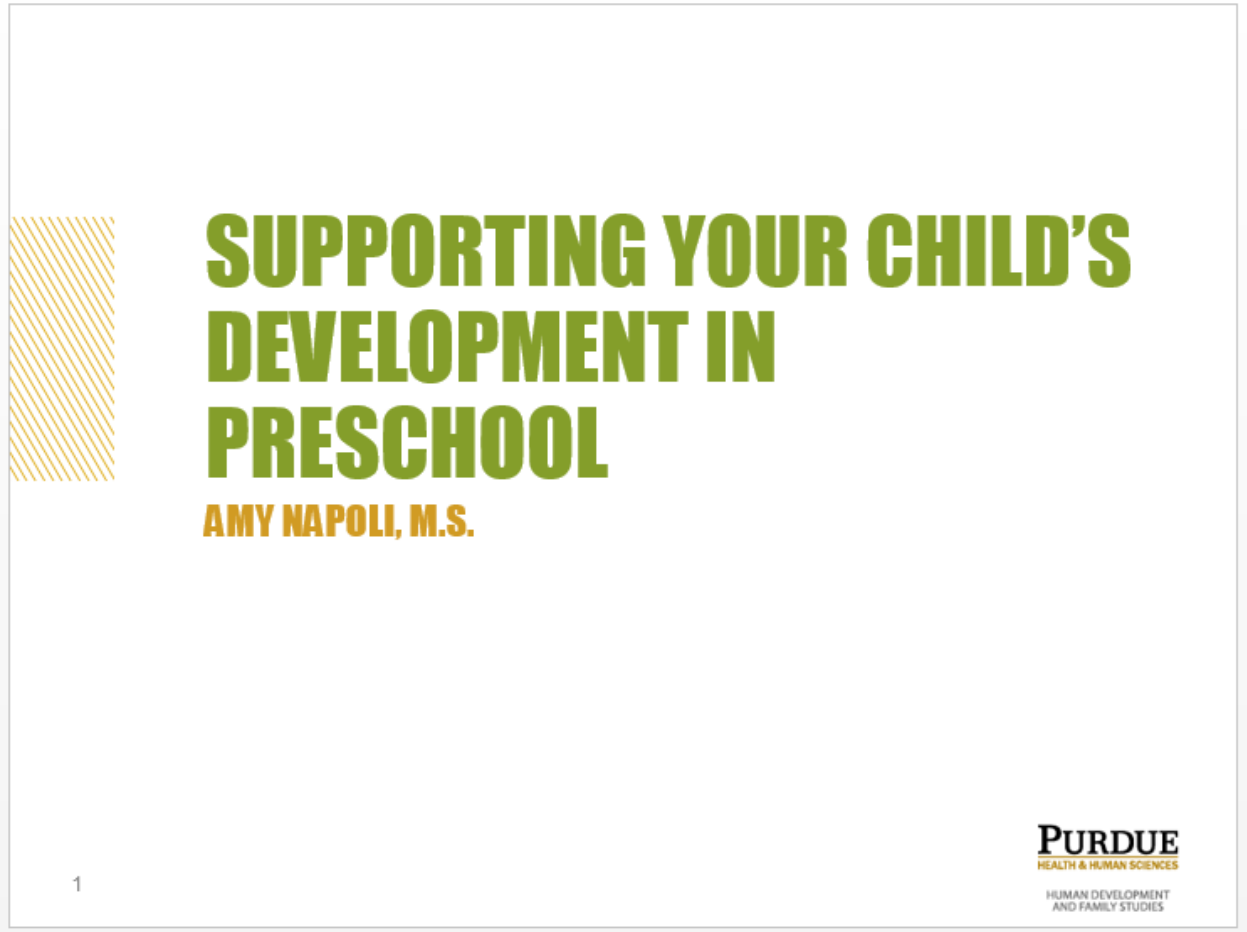
Week 3

Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
You can incorporate math into anything your child likes. Playing house? Talk about how many bottles s/he needs to feed 2 babies. Playing school? Ask how many pencils for 5 students. Playing with cars, ask how many wheels each car has. How many do 2 cars have?	Math skills in kindergarten are related to higher rates of college attendance! Have your child help you bake. Measure & count together. "We added 3 cups flour & 1 cup sugar. Did we add more flour or sugar?" Count the finished product & talk about subtraction as you eat	Don't get caught up in what you can't do–you don't need calculus to help your child learn about numbers! Play a card game like War or Go Fish with your child using only the number cards. Help him/her identify numbers & talk about which is bigger/smaller/means more, etc.	Early curiosity in math predicts creativity and leadership in later careers. You can help foster that curiosity! Use a 10 to 20 piece puzzle, or make one yourself out of cardboard or paper. Write the numbers in order on the pieces. Talk about the numbers as your child puts the puzzle together. Give hints like "10 is the biggest number in your puzzle, so it goes at the bottom." [Picture examples]	Knowing math terms like "many" & "few" is related to important early math skills. Make comparisons throughout the day using these terms. Ask questions (Who has more?) & make observations (You have the most)	The more your child knows about math now, the more likely s/he is to graduate from high school! Try a number scavenger hunt. Use number cards from your kit. Ask him/her to pick a number & find that many of an object. Ex: if s/he picks the 2, get 2 books or 2 toys.	Try not to say things like "I don't like math" or "I'm not good at math." Try to make math positive! Ask your child his/her favorite number game or activity. Play the game together. Many board games & card games offer good opportunities to count & talk about numbers.
E; A; R	B; E; R	E; A; R	B; E; A; R	B; E	B; E; R	E; A; R

Week 4

Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
Early math skills are related to later math skills, and also to skills in other areas like reading. Play a matching game together. Use the number and dot cards in your kit. You can also make new "dot" cards with different shapes or stickers on them.	Kids who have fun experiences w/ math learn to love it. Play a game using dice & blocks. Roll dice & see if s/he can stack that many blocks. Roll the die again & add that many blocks to the stack. Write down the number of the tallest stack & try to beat the record another day.	When kids learn basic math, they are preparing to learn more complex concepts. Have fun w/ math! Play a game using die, bowl, & small items. Start w/ 20 items each. Take turns. Roll a die & count items into the bowl. Goal: be 1st to get your items in the bowl.	Being comfortable w/math will help your child in his/her everyday life. Ask math questions throughout the day. "We decided to read 2 books. "We read 1. How many are left?" "You ate 1 cookie. Now you're going to eat another. How many cookies is that together?"	Think about how often you do math successfully in your everyday life: measuring when cooking, paying for items at the store, estimating when you'll arrive somewhere. These are all math concepts! These skills are important for your child, too. Play a number game together	Learning about sharing helps your child learn math. Talk to her/him about sharing & equal parts. Use items in your house. If you have 2 items, how do you share them equally? 4 items? Use the words "same" & "similar" to talk about how things are divided.	You have introduced your child to so many new math concepts and activities – you can teach your child about math! Try the Bedtime Math app to get ideas for math questions you can solve with your child. http://bedtimemath.org/
B; E; R	E; A; R	B; E; A; R	B; E	B; E; A	B; E; R	E; A; R

APPENDIX E. CONTROL GROUP INFORMATIONAL SLIDES

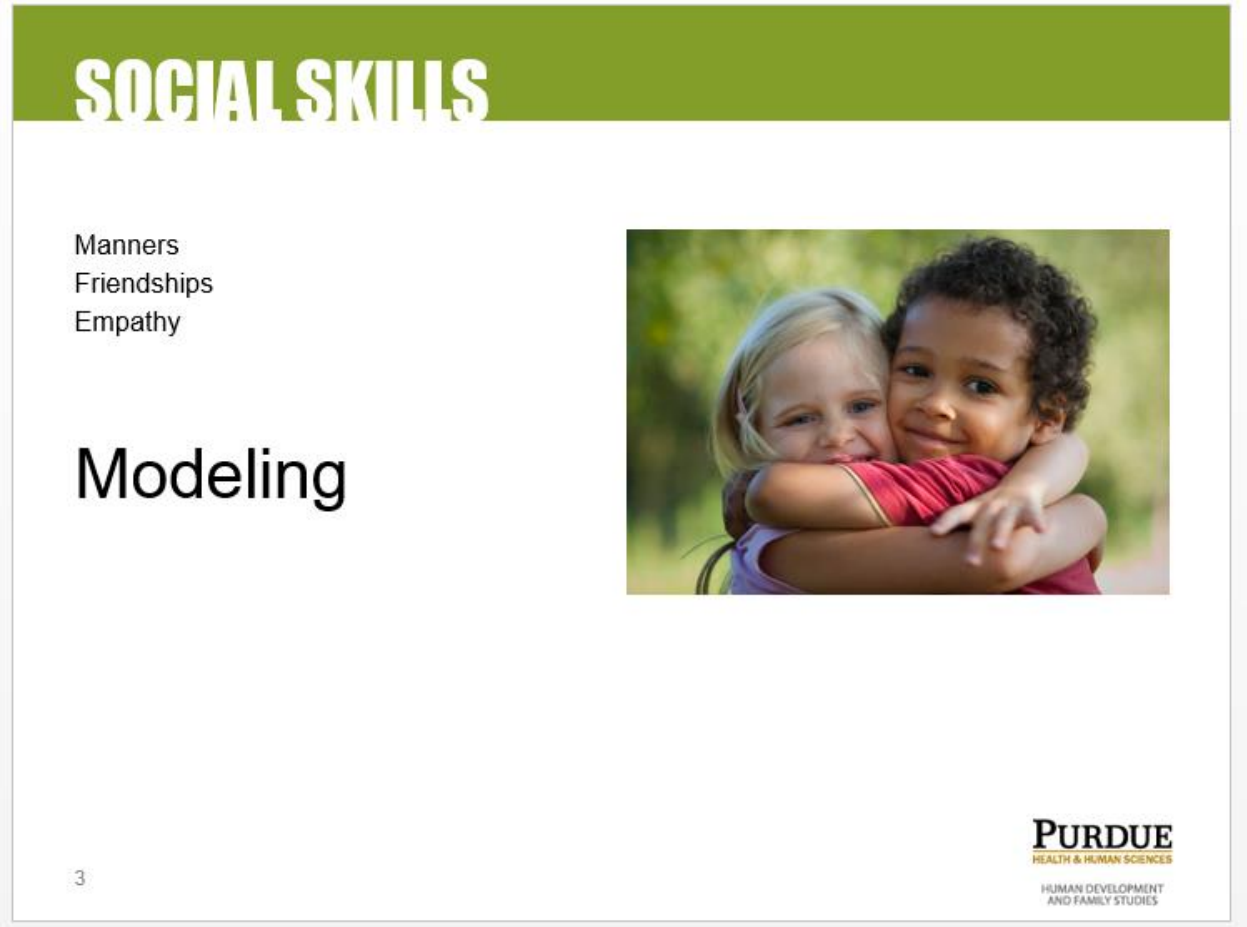


Presenter: Today we're going to talk about things that you can do to promote your child's development during the preschool years and different ways that you can spend quality time with your child.

Presenter: There are milestones that children are expected to reach during these years. These fall under the domains of:

Social and emotional skills, language, cognitive development, and physical development.

Each of the activities we'll talk about today relates to promoting one of these developmental milestones.



Presenter: Children learn many social skills during preschool.

They learn about manners and behavioral expectations,

Friendships,

And children may begin learning about how to understand other people's feelings and empathize.

The most important thing that you can do to promote these things is to model positive behaviors and show your child what good manners and positive relationships look like.

Presenter: These are some ways for promoting social skills and encouraging your child's imagination.

One things is encouraging your child to tell stories and ask questions like "How would that make you feel?" or "How does that person feel?" or asking him/her to elaborate on things.

Another thing that you can do is encourage and engage in imaginative play with your child. Imaginative play allows your child to play the role of another person and imagine what it might be like in his or her shoes.

You can also use objects in other ways than their intended purpose, such as pretending a banana is a phone or pretending a broom is a rocket ship.

Presenter: It's also important to help your child master the ability of self-control and self-regulation.

Self-regulation is related to the ways that your child inhibits his/her impulses.

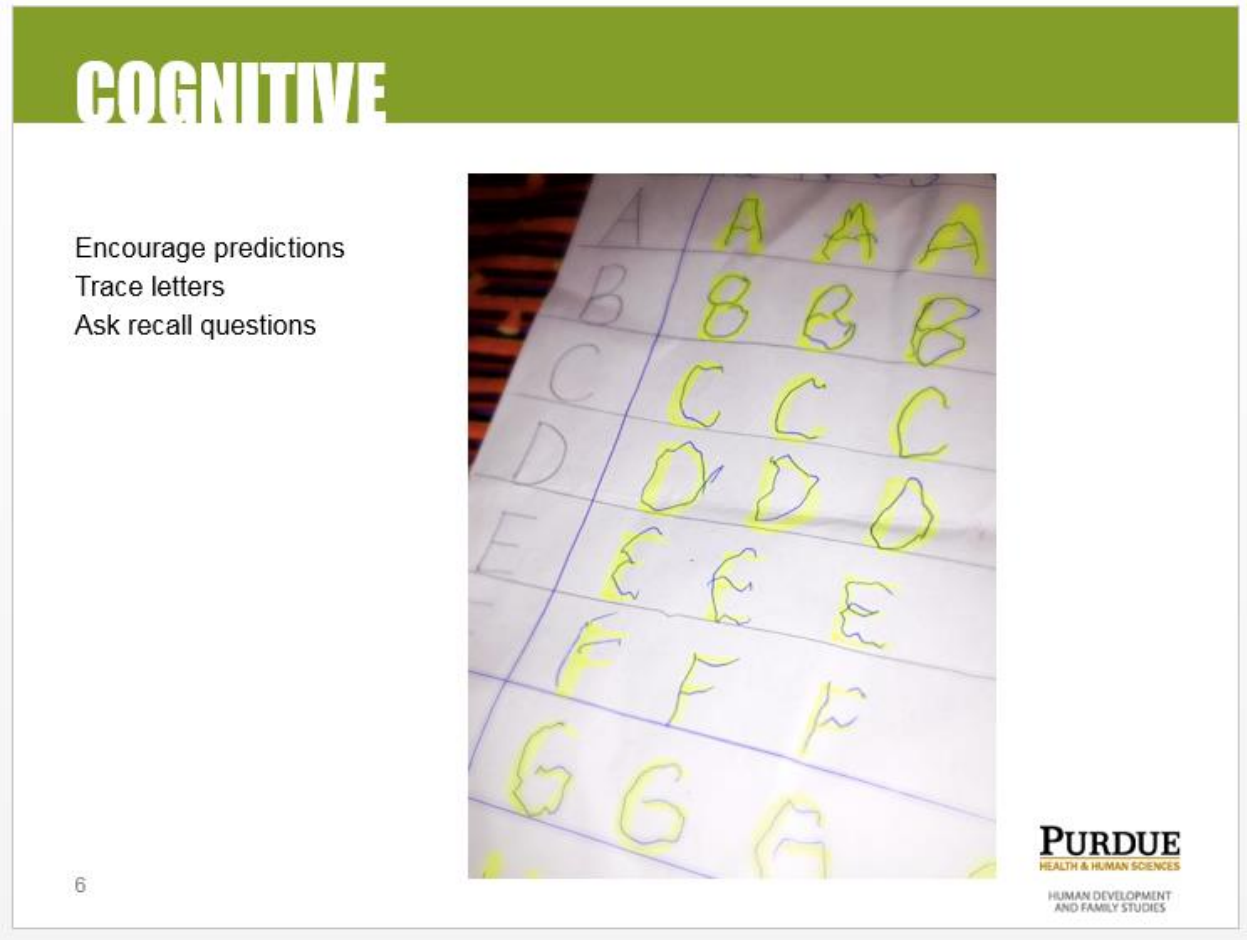
For example, if you see a toy that you really want in someone else's hand, your first impulse may be to grab it.

But it's very important to learn how to control that impulse and not to act on it.

Some things that you can do to promote self-regulation are teaching your child strategies for being patient while waiting, such as singing a song or telling a story.

Playing memory games also promotes self-regulation.

And, again, modeling these skills yourself helps your child to learn that positive outcomes associated with them.

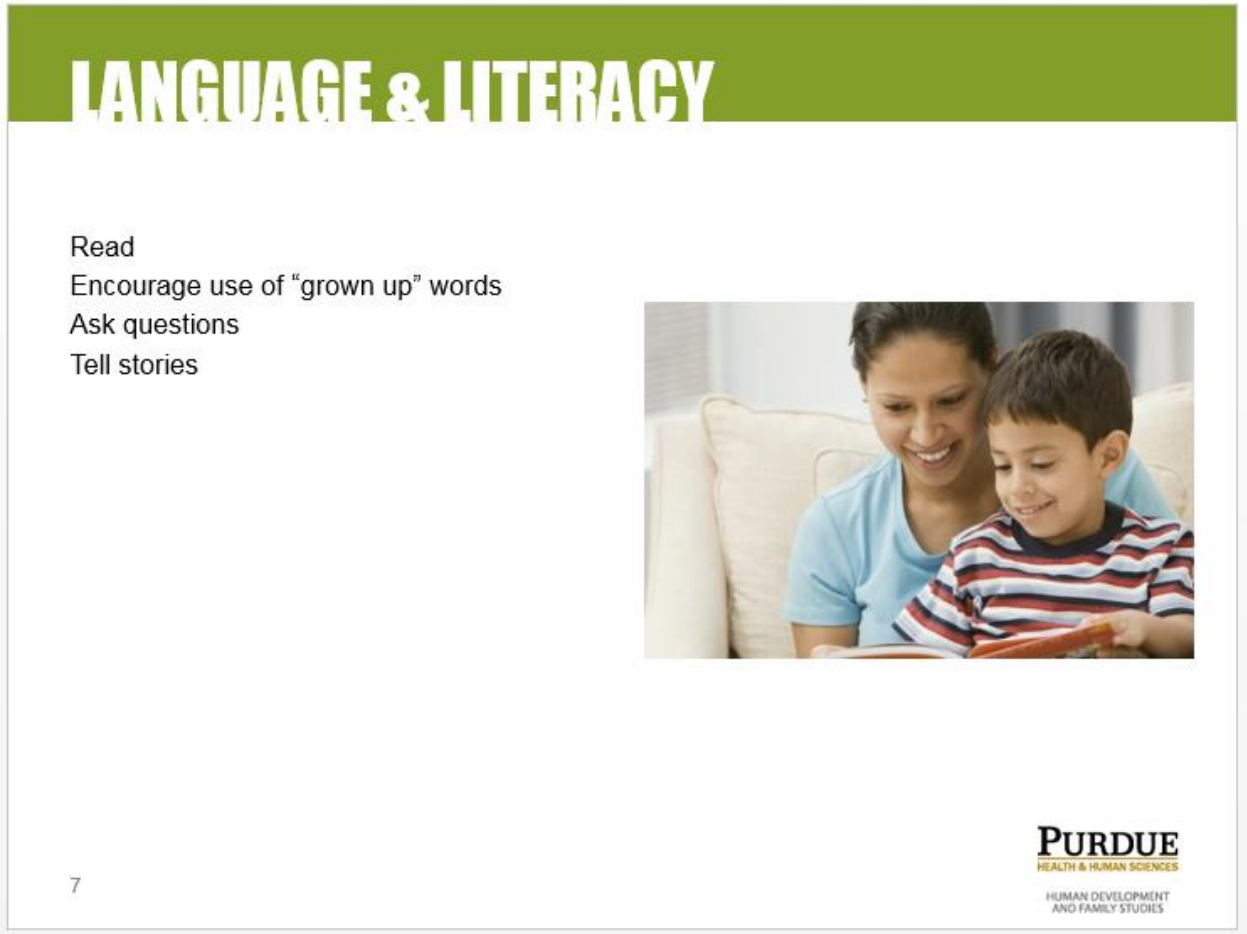


Presenter: One way that you can promote cognitive development is encouraging your child to make predictions.

For example, if you are on the way to drop your child off at school for the day, you might ask what she/he thinks s/he'll have for lunch or what the activities will be that day.

You can also help your child learn about letters by writing letters yourself in a highlighter or light marker and encouraging your child to trace over them.

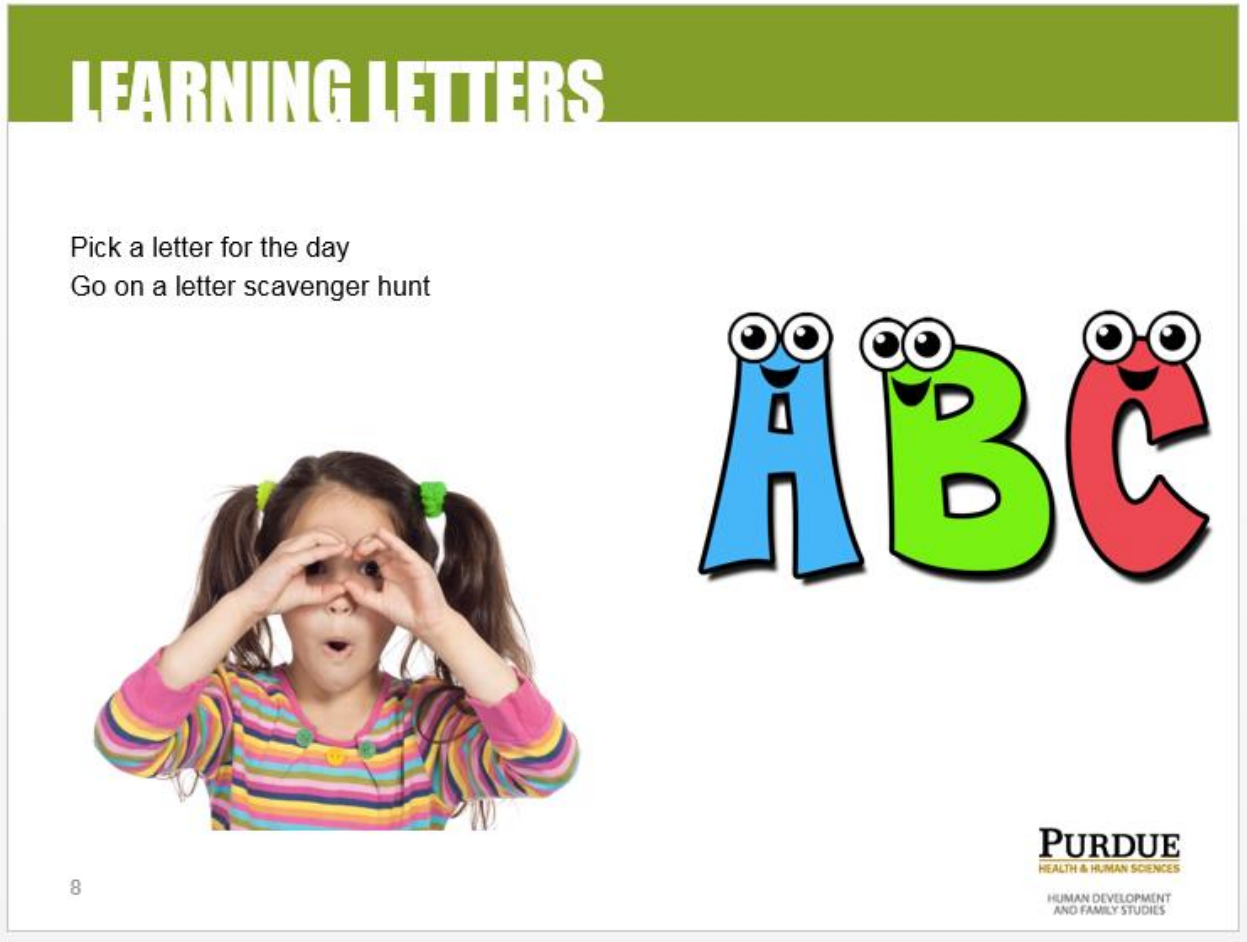
Asking recall questions, such as "What happened in the book we read?" or asking your child to retell a story that you told, promotes positive skills.



Presenter: Language and literacy development are crucial during the preschool years. Children can't read yet, but they're developing preliteracy skills that will set them up to become readers. Reading to your child is very important.

You should also begin encouraging grown up words, such as saying "water" instead of "wah wah." Asking your child questions throughout the day and while reading stories will help to promote language skills and learn new words.

Finally, telling oral stories promotes language and vocabulary skills.



Presenter: Pick a letter for the day and throughout the day point out things you see that start with that letter.

You can also go on a letter scavenger hunt around your home or neighborhood and look for all of the things you can find that start with the letter.

Presenter: Encourage your child to learn some independent skills.

Involve him or her in basic chores, such as making the bed or dusting.

You should also promote and model self-care and encourage your child to do some self-care tasks independently,

Such as getting dressed, brushing teeth, and some aspects of bathing.

You can also offer your child choices. Not choices like “Would you like to drive the car today?” or “Do you want to go to school?” but simple things like deciding what snack s/he’ll have or what activity to do that day.

Presenter: Screen time is something to be aware of during this age.

You should limit your child's time in front of a screen to one hour per day.

Probably more important than the frequency of engaging in screen time is the content that's being watched.

Sesame Street can be educational and promote important skills that shows like Sponge Bob probably don't.

Of course many of us use screen time as a way to distract kids while we're trying to get stuff done. But as often as possible, watch shows together with your child.

Ask questions and relate what you're seeing to your child's life. This also helps you monitor the content.

Presenter: Children begin forming habits during this age, so it's important that you show that you value physical health.

Talk to your child about nutrition and making good food choices.

Eat meals together as a family as often as possible.

Exercise yourself to model positive behaviors, and also exercise with your child. This can be something simple like doing jumping jacks or going on a walk.

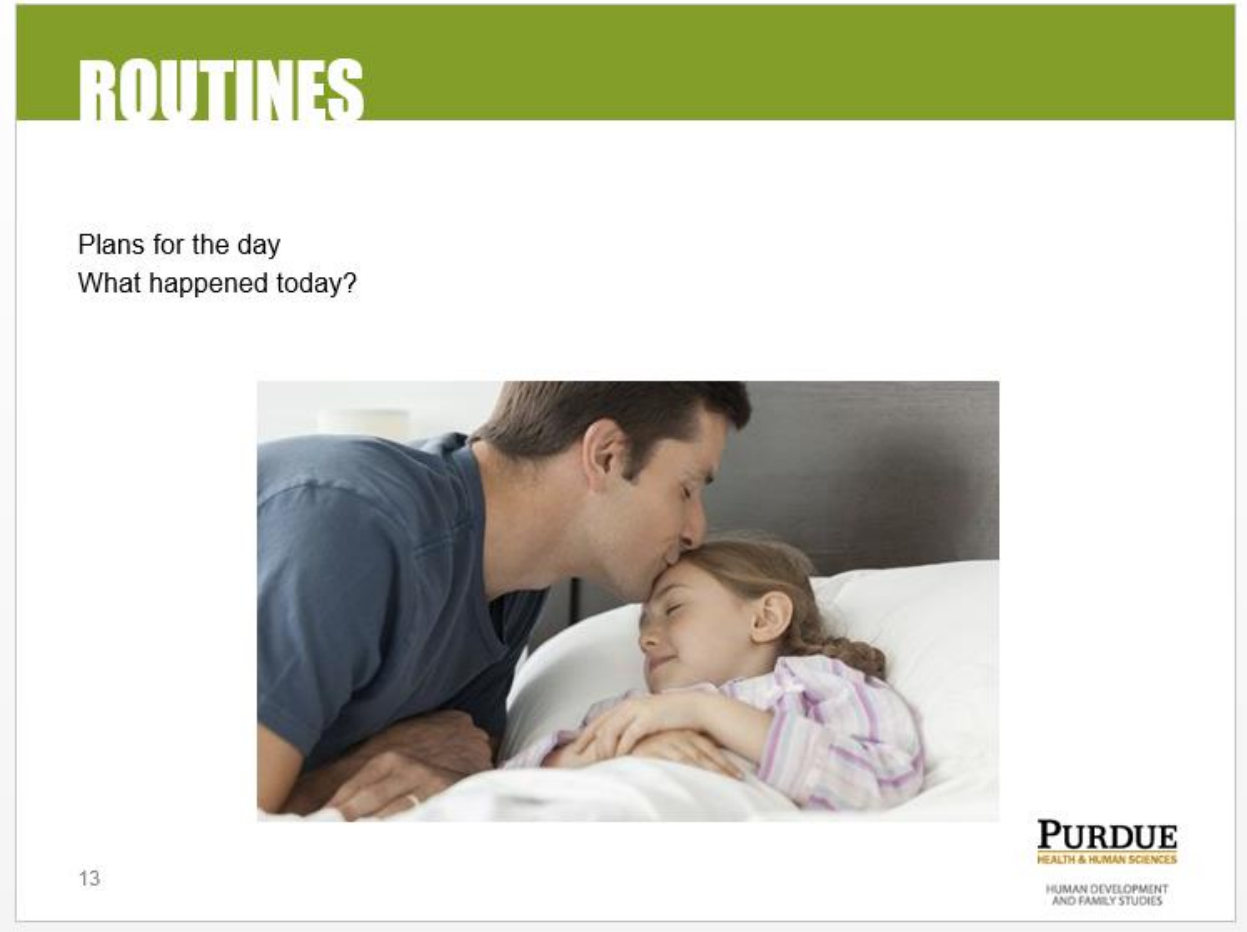
Demonstrate that sweets are special treats that are eaten rarely and on special occasions.

Presenter: There are also things you can do to promote fine motor skills.

Supervise your child using scissors and encourage him/her to cut shapes out from paper.

Encourage drawing and writing.

Stringing beads onto string, such as making a necklace or bracelet, also helps.



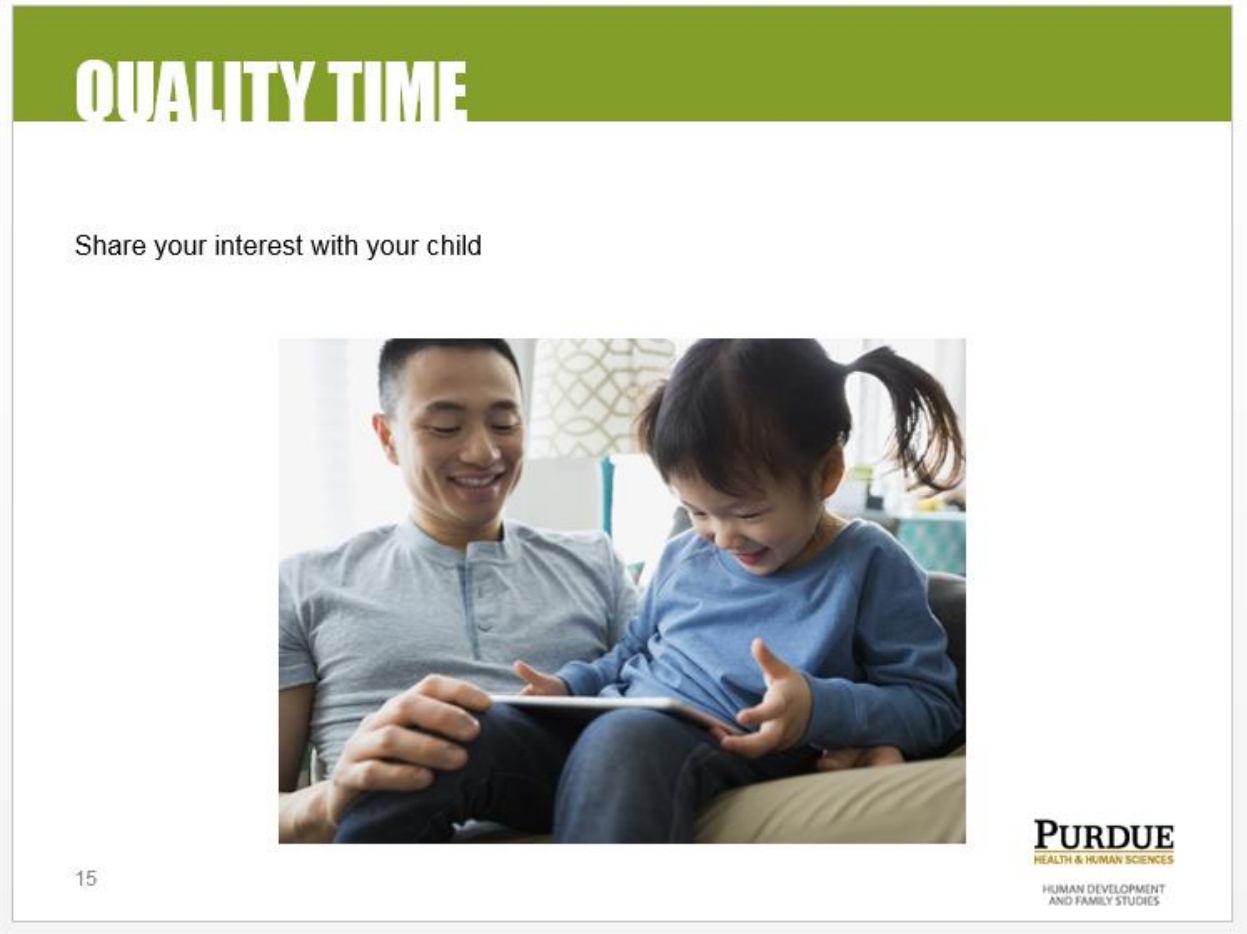
Presenter: Build routines with your child that center around talking about the day.

In the morning, talk about the plans for the day.

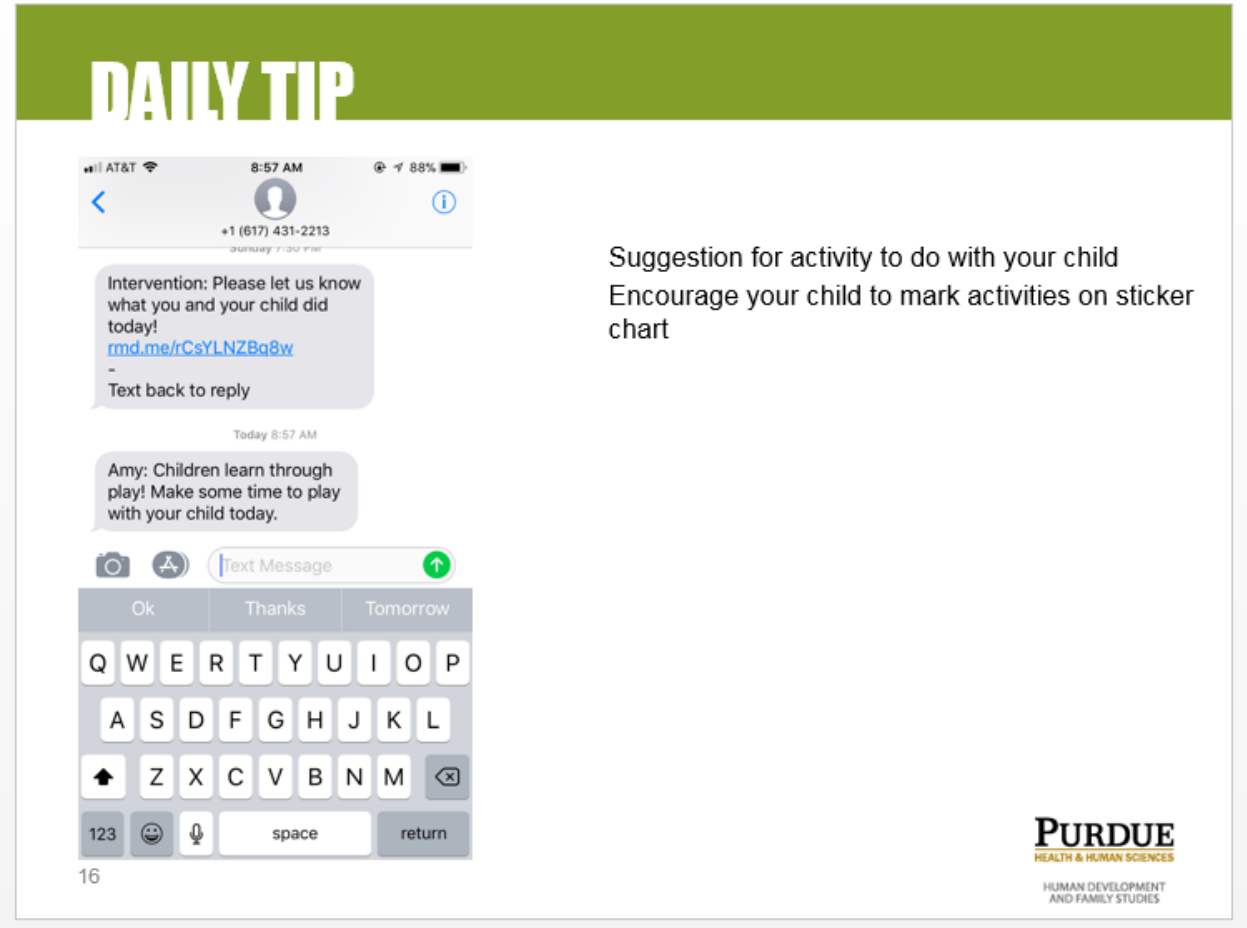
In the evening, ask about your child's day and tell him or her about your day.

Presenter: Show interest in the things that your child enjoys doing.

Expand on this interest by checking books out from the library or looking things up on the internet together.



Presenter: You can also share with your child the things that you like to do. If you like watching sports, engage them in that. If you like reading, encourage your child to grab a book and read it while you read your book.



Presenter: Now I'll show you what will happen over the next four weeks.

Each day you'll receive a text message to your phone with a new tip or idea for engaging with your child.

You may not be able to do the particular strategy on the day that you receive it, but please try to use all of the strategies at some point during the month.

If you can't do the tip that day, try to do something we talked about today or a tip that you received earlier.

Presenter: You'll also receive a link each evening to a survey. The survey is very brief and shouldn't take more than a minute or two.

The most important thing about the survey is that you respond honestly.

You are all busy and I know that you will not be able to do every single thing every single day.

The purpose of the survey is to find out how much you do,

And how much is realistic for most parents.

Please do not feel that you should report doing something because I will think poorly of you.

The most helpful thing you can do is be honest and report what you did that day.

Also, please try your best to respond to the survey each night. If you don't submit a survey two nights in a row, I will follow up with a text message. If you miss 3 in a row, I'll call to check in.

APPENDIX F. CONTROL GROUP SMS TIPS

Week 1

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Spend some quality time with your child. Read a book or watch a show together. Leave your phone in another room.	You are your child's best role model. Try a new food together. Talk about the texture & taste, what the food is made of, or how it grows.	Spending time with your child is good for you both! Write a letter to a friend or family member. Your child can dictate as you write. Encourage him/her to sign his/her own name at the end.	You can engage with your child any time. Pick out clothes together. Explain what you'll be doing & the types of clothes you should wear.	You have the skills to be a great parent! Ask your child what s/he wants to be when s/he grows up & talk about the skills s/he'll need.	You can teach your child new words just by talking together. Look through a magazine with your child and talk about the pictures you see.	There are so many ways you can spend time with your child! Take turns drawing pictures and making up a story to go with the other person's picture. Write down the stories that your child makes up.

Week 2

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
You have what it takes to teach your child new things! Let your child lock and unlock the door when you leave or come home together. Explain what the keys on your ring are for.	Keep doing your best as a parent! Create a grocery list with your child and let him/her be in charge of it while shopping.	Simply talking with your child is one of the best ways you can spend time together. Ask your child to tell you about an event that happened today. Prompt with questions like "And then what happened?"	You can spend time with your child while doing chores. Encourage him/her to help you fold laundry. Let him/her sort clothes by who they belong to.	Parenting can be challenging, but you are doing a great job! Teach your child a new song or rhyme.	Keep up the good work! Talk to your child about the weather and ask about the types of clothes you should wear today.	Learn something new together! Look up a new location on your computer or phone and talk about it with your child. Explain if it's near or far, how you would get there (car, bus, airplane), and what people like to do or eat there.

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Week 3

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Being patient is hard, but you can help your child learn how. Teach your child a new technique for being patient. Try singing a song or describing the clothes you are both wearing.	Children learn through play! Make some time to play with your child to boost important cognitive and social skills through play.	Keep asking questions! Ask your child what his/her favorite part of the day was. Why? Then tell her/him what your favorite part of your day was.	Use your imagination together! Ask your child to tell you a story about someone you see (cashier at the grocery store, woman waiting for the bus). Ask questions like "Where is he going? What will he do when he gets there?"	Use the resources you have to engage with your child. Make connections with things that you see while you're out and about with things that you and your child read about in a book. ("Look at the cakes in the bakery. We just read about a birthday cake!")	Compassion is an important skill to build early. Make a card with your child to brighten someone's day or for someone who is sick.	You and your child can both have fun when you spend time together! Play "follow the leader" with your child. Try jumping, skipping, and other fun movements. Go fast or slow. Take turns being the leader.

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Week 4

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Get silly together! Make faces & ask your child what emotion s/he thinks you feel when you make that face (sad, happy, angry, silly, tired).	Knowing the plans can help your child have a better week. Sit down and talk to your child about the plans for the week. Is there anything s/he is looking forward to? Is there anything out of ordinary from your usual routine?	Follow your child's interests and pay attention to things s/he likes to talk about or asks a lot of questions about. Learn more about the topic together by looking it up on the internet or checking out a book from the library.	Encourage your child to make predictions. On the way to school? Ask who will be there when you arrive & what s/he will do today. On your way to the grocery store? Ask if s/he thinks it will be busy & what people will be buying.	Have fun together while you're out & about! Before leaving, pick a letter of the alphabet. Point out whenever you see that letter. Talk about the sound the letter makes & things that start with the letter. Next time you go out, have him/her pick a new letter.	Learn about a new animal. Look up pictures in books or on the internet. Where does it live? What does it eat? Does it have fur? Feathers?	Exercise is important for both you and your child! Try taking a walk together, riding bikes, or doing some jumping jacks in the living room.

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APPENDIX G. INTERVENTION GROUP FEEDBACK SURVEY

1. Participating in this project increased my knowledge about how to engage my child with math at home.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

2. I feel confident about my ability to engage my child in math at home.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

3. The informational meeting was easy to understand.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

4. The text messages were easy to understand.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

5. I intend to continue trying to engage my child in math at home.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

6. The frequency of text messages was:
    a. Too frequent
       How often would you prefer to receive messages? _____
    b. Not frequent enough
       How often would you prefer to receive messages? _____
    c. About right

7. Did you refer to the informational slides at home?
    a. Yes – slides only
    b. Yes – notes only
    c. Yes – slides and notes
    d. No

8. If you referred to the slides/notes at home, how often?
    a. 1-2 times
    b. About once per week
    c. 2-4 times per week
    d. 5 or more times per week

9. If you referred to the slides/notes at home, when did you refer to them?
    a. Only the first week or so
    b. Only the last week or so
    c. Throughout the project
    d. Other: _____

10. Would you have preferred a different form of communication throughout the project?

    _____

11. Were there any activities that you particularly enjoyed?

    _____

    _____

12. Were there any activities that you found to be unrealistic to do with your child?

    _____

    _____

13. Did you notice benefits for your child during your participation in the study? Please circle a response for each category.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
Math	1	2	3	4
Literacy	1	2	3	4
Vocabulary	1	2	3	4
Self-control	1	2	3	4

APPENDIX H. CONTROL GROUP FEEDBACK SURVEY

1. Participating in this project increased my knowledge about how to engage with my child.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

2. I feel confident about my ability to engage my child in activities at home.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

3. The informational meeting was easy to understand.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

4. The text messages were easy to understand.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

5. I intend to continue trying to engage with my child at home.

Strongly disagree	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*

6. The frequency of text messages was:
    a. Too frequent
       How often would you prefer to receive messages? _____
    b. Not frequent enough
       How often would you prefer to receive messages? _____
    c. About right

7. Did you refer to the informational slides at home?
    a. Yes – slides only
    b. Yes – notes only
    c. Yes – slides and notes
    d. No

8. If you referred to the slides/notes at home, how often?
    a. 1-2 times
    b. About once per week
    c. 2-4 times per week
    d. 5 or more times per week

9. If you referred to the slides/notes at home, when did you refer to them?
    a. Only the first week or so
    b. Only the last week or so
    c. Throughout the project
    d. Other: _____

10. Would you have preferred a different form of communication throughout the project?

    _____

11. Were there any activities that you particularly enjoyed?

    _____

    _____

12. Were there any activities that you found to be unrealistic to do with your child?

    _____

    _____

13. Did you notice benefits for your child during your participation in the study? Please circle a response for each category.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
Math	1	2	3	4
Literacy	1	2	3	4
Vocabulary	1	2	3	4
Self-control	1	2	3	4