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Preschoolers' Physical, Social, and Engineering Play Behaviors: Differences in Gender and Play Environment

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PRESCHOOLERS' PHYSICAL, SOCIAL, AND ENGINEERING PLAY BEHAVIORS: DIFFERENCES IN GENDER AND PLAY ENVIRONMENT

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ABSTRACT

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This study explored gender differences in the occurrence of 66 preschoolers' (ages 3-to-5; 29 girls, 37 boys) physical, social, and "engineering thinking play" behaviors across three play environments: the traditional playground, the dramatic play area, and an environment in which children played with large, manipulable, loose parts. Previous research has indicated that young children are not engaging in enough physical play to maintain healthy lifestyles. Play may also have benefits for social competency and cognitive development. Observations of children's engagement with a new and engaging play material, Imagination Playground™ blocks, which are designed to foster imaginative and creative constructive play, were used to understand more about preschoolers' physical activity, social behaviors, and "engineering thinking play," a recently developed construct that focuses on early design- and construction-related thinking and behavior. The "engineering thinking play" observation measure was used as an index of the types of behaviors in which preschoolers are engaging that parallel thought-processes and behaviors associated with the engineering process (e.g., explanations of how things are built, construction, and generation of innovative and creative ideas). Results indicated no gender difference in the frequency of occurrence of

early engineering thinking play, suggesting that research is needed exploring processes underlying boys' and girls' early cognition, and girls' subsequent disinterest in science, technology, engineering, and mathematics-related (STEM) careers, compared to boys. Additionally, children's play with large, manipulable, loose parts was associated with three times the frequency of engineering thinking play than occurred in the traditional outdoor playground. Large loose parts play also included high levels of gross motor and fine motor physical activity, and positive social play behaviors. These observations suggested that play with loose parts and other manipulable materials may benefit children's development in multiple domains.

CHAPTER 1. INTRODUCTION

Preschool play research has declined in recent years as studies on early childhood education have focused more on instruction of discrete skills, such as mathematics and reading, which have been strongly correlated with future academic outcomes (Duncan et al., 2007; Romano, Babchishin, Pagani & Cohen, 2010). Research on play should not be ignored because physical and social play have implications for health (Cardon & Ils De Bourdeaudhuij, 2008) and positive and negative peer interactions (Denham, Blair, Schmidt, & De Mulder, 2002). In addition to the physical and social benefits of play, it is possible that play during the preschool years cognitively stimulates children and lays the foundation for future logico-mathematical abilities through children's active experimentation during play (Piaget, 1973). Some research has suggested that play with engaging materials may provide preschool-aged boys and girls with a simpler method than classroom instruction through which to explore early cognitive abilities and thinking that precedes higher-order mathematical abilities (Sutton, 2011). Play with engaging materials may be useful in exploring Piaget's ideas about children's development of intelligence as spontaneously and gradually emerging from children's construction of simple logico-mathematical structures through early experience that is less dependent on teachers (Piaget 1962, 1973). Bandura's social learning theory (1962) is also useful in discussions of children's choices about play materials and play behaviors.

Current research on early mathematical learning suggests that the design of classroom instruction in discrete skills may be associated with girls' decreased interest in science, technology, engineering, and mathematics (STEM)-related careers in early-adulthood, compared to boys (Villalobos, 2009). As such, more research is needed exploring the presence of behaviors in preschoolers that are related to future mathematical skills, especially in the context of gender and environment. Block play has been seen as an important tool in children's cognitive development and learning. Playing with blocks has been correlated with spatial abilities and preschoolers' early understanding of shapes and sizes (Caldera et al., 1999; Park, Chae, & Boyd, 2008). Additionally, preschool play with loose parts such as blocks, sand, stones, and water, has been shown to elicit behaviors associated with the development of construction-related thinking in children (Sutton, 2011).

The current study sought to explore the association between preschool play and construction and design-related thinking, using the recently developed construct of "early engineering thinking play," play in which children engage in behaviors associated with the engineering design process (e.g., explaining how things are built, communicating goals, generating ideas, and constructing). Sparse work done in this area has shown that when preschoolers play with loose parts they devote considerable attention to the process as well as the product of their designs (Brophy & Evangelou, 2007). Studies have also correlated construction-type play with children's abilities to imagine, create, think about problems and solutions, and explain processes to others (Bairaktorava, Evangelou, Bagiati, & Brophy, 2011).

The current study examined gender and environmental differences in preschoolers' physical, social, and engineering thinking play behaviors. Particularly relevant was the inclusion of the Imagination Playground™ materials as a new and potentially unique play context: large, manipulable, loose parts that were specifically designed to foster creative and imaginative play in young children. The main goal of this study was to explore preschoolers' engagement in a wide array of physical, social, and engineering thinking play behaviors, to draw implications about future research on gender and environmental differences during play with materials designed to stimulate imaginative thinking. Gender differences in the mean rates per hour of physical, social, and engineering thinking play behaviors were explored and compared in the same selected play settings: the traditional playground, the dramatic play area, and a play area that included the Imagination Playground™ blocks.

CHAPTER 2. LITERATURE REVIEW

2.1 The Importance of Play

Theories and frameworks about young children's play date back to the early 19th century, when Schiller (1800; 1954) posited that children play to expend surplus energy. More recently, contemporary theorists such as Freud (1922; 1959), Erickson (1950), and Piaget (1962) have offered varying opinions about play in the context of pleasure and intellectual development. Freud (1959), postulated that the motivation for play was the pleasure principle and that children play in order act out the things they desire, such as becoming a police officer. He also believed that children play to reenact unpleasant experiences to gain a mastery over them. Erikson (1950) offered the idea that play develops in stages, according to the development of the child. According to Erikson, play begins with self-centered actions and exploration of such things as daydreaming and thumbsucking. Erikson believed play develops in complexity until children begin to focus less on themselves and play more cooperatively with other children. Piaget (1962) posited that play has implications for intelligence, such that play allows children to assimilate environmental stimuli. He also believed that play is important in building the earlier structural foundations of intelligence (Piaget, 1973). Piaget thought that intelligence gradually emerges from children’s experiences with their environments, piecing together ideas about objects and experiences that help lay the foundation for future abilities to think logically. Today, child-initiated play is characterized as an essential activity for exploration, imagination, and learning, because it is thought to help children make sense of the world (Gopnik, 2009; Nicolopoulou, 2010).

Although research interest in children's play gained momentum in the 1980s and 1990s (Fein, 1981; Frost, 1992), there has been a recent shift in researchers' focus on early childhood learning. The importance of play in learning has sometimes been overlooked, as instruction in discrete skills in mathematics and literacy have been found to correlate strongly with future academic outcomes (Duncan et al., 2007; Romano et al., 2010). Evidence on math and reading, coupled with political and social pressure to increase academic achievement in low income and disadvantaged children, has led to earlier installation of didactic instruction in classrooms (Miller & Almon, 2009). In early childhood education practice, high stakes achievement testing, at younger ages, plus academic standards that prescribe skills that should be learned at each age level, recently extending downward into the pre-kindergarten years, have children seeing reduced playground time (Nicolopoulou, 2010).

Some scholars believe that play has not been researched enough in the context of children's cognitive, socio-emotional, and physical development, and that play is as important in development as specific instruction in discrete classroom skills (Miller & Almon, 2009). Research on children's physical activity (Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003) and socio-emotional well-being (Blair, Denham, Kochanoff, & Whipple, 2004) has led to recent suggestions that children are not provided with enough opportunities for child-initiated play. The current study attempted to address these concerns by conducting exploratory research, examining the natural occurrence of physical, social, and engineering thinking play behaviors with engaging materials in multiple play environments. Before reviewing the engineering thinking play construct, as well as research on physical and social play, it is important to outline two major theories that guided this study.

2.2 Theories of Young Children's Differences In Play Behavior

A discussion of theories about variations in young children's play behavior is necessary in explaining the roots of research on preschoolers' play differences in the context of physical play, social play, and engineering thinking play. Social learning theory (Bandura, 1962), and Piaget's theories about cognitive development (1962) and mathematical education (1973) have been useful in providing a context for preschool play.

Social learning theory (Bandura, 1962) posits that learning takes place in social contexts and may occur simply through observing others and imitating their actions. Current research suggests that children begin imitation within minutes after birth by mimicking mother's facial expressions, such as smiling and frowning (Melztoff & Moore, 1989). Research also indicates that learning through social observation is an important mechanism through which young children develop knowledge and social skills (Barr, Viera, & Rovee-Collier, 2001). Although social learning continues through adulthood, it is perhaps more important in early stages of life, as children navigate their environment and curiously observe their surroundings (Barr, Viera, & Rovee-Collier, 2001). In the context of the current study, play with large blocks and other play materials, within various environments, may be related to children's creativity, thinking, and behavior based on observations of other children's play.

Other useful models in explaining young children's play are Piaget's theory of cognitive development (1962) and Piaget’s ideas about the development of mathematical education (1973). Piaget (1962) posited that children are actively curious about their environments, and in order to satisfy their curiosities they engage in trial-and-error processes to learn which behaviors are useful or useless in accomplishing tasks. According to Piaget, preschool-aged children do not yet understand concrete logic, and it is difficult for them to mentally manipulate information. During this time, children frequently engage in symbolic and dramatic play. Behaviors such as playing house, pretend fighting, and the use of various objects to symbolize something else, are common. Also, as children engage in social play they may challenge each other’s ideas and explanations for social and physical processes, resulting in accommodation and development of thinking. Preschoolers' active curiosity, combined with dramatic play and a gradually more complex understanding of environments and other people, may be potentially beneficial for learning and social competency. In this regard, Piaget's ideas about cognition are still applicable to contemporary research on play. Piaget (1973) has also suggested that young children’s intelligence gradually emerges from experiences with their environment. He posits that early experiences with structural elements of young children’s environments, such as toys, objects, and materials, promote a basic level of cognition in children that helps develop early mathematical foundations. These experiences build upon one another, until a point later in development when children become capable of logico-mathematical thinking. During the preschool years, many of these early structural experiences occur regularly during play.

As a whole, preschool play may be viewed from any or all of the perspectives described. Play is multi-dimensional, as children might have different motives and desires while they explore various play materials alone and with other children (Fleer, 2012). It is possible that social learning theory and Piaget's theories of cognitive development and mathematical development each play important roles in a full understanding of preschoolers' development in the context of play. Children's curiosity and observation of the processes by which other children play, may promote active learning in various play environments and influence cognitive, physical, and social learning skills. Parts of these theoretical frameworks are useful in providing context on some of the physical, social, and cognitive elements of preschool play. Before reviewing the relevant literature on physical and social play, it is important to place engineering thinking play into a developmental context and provide previous research and general ideas about the potential benefits of studying early engineering thinking through play.

2.3 Exploring Engineering Play

Early engineering thinking play is a recent construct in the early childhood education field. It has been categorized by Bairaktarova and colleagues (2011) and includes 9 types of frequently observed engineering thinking during preschoolers' play: communicates goals, generating design ideas, construction, problem-solving and replication, expressing creative or innovative ideas, solution-testing and evaluating design, explaining how things are built or work, following patterns and prototypes and using logical and mathematical thinking and technical vocabulary (Bairaktarova et al., 2011). The current study defined the early engineering thinking construct, and distinguished it from other types of early creative thinking, as young children's observable thought-processes specifically related to design in the context of construction (Bairaktarova et al., 2011; Brophy & Evangelou, 2007; Evangelou, 2010).

According to Piaget's theory of intellectual development, preschool-aged children are not capable of abstract thinking (Piaget, 1962). As such, it is possible to misinterpret ideas about engineering thinking play as suggesting that preschoolers can think abstractly. Piaget (1973) posited that although preschoolers are incapable of logico-mathematical thinking, early experiences help children formulate ideas that gradually develop into higher-order intellectual thinking at older ages. As children actively engage with their environments, through trial-and-error processes, they are learning things that work and things that fail, and can assimilate environmental stimuli into their thoughts about the world (Piaget, 1962; Piaget, 1973). Based on previous research, it is possible that play with engaging play materials, such as the Imagination Playground™ blocks used in this study, helps preschoolers build some of the early structural ideas that eventually lead to logico-mathematical thinking, as Piaget described (Sutton, 2011). Although abstract thinking is not possible in young children, it has been suggested that engaging play materials in preschools, stimulate children's cognition using simpler methods than classroom instruction, and may help push children toward the eventual manifestation of abstract thinking later in development (Sutton, 2011). It is important to place developmental context around each of the 9 engineering play behaviors, in order to support preschoolers' abilities to engage in these behaviors:

"Communicates goals," is categorized as occurring when a child has a goal or purpose and communicates the goal while constructing or using materials. For example, during the construction of a castle, Susan might say, “Let’s put the little block on top like a tower.” Susan is expressing her idea about a purpose during construction. This statement suggests that if the small block on top works as a tower, Susan and her peers might understand something about how castles are meant to look. Having a goal is also important in the engineering process.

“Design and construction,” is categorized as occurring when a child constructs a model of something and builds an object using materials trying to make this object work in a certain way. For instance, Susan might join her friend Tommy in collecting all of the blocks they will need to build the castle and its tower, discussing which blocks they think they will need, and then building the tower based on their conversation.

“Problem solving and replication,” is categorized as occurring when a child states intention to change something in order for it to work better. This might include redoing something in order to improve its function or process. For instance, during the construction of the castle tower, Tommy might say, “Susan, the little block does not look like a tower. It is not tall enough. Let’s get the long thin block for the tower.” Tommy may have seen a better version of a tower in his previous experiences with castles, and he thought Susan’s version was not accurate. This example is also possible for preschoolers, and it does not suggest that preschoolers are engaging in activities more complex than taking the castle down and reworking it.

“Creative and innovative ideas,” are categorized as occurring when a child tries a different, less common approach when playing with materials and/or building an object in regard to shapes or functionality. For example, after observing Tommy and Susan building the castle tower, William decides that he will build his own tower, but he wants to be able to climb up to his tower, like a real castle. For this reason, William stacks some larger blocks on top of one another, to make stairs, so that he may reach the top of his tower by climbing the stairs. Functionally, Williams has used his innovate idea to build stairs and actually reach the top of his tower. He did this through observing his peers and thinking about a way to do something better.

"Solution testing and evaluating design," is categorized as occurring when a child stops constructing to evaluate the object and whether it functions as needed or planned. For example, while William is building his stairs, he might realize that his stairs only allow him to climb up to the side of the tower and not actually in the tower. For this reason, he might pull down the side of the castle near his tower, to see if he can make his stairs go inside the castle.

"Explaining how things are built or work," is categorized as occurring when a child explains during or after the activity, what the child thinks he/she has made or done. This might include Susan saying, "Look Tommy, we built the castle, and the long thin block looks like a tower!" This engineering thinking behavior is useful when children are excited and talking about what they have just created.

"Following patterns and prototypes," is categorized as occurring when a child attempts to use his/her new creation in different settings, or trying to talk about where he/she has used these ideas before. For instance, Tommy might say, "Susan, I saw Dora the Explorer look down from a tower in a castle. Then my Dad made a castle with me from a box. Let's build a castle with these blocks." Tommy is incorporating his previous experiences and knowledge into a new environment with Susan.

"Logical mathematical thinking," is categorized as occurring when a child references numbers or displays some level of mathematical concepts during play, like shapes, sizes, or estimation. Perhaps those who developed this category should not have described these behaviors as "logical/mathematical," given that they are simpler mathematical-related abilities in which some preschoolers certainly display, but are not necessarily abstract or logical as the title implies. For instance, Tommy might say, "Look Susan, we have one tower on our castle. What if we build another castle with two towers? Wouldn't this make the castle bigger or taller or better?" Tommy's suggestion shows his awareness of two being greater than one, and that a castle with two towers might be larger. Nevertheless, since this study used a previously developed observation instrument, it used the previous category titles, but attempted to qualify results pertaining to the measure.

"Technical vocabulary," is categorized as occurring when a child uses accurate technical vocabulary, such as "push," "gear," or "hammer this." For example, William might say, "Look Susan, I *stacked* the blocks to make stairs, and now I have a way to see from my tower."

The 9 engineering thinking play behaviors described were each observed in preschoolers during the current study. They are not meant to suggest that preschoolers display cognitive abilities rarely seen in 3-to-5 year-old children. They are meant to parallel engineering thinking later in development, in ways that preschoolers are capable of expressing the engineering process. Many times, preschoolers may even engage in these behaviors without direct intentions to do so. The 9 engineering thinking play behaviors do align with Piaget's ideas about early structural experiences influencing the development of thinking in young children (Piaget, 1973). As preschoolers are building, constructing, tearing down, talking about building, changing things, using previous knowledge, and observing each other, they are learning about structural differences in the design and construction process that may help formulate early cognitive abilities that eventually develop into logico-mathematical abilities. This may be useful in the development of curriculum during early childhood. Although research on engineering thinking play is scarce, previous studies on the construct have supported the notion that preschoolers gain some cognitive benefits from play with engaging materials. This supports their ability to display early engineering thinking through play.

2.4 Engineering Thinking Play in Young Children

The few studies on early childhood engineering skills indicate that children as young as preschoolers are capable of understanding ideas about the engineering process (Bagiati, 2011; Bagiati & Evangelou, 2011; Brophy & Evangelou, 2007). According to Brophy and Evangelou (2007), children are as interested in the block-building process as they are in the block-building product. This indicates that children are interested in engineering, at least on a basic level, regardless of whether they realize their interests. Evangelou and colleagues (2010) showed that young children's play with tangible artifacts leads to numerous questions and discussions about those artifacts, leading researchers to believe that young children are capable of evaluating their play and the things they create (Evangelou, Dobbs-Oates, Bagiati, Liang, & Choi, 2010). Bagiati (2011) has even observed early engineering thinking in young children's group interactions and discussions. Bairaktarova and colleagues (2011) were able to observe 3-

to-5 year old children engaging in play with various loose parts such as blocks, sand towers, water tables, and snap circuits. From their observations, they concluded that preschoolers engage in various kinds of engineering skills. Specifically, they used these observations to create the 9 types of engineering thinking play used in this study (Bairaktarova et al., 2011). These studies lend support to the notion that engaging play materials, especially loose parts, promote thinking and some level of cognitive skills in preschoolers and young children. Many of these cognitive abilities may be related to Piaget's ideas (1962, 1973) about intellectual development in young children, as they involve thought processes resulting from the active use of materials in their environment. In order to understand why engineering thinking play might be promoted by the large, loose parts play context used in this study, it is necessary to discuss elements of physical and social play in the context of cognition and learning. In order to do so, readers must understand why play with loose parts and blocks has the potential to promote early engineering thinking.

2.5 Loose Parts and Block Play

Research has shown that creativity, imagination, problem-solving, and other descriptors associated with engineering thinking are made possible for preschoolers and young children through play with loose parts (Sutton, 2011). Loose parts include common play materials such as blocks, but also materials such as sand, stones, and water (Sutton, 2011).

Children’s physical play has been correlated with the complexity of play materials offered on playgrounds. For instance, studies have suggested that “loose parts” play materials (e.g., balls, tricycles, digging and scooping toys) increase physical activity, above and beyond fixed playground structures (e.g., swings, ladders, slides) (Hannon & Brown, 2008). Although children are active on fixed playground structures, playgrounds with loose materials provide preschoolers with more opportunities to move and experiment physically than do less diverse playgrounds (Farley, Meriwether, Baker, Rice, & Weber, 2008).

There is also an increasing viewpoint that social play and dramatic play on playgrounds is increased when loose play materials are present. The presence of pretend house materials, digging materials, balls, and other loose parts, allows children to role-play much the same as they would indoors (Campbell & Frost, 1985; Sutton, 2011). Loose play parts may also be beneficial for social interaction, as preschoolers' may find themselves kicking, throwing and catching, and interacting as they engage in physical activity with these materials (Hannon & Brown, 2008). Some loose parts, such as blocks, have also been shown to be more cognitively engaging for preschoolers, because they allow skills and behaviors to occur, such as object manipulation, problem solving, and recognition of space, relative size, and shapes (Caldera et al., 1999; Park et al., 2008).

Block play has generally been viewed as cognitively stimulating for young children. Research has suggested that playing with blocks is related to various positive cognitive outcomes such as mathematical learning and spatial abilities (Caldera et al., 1999; Park et al., 2008). In a qualitative study of two 6 and 7 year-old boys' block play, Park and colleagues (2008) observed children categorizing geometric shapes, transforming shapes, and making larger shapes from smaller shapes. The children were able to block build while understanding the principles of parts and wholes. Caldera and colleagues' (1999) study of 51 preschoolers demonstrated that young children are able to accurately recreate block structures from observation. This suggests that preschoolers can learn through observation and adjust their construction with blocks accordingly, consistent with Piaget's principles of learning, and social learning theory, as active and stimulating in preschoolers' cognitive development. Overall, play with blocks has implications for preschoolers' intellectual development as it is related to various aspects of learning and mental capacity.

Play with blocks is also typically associated with fine motor movements, as blocks are often smaller and are used to build with hands (Sutton, 2011). In this way, block play has been related to children's ability to manipulate small objects and apply creativity and imagination skills through construction (Caldera et al., 1999). Interestingly, the larger "loose part" blocks used in the current study provide a new angle from which to view block play, because they allow for similar manipulation and creativity, but also require the use of gross motor play and large muscle movements. It is hypothesized that the large, loose part blocks in the current study will promote cognitive stimulation associated with block play, as well as physical and social tools necessary for moving blocks and interaction with other children during construction processes. In this way, it is thought that large, manipulable, loose parts may engage children in ways that promote early engineering thinking play in relation to physical and social development.

In the current study, engineering thinking play was specifically explored during preschoolers' play with large, manipulable, loose parts, resembling over-sized light-weight blocks. In addition to implications about young children's observed engineering thinking during play with these blocks, physical and social play were also examined during block play, as well as engineering thinking play, physical play, and social play within two additional play environments: the traditional playground and the dramatic play area. Differences in play were also examined by gender.

To our knowledge, the comparisons made between young children's engineering thinking play, physical play, and social play, across three play environments, have never been explored in previous research. Additionally, this study sought to make recommendations about future research concerning gender, and possible suggestions for shaping early childhood curriculum. For instance, results about physical and social play during preschoolers' engagement with the Imagination Playground™ blocks, may be helpful in understand how to use engaging play materials in preschools. Since this study may provide ideas about future research, ideas about play materials in early education curriculum, and also on the broader health-benefits of active, unstructured play, it fills an important research gap.

2.6 Implications of Engineering and in Early Education

The National Association for the Education of Young Children (NAEYC) has emphasized the importance of including science, technology, engineering, and mathematics (STEM) in early childhood curriculum (NAEYC, 2003). Although engineering education has been established in many high schools, engineering skills in early childhood education are not as well established, because educators have long thought that young children cannot understand many of the abstract ideas associated with the engineering process (Bairaktarova et al., 2011). Recent studies have indicated that although young children are not capable of abstract thinking, they are capable of learning some basic scientific and mathematical principles through use of simpler methods such as play materials (Gelman, 2006). For this reason, engineering education might be possible during the early education years through play. Researchers have also argued that children's creativity and imagination are traits that are desirable in future engineers and should be promoted in early childhood (Evangelou, 2010).

There is also a social stigma that boys are more interested in mathematics and technology because they perform better on math and science-related tasks than do girls (Villalobos, 2009). This thinking has been used to justify why boys are more likely to pursue careers in the science-related fields, such as engineering. Villalobos (2009) argued that much of the reason boys have performed better in mathematics during later education is because girls' methods of mathematical thinking during early education are discouraged over time. During early childhood, girls tend to think more algorithmically, which often leads to better performance in mathematics than boys on tasks such as addition and subtraction, in which there are right-and-wrong answers. However, boys' typical mathematical strategies of problem-solving lend more to success in more difficult mathematics, such as calculus, when right-and-wrong answers are less clearly defined (Villalobos, 2009). Villalobos (2009) suggested that changes in early childhood education are needed in order to promote girls' ability to succeed in mathematics during later education. Some of these changes include avoiding rigid, didactic classroom teaching that focuses too much on discrete skills and does not promote problem-solving strategies early enough in young children's education. In consequence of current educational practices, Villalobos claims that young girls are being socialized in ways that reinforce algorithimic thinking, placing them at a disadvantage during later mathematical education.

Although the current study did not assess mathematical processes or abilities, it was important to explore boys' and girls' frequencies of engineering thinking play behaviors. Based on studies of engineering thinking play and loose parts (Bairaktarova, 2011; Sutton, 2011), researchers are beginning to understand that mathematics-related education is possible outside of typical classrooms, and that play might reveal new ideas about how boys and girls display early engineering thinking. This study cannot be used to make implications about gender in early mathematics education. However, engineering thinking play in preschoolers is meant to parallel engineering thinking at higher-levels, later in development. It also provides researchers with a tool to observe preschoolers' frequency of engineering play behaviors, many of which include mathematical elements. At the very least, it is important to acknowledge gender in education, in order to make recommendations about future early engineering studies concerning gender. This would be helpful, because future studies may help understand why boys are more likely to choose STEM-related careers. The current study helped move these ideas forward.

In order to better understand the potential educational contribution of a new construct like engineering thinking play, and place it within the context of current research, it is important to review current findings about gender and environmental differences in play. Placing engineering education within the larger context of preschool play will help emphasize both the importance and exploratory nature of this study.

2.7 Gender Differences in Preschool Play

Although there is a continuing debate concerning the relative influences of culture and genetics on gender differences in play, it is acknowledged that boys and girls have different preferences for play activities and materials (Freeman, 2007). It is also acknowledged that social learning theory may help predict some of the gender differences in preschool play. Gender differences in play and toy preference can emerge as early as 13-14 months of age (Jacklin, Maccoby, & Dick, 1975). By 20 months, children's play preferences often align with adult gender-typed preferences (Fein, Johnson, Kosson, Stork, & Wasserman, 1975). By the time children reach preschool (ages 3-to-5), gender preferences for certain types of toys and behaviors are clear. Boys are more likely to play with blocks, transportation toys, and things they can manipulate (Dezouza & Czerniak, 2002). They also display more physical and verbal aggression during play than do girls (Dezouza & Czerniak, 2002). Girls are more likely to play with domestic toys and to fantasize (Dezouza & Czerniak, 2002) and girls' aggression is more relational and is sometimes used to alienate instead of physically harm (Crick & Grotpeter, 1995).

In addition to play preferences, preschool-aged boys’ and girls’ social interaction styles differ on some dimensions. Boys have been shown to display more competitive, goal-oriented styles of interaction, whereas girls display more nurturing and socially proximal activities (Segal, Montie, & Iverson, 2000). Gender differences in social play reveal important differences about social functioning in young children. For instance, girls have been shown to be, in general, more socially competent than boys, while boys are more likely to display problem behaviors and internalizing stressors (Blair et al., 2004). A clearer understanding of powerfully socialized preferences in play may shed light on the origins of important gender-related differences in social functioning as young children develop, as well as the development of career-related choices, such as engineering.

2.8 Gender Differences in Physical Play Across Environments

The importance of play in children's physical development and health has been emphasized by researchers and some government agencies, such as the Center for Disease Control (CDC) and the National Institute of Child Health and Human Development (NICHD) (Iannotti & Wong, 2013). Understanding boys' and girls' differences in physical play preference has implications for the implementation of effective play allocation and free time in preschools. Research has shown that reduced physical activity contributes to childhood obesity in preschoolers (Trost et al., 2003). In a study of 76, four- and five-year old children, only 7% engaged in at least 60 minutes of daily moderate to vigorous physical activity (Cardon & Ils De Bourdeaudhuij, 2008). 60 minutes of moderate to vigorous physical activity has been recommended for preschoolers to reduce obesity (Strong et al., 2005). As such, it is important to explore alternatives for physical play as children are spending more time in classroom settings sitting in front of electronic screens, and less time on playgrounds where physical play is encouraged. A review of preschool-aged boys' and girls' physical play preferences and common physical activities, may help researchers understand how to best allocate playground space and time in order to maximize physical activity and play-related health benefits.

Research suggests that boys typically engage in more gross motor behaviors, such as running, jumping, throwing, and kicking, than do girls. Jackson et al. (2003), showed that boys (ages 3-to-4) physically accelerate more than girls and have higher mean physical activity counts. Additionally, because boys more frequently engage in gross motor play, compared to girls, boys tend to prefer outdoor play more than girls do, as outdoor environments provide more opportunities for large muscle physical play in expansive open spaces (Blanchet-Cohen & Elliot, 2011; Tannock, 2008). As a whole, boys display more physical behaviors and more physically rigorous behaviors than do girls (Jackson et al., 2003). Some of these preferences in physical activity, particularly the predominance of physical activities in boys, have been associated with more outright aggressive natures (Crick & Grotpeter, 1995) and the need to expend energy as a release (Schiller, 1954). Early theorists, such as Schiller (1800) argued that play’s importance rests with energy expenditure. It is possible that the frequency of boys’ physical and verbal aggression manifests in physical play acting as a pressure release valve. This can be seen in boys’ frequent use of dramatic play to act out fighting and dueling outdoors (Campbell & Frost, 1985). Girls, on the other hand, have been observed to be less physical than boys, often manifesting their aggression relationally, instead of physically. At ages 3-to-5, this distinction may not be as important, because relational aggression (i.e., aggression used for the purpose of damaging relationships) is more prevalent when girls are older and have more complex motives (Crick & Grorpeter, 1995). Nevertheless, preschool-aged girls are less physical than boys. For this reason, play may have more implications for girls’ social development than physical development, as girls' may rely more on a kind of social energy expenditure than on physical energy release (Crick & Grotpeter, 1995). Underlying the idea of energy release is the potential that physical play is healthy for young children's cognitive development (Nicolopoulou, 2010), emphasizing another possible reason that physical play with large, loose, parts may be beneficial for preschoolers across multiple domains.

2.9 Gender Differences in Preschoolers' Social Play Across Environments

Play has also been associated with preschoolers' social and emotional well-being. Blair and colleagues (2004) showed that children who play effectively with peers have also been perceived as more socially competent by teachers and peers. Children who are able to effectively manage negative social peer interactions are better able to regulate their emotions (Denham et al., 2002). Social competence also predicts social and academic outcomes, such as school readiness (Carlton & Winsler, 1999) and positive attitudes toward school (Ladd, Birch, & Buhs, 1999). Therefore social play may be similarly important to academic outcomes as is the acquisition of discrete academic skills.

Patterns of social play are considerably more dynamic across gender and environment than physical play, because as a whole, both boys and girls engage in social play frequently (Lindsey & Colwell, 2013). Gender differences in social play are associated with a variety of factors including, socialization by parents and boys' and girls' observed preferences for gender-specific toys and behaviors. Parents often attempt to gender type their children by providing them with toys they deem appropriate for boys and girls, and also with positive or negative reinforcement about specific toys and behaviors (Freeman, 2007). Additionally, there is evidence that some of the differences between boys' and girls' social play exist above and beyond socialization. However, it has been difficult for researchers to isolate genetic links (Frost, 1992). Regardless of etiology, boys' and girls' social play varies significantly.

For instance, dramatic play is different in nature for boys and girls. Girls often prefer dramatic play in proximal and more intimate settings that allow for socializing and nurturance (Frost, 1992). For example, girls prefer playing house and using toys to role-play helping and other prosocial behaviors (Freeman, 2007). Likewise, girls like using symbolic toys, such as dolls in dramatic play (Freeman, 2007). Interestingly, boys also use toys in dramatic play. The use of action figures and toys, such as dinosaurs, superheroes, and play swords is common among preschool boys (Freeman, 2007). However, although boys do engage in dramatic play indoors, it is also common to see boys role-playing outdoors, where they can more easily use gross motor movements in tandem (Campbell & Frost, 1985).

Overall, the gender differences and play environment literatures tell us that boys and girls engage in a wide variety of physical and social play behaviors, and gender-related patterns of play emerge before and during the preschool developmental period. Although boys are more physical and girls are more social, there are some overlapping dynamics, such as the use of dramatic play indoors and outdoors, and the use of similar kinds of symbolic toys. Additionally, it is possible that boys' and girls' physical and social play should be emphasized differently. Boys' increased use of physical play, compared to girls, suggests that maybe boys need more physical outlets than do girls. In contrast, girls' increased social behavior, compared to boys, suggests that social play may be more important for girls than physical play. Nevertheless, physical activity and the development of social competency through play, is important for both boys' and girls' health.

It is clear that physical and social play have implications for preschoolers' health, as well as their ability to interact successfully with other children. It also clear that one must consider both gender and environment when examining preschool play, as boys' and girls' play preference and interaction styles vary across play context. However, the current study’s emphasis on boys’ and girls’ physical and social play is specifically important as a tool for comparison with engineering thinking play. Little is known about preschool boys' and girls' differences in play across multiple contexts, especially in relation to cognitive factors rooted in early engineering thinking play.

2.10 Conclusions and the Present Study

Previous work has highlighted that play is an important and often ignored activity that stimulates young children’s development, physically, socially, and cognitively (Blair et al., 2004; Cardon & Ils De Bourdeaudhuij, 2008). Preschool-aged boys and girls engage in various kinds of physical and social play, often displaying gender-related preferences for play materials and toys, and the potential for both positive and negative outcomes related to frequency of play and types of social interactions (Cardon & Ils De Bourdeaudhuij, 2008; Denham et al., 2002). Play also varies depending on context, with more physical play occurring outdoors, and different social play dynamics happening on the traditional playground and indoors (Campbell & Frost, 1985; Lindsey & Colwell, 2013). Previous studies have also suggested that block play and play with other loose parts stimulate mathematics-related thinking in preschoolers, which may in some cases be equated with basic engineering thinking (Bairaktarova et al., 2011; Caldera et al., 1999; Sutton, 2011). Contemporary theories of intellectual development (Piaget, 1962; Piaget, 1973) and social learning (Bandura, 1962) have lent support to these studies, promoting the idea that preschoolers have curious and active minds, and that children learn through active play, in which they experiment, observe others, and pose questions about their environments. However, more research is needed about preschoolers' physical and social play, particularly in regard to play in different types of environments with new types of engaging play materials. Although research has been done on the value of loose parts play, and on gender differences in play in various environments, little is known about differences in boys' and girls' play across different play contexts, including play with large, loose parts, and especially in relation to the new conception of play that reflects early engineering thinking.

It is also important to consider gender when interpreting results on preschoolers' engineering thinking play, because previous research recognizes early and later developmental differences in boys' and girls' performance in mathematics (Villalobos, 2009). With more data about naturally-occurring early engineering play, it is possible that more can be understood about engineering thinking play and its relation to mathematical learning, especially in regard to gender.

2.11 Research Questions

Given that this study was a descriptive, exploratory investigation, and that little is known about preschool engineering thinking play (Bagiati, 2011; Bagiati & Evangelou, 2011; Bairaktarova et al., 2011; Brophy & Evangelou, 2007), especially in relation to physical and social play, and to play environments, three general research questions and hypothesis were presented:

Question 1. Are there mean differences in boys' and girls' rates of physical, social, and engineering thinking play behaviors per hour?

Hypothesis 1. Boys will be more physically active than girls.

Hypothesis 2. Girls will engage in more social behaviors than boys.

Hypothesis 3. It is unclear whether there will be gender differences in the rate of early engineering thinking play, given the lack of previous research on the construct.

Question 2. Are there mean differences in preschoolers' rates of physical, social, and engineering thinking play behaviors per hour within the three play settings: the traditional playground, the dramatic play area, and in settings with large, manipulable, loose parts?

Hypothesis 1. Rates of physical play will be highest in the traditional playground.

Hypothesis 2. Rates of social play will be highest in the dramatic play area.

Hypothesis 3. Rates of engineering thinking play will be highest in the Imagination Playground™, given the designed purpose of the blocks.

Question 3. Are there any interactions between preschoolers' gender and play environment in their rates of physical, social, and engineering play behaviors per hour?

Hypothesis 1. It is possible that boys' and girls' engagement in various types of play in the Imagination Playground^{TM} setting will be different, compared to the dramatic play area and the traditional playground, given boys' and girls' preferences for different types of play and different toys, especially considering the unique design of the new play material.

CHAPTER 3. METHOD

This study used observational data collected by Professor Jim Elicker and his research team in 2013, funded by the KaBOOM! organization.

3.1 Participants

Sixty eight preschool children (ages 3-to-5) from two classrooms in the Purdue University Miller Child Development Laboratory School (MCDLS) and two classrooms in a local Head Start Center (HS) were observed by two graduate student researchers in three play settings: (1) the Imagination Playground™ (large loose parts); (2) the traditional outdoor playground, and (3) the dramatic play area. Parents were given a written explanation of the study and a detailed consent form. Consent forms translated into Spanish, Chinese, and Korean were made available upon request for families whose primary language was not English. Among families invited to participate, 56% of children in the MCDLS classrooms (10 girls; 20 boys) and 42% of children in the HS classrooms (20 girls; 18 boys) returned signed consent forms from parents agreeing to participate. Two of the original sixty eight children (1 girl, HS; 1 boy, MCDLS) were dropped from the sample, because they were not observed for enough time for inclusion in the study (at least 15 total minutes). Thus, the final sample size was sixty-six (66) preschoolers. Ethnicity and age were not collected on an individual basis. However, the sample was racially diverse, comprised of children from Caucasian, African-American, Asian, and Latino backgrounds. Children in the Head Start program generally came from families whose annual income was below the U.S. Poverty Level. Children in the MCDLS primarily had parents who were university faculty, staff, or students. All children in the sample were taken from preschool classrooms where ages ranged from 3-to-5 years-old.

3.2 Observation Settings

3.2.1 Imagination Playground™

The Imagination Playground™ setting included both indoor and outdoor play activities involving large, light-weight, moveable objects and attachable pieces. Promoted by KaBOOM!, a national non-profit that creates new play opportunities for children, these moveable objects were designed to create a child-centered environment through three core elements: (1) Loose Parts – where children can create something, tear it down, and appreciate shapes and textures. (2) Manipulable Environment – that allows for many types of activities where children can influence the space around them. (3) Play Associates – an open setting where trained adults can provide a secure environment and renew and vary the supply of Loose Parts. Together, these elements attempted to promote strong skills in creativity, communication, and collaboration, as well as provide children with a safe environment in which to physically challenge themselves. This type of enhanced play was meant to facilitate both cognitive and social development, and for the purposes of the current study, early engineering thinking play (KaBOOM!, 2014). The

Imagination Playground™ blocks varied by shape and size: large rectangular blocks, smaller square blocks, blocks with holes in which tubes could be inserted, wheel-shaped pieces, and other cylindrical pieces. The indoor settings were open play areas of a preschool classroom. The outdoor settings were traditional open playground areas. Within the Imagination Playground™ setting, children were asked to play with only the blocks and not to use other toys or playground structures.

3.2.2 Traditional Playground

The traditional playground setting was outdoors and included fixed structures, such as slides, ladders, swings, playhouses, and sandboxes. Some moveable play materials were also available including playhouse toys, buckets, bicycles, scooters, and wagons. Children were allowed to roam the traditional playground freely, and researchers observed each child's play, regardless of which material or structure the child chose to use. In the current study, it was possible that because loose parts were available to children on the traditional playground, that object manipulation physical play, as well as gross and fine motor skills, were more prevalent in the traditional playground. However, traditional playgrounds usually include some of these materials, so the presence of loose parts was not seen as unusual.

3.2.3 Dramatic Play

The dramatic play area was indoors in each classroom and included an assortment of toys, action-figures and dolls, cooking and household toys, and writing and drawing materials. Prominent themes included a kitchen area, some small furniture, a table, and an assortment of smaller toys children could use. On the table there was often paper, markers, crayons, other art-related utensils. The dramatic play areas were separate areas in the larger preschool classroom that usually had cubbies or smaller walls around them to create different sections within the room. In the MCDLS, weekly themes were chosen for the play materials available for children in the dramatic play area, so some of the objects for pretending changed weekly. Themes could include dinosaurs, house, superheroes, or farm animals, among others. In the HS, themes did not change on a weekly basis. However, some HS classrooms added new play materials a few times during the entire data collection period.

3.3 Observation Procedure

Two graduate student research assistants visited each preschool classroom on a regular weekly schedule, in order to observe all participating children engaged in free play in the three play settings. The observers did not collect data together and were on difference schedules. During each observation session, the observer focused on one child at a time in one play setting and documented all of the social, physical, and engineering play behaviors the child displayed. The teachers and students in the classrooms were familiar with the data collectors, and data collectors were allowed to sit quietly in a corner or non-intrusive location. Each child was observed in each of the three play settings, one setting at a time. However it was not always possible for the data collectors to observe a child in all three play settings during the same visit to the preschool. In some cases, more than one visit was required to observe one child's play in each of the three play settings. Observation intervals were 20 seconds: the observer watched the child carefully for 20 seconds, then used 20 seconds to note all behavior categories that occurred during that interval on a checklist. The checklist included 21 social behaviors, 30 physical behaviors, and 9 early engineering thinking play behaviors derived from valid and reliable coding schemes (See Appendix for the complete observation instrument). Each behavior was coded during each interval as 1 = present, or 0 = absent (i.e. if a behavior was observed at least one time in a given interval, it was given a check mark. If it was not observed at all, it was left blank). It was possible, for instance, that a child could kick 10 times during one 20 second interval, and for that interval, kicking would receive one check mark. The observers watched a child for as many intervals as possible during one observation session, until the child stopped playing in the target play area. In other words, the observer watched a single child for as long as the child engaged in play in one play setting before leaving that setting. For example, in some cases, an unengaged child decided to leave the dramatic play area, in which case that child was observed in that setting either later in the day, or during a separate visit, in order to obtain the minimum number of intervals for inclusion in the study. If a child stopped playing in one of the play settings, the researchers often began coding a different child, gathering as many intervals on the different child as possible during that observation visit. Some of the data on certain children were collected over the course of several visits in order to observe those children for the target number of minutes. The target number of minutes for inclusion in the sample was 15 minutes (i.e., 45 intervals). However, it was not required that a child had to play in each play setting for an equal number of intervals. The total observation time was spread over 3 ½ months, ranging from 15-to-41 minutes (*M* =

24) of observation for each child (See Table 1. for descriptive statistics on the number of minutes observed by gender, school, and play setting). Since the number of minutes each child was observed in each play setting varied, each child's of rate of play was calculated (the number of times each behavior was observed per hour), rather than total frequency of behaviors. The presence of each of the 60 behaviors in each interval was summed to produce a total number of behaviors score for each child. Sums were then converted to mean rates per hour for each child, depending on the total number of minutes the child was observed. Means rates per hour were calculated for each of the 60 play behaviors.

3.4 Observation Measures and Reliability

Structured observation measures were used to provide comprehensive descriptions of children's play behaviors in three domains: social play, physical play, and early engineering thinking play. Observation measures were either derived from instruments successfully used in previous studies or adapted from widely researched topics that have not been previously used in measures. Two observers were trained on each of three observation measures using both filmed and live practice observations and demonstrated a high degree of reliability on each observation instrument before data were collected. Reliability for each of the three variable groups was established separately, prior to the data collection period. The two observers achieved agreement with Cohen's Kappa values of at least .70 (*range* = .71-1.00) on each of the physical, social, and engineering variable groups. In order for the observers to be considered reliable they had to achieve a minimum Cohen’s Kappa of .70 on each of the variable groups for 10 intervals, 5 consecutive times in each observation setting. For instance, the two observers were said to be reliable in coding physical behaviors on the traditional playground, when they achieved a .70 Kappa over 10 intervals of coding. However, they needed to reach a .70 Kappa for 10 intervals 5 times in-a-row, before they were said to have achieved reliability. This process was done for physical behaviors, social behaviors, and engineering play behaviors in each of the three settings until reliability was established for all groups in all settings. In total, the reliability check assessed 297 intervals. Reliability for these measures was achieved in the following order: physical play, social play and early engineering thinking play. Reliability checks were not done during the actual data collection period. However, the two researchers achieved reliability over the course of 2 ½ months, and the total data collection period was 3 ½ months, immediately after reliability was reached.

3.5 Social Play

Categories for social play were derived from Denham and colleagues' observation instrument for measuring preschoolers' social-emotional behaviors (Denham, Bassett, Thayer, Mincic, Sirotkin, & Zinsser, 2012). Denham and colleagues' observation instrument was adapted and shortened from the Minnesota Preschool Affect Checklist (MPAC) (Sroufe, Schork, Motti, Lawroski, & LaFreniere, 1984). Concurrent validity for this measure was established with versions of the MPAC in two studies (Denham, Zahn-Waxler, Cummings, & Iannotti, 1991; Sroufe et al., 1984). Denham and Burton (1996) established inter-rater reliability for the MPAC-R (revised) measure with intraclass correlations > .84, *ps* < .001 (Denham & Burton, 1996).

Two main social play categories were included in the current study: 11 categories of positive, competent play with other children (for example: takes turns, cooperates, and shares) and 10 types of negative, less competent play (for example: hits, shoves, knocks over, throws objects, or displays interpersonal aggression; Denham et al., 2012). For each child, summary scores for each social behavior were calculated indicating the average number of behaviors that occurred per hour.

3.6 Physical Play

Categories for physical play were adapted from Gallahue and Ozmun's descriptions of motor activities in young children (Gallahue and Ozmun, 2006). Physical behaviors were divided into two categories: gross motor movement (27 behaviors, e.g., running, jumping, walking, and kicking) and fine motor movement (3 behaviors, e.g., manipulates small object, drawing/painting, writing). Summary scores for each of the 30 physical behaviors for each child were calculated, indicating the average number of behaviors per hour.

3.7 Early Engineering Thinking Play

Play behaviors consistent with children's engineering thinking design processes were observed using a nine-category system developed by Bairaktarova and colleagues (Bairaktarova et al., 2011). Categories included: communicates goals (Child says, "Let's build a caste, OK?"), generating design and construction ideas (Child says, "I think we should put the big block on top."), problem solving/replication (Child says, "I think the little block is better than the big block for that.”), expresses creative/innovation ideas (Child says, “I think we should build the castle upside-down. That would be cool!”), solution testing/evaluation design (Child climbs stairs he/she has just built to see if they actually work like stairs), explanation of how things are built/work (Child says, “Look, I have just made a castle by putting the smaller blocks on top of the bigger ones”), following patterns and prototypes (Child says, “My dad showed me how to make a castle at home. Let’s build one using these blocks. I already know how.”), logical mathematical thinking (Child says, there are three castles on our playground. Look how many there are!”), and use of technical vocabulary (Child describes his/her castle as having many *sections* or *stacked* parts). Inter-observer agreement for this measure was established by four researchers who coded 33% of video tapes used in their study with 95% agreement. Since engineering design processes in play had not been studied until the creation of this instrument, face validity was used to match constructs with observed play behaviors. Summary scores for each engineering behavior category for each child were calculated, indicating the average number per hour.

CHAPTER 4. ANALYTIC PLAN

First, data reduction was necessary in order to avoid type I error, as 60 total play behaviors were observed. Including this many dependent variables in the analytic model would have been problematic because it is likely some statistical significance would be found by chance at the .05 level. Typically, an exploratory factor analysis would be used to reduce this data in order to create meaningful groups (factors) of related play behaviors and eliminate behaviors that are unimportant (Thompson, 2004). However, the current study did not meet the recommended minimum number of cases (e.g., 100-200) in order to use exploratory factor analysis, as 66 children were included in the analytic model.

As such, data reduction consisted of a more conceptual form. Previous research on play shows that certain types of play behaviors often occur together such as gross motor behaviors (e.g., kicking, running, jumping, throwing, catching) and positive social behaviors (e.g., sharing, cooperation) (Blanchet-Cohen & Elliot, 2011; Campbell & Frost, 1985). It is also likely that children engage in certain types of play behaviors inversely with other types of play behaviors (e.g., positive social play vs. negative social play) and so these behaviors should be separated from one another. For these reasons, conceptual groups of observation categories were created as a heuristic strategy in order to describe the frequencies of several broad types of play behaviors, in a summative matter. This was done to avoid using multiple statistical tests of group mean differences. A combination of descriptive statistics and conceptual knowledge derived from previous authors' research, was used in order to form groups comprised of behaviors that were most correlated with one another. This method of data reduction was viewed as satisfactory, since this is an exploratory analysis, to discover basic broad patterns, which can be explored in more detail in future studies.

This process led to the creation of 7 conceptual groups of play behaviors that were used as the dependent variables in each analytic model: (1) Engineering Thinking Play (9 of 9 variables were included). (2) Positive Social Play (9 of 11 variables were included). *Plays with a child of special needs* was removed (M = 0). *Engages in independent activity* was used as a separate dependent variable because it had the highest rate per hour of any play behavior, and it was conceptually different than the other social play behaviors. (3) Negative Social Play (10 of 10 variables were included). (4) Engages in Independent activity. (5) Fine Motor Play (3 of 3 variables were included). (6) Gross Motor Locomotor/Stability Play, conceptualized as gross motor physical play that included whole body movement not associated with manipulating an object. This group was created by combining the Locomotor and Stability categories on the observation instrument (12 of 12 variables were included). (7) Gross Motor Object Manipulation Play, conceptualized as gross motor physical play that involved manipulating or playing with an object (14 of 15 variables were included). Excluded from this group was *Riding a bike or scooter* due to a data collection error limited to this one variable.

Each conceptual group's play behaviors consist of mean rates per hour of each play behavior. In order to quantify each group as a meaningful set of related variables, play behaviors' mean rates per hour were summed to produce a total mean rate of play per hour score. These sums were used during analyses. Intercorrelations of the groups were tested for mutual exclusivity.

After data reduction, 7 statistical models were tested using 2 (gender: boy vs. girl) X 3 (play setting: traditional playground vs. dramatic play area vs. Imagination Playground™) repeated measures analyses of variance (ANOVA). The child's gender served as the between subjects-factor, while play setting served as the within-subjects factor for each of the seven statistical models. Each of the seven conceptual groups, developed during data reduction, was used as a dependent variable in one repeated measures ANOVA. Main effects of gender and play setting, and interactions between gender and play setting, were found to be significant if *p*-values were less than .05.

In order to parse out significant mean differences in the 3-level within-subjects play setting variable, a post hoc test was required for each repeated measures ANOVA. A Bonferroni correction was used as the most conservative method to control for family-wise error-rate, providing SPSS outputs for pair-wise comparisons for the play setting variable. Since post hoc tests are not used to interpret significant interactions in repeated measures ANOVA, confidence intervals were used to interpret any significant interactions. If confidence intervals in an interaction do not overlap for boys and girls within one play setting, then that portion of the interaction is significant. If confidence intervals for boys and girls within one play setting overlap, then that portion of the interaction is not significant (Loftus & Masson, 1994). For each of the seven statistical models repeated measures ANOVAs, three research questions were asked, along with some general hypotheses.

Question 1. Are there mean differences in boys' and girls' rates of physical, social, and engineering thinking play behaviors per hour?

Hypothesis 1. Boys will be more physically active than girls.

Hypothesis 2. Girls will engage in more social behaviors than boys.

Hypothesis 3. It is unclear whether there will be gender differences in the rate of early engineering thinking play, given the lack of previous research on the construct.

Question 2. Are there mean differences in preschoolers' rates of physical, social, and engineering thinking play behaviors per hour within the three play settings: the traditional playground, the dramatic play area, and in settings with large, manipulable, loose parts?

Hypothesis 1. Rates of physical play will be highest in the traditional playground.

Hypothesis 2. Rates of social play will be highest in the dramatic play area.

Hypothesis 3. Rates of engineering thinking play will be highest in the Imagination Playground™, given the designed purpose of the blocks.

Question 3. Are there any interactions between preschoolers' gender and play environment in their rates of physical, social, and engineering play behaviors per hour?

Hypothesis 1. It is possible that boys' and girls' engagement in various types of play in the Imagination Playground^{TM} setting will be different, compared to the dramatic play area and the traditional playground, given boys' and girls' preferences for different types of play and different toys, especially considering the unique design of the new play material.

CHAPTER 5. RESULTS

5.1 Conceptual Group Intercorrelations

There were several conceptual groups that were significantly correlated. Engineering thinking play behaviors were significantly positively correlated with engagement in independent activity, $r = .25$, $p < .05$. Engineering thinking play behaviors were significantly positively correlated with fine motor physical behaviors, $r = .41$, $p < .01$. Positive social play behaviors were significantly negatively correlated with engagement in independent activity, $r = -.45$, $p < .01$. Negative social play behaviors were significantly negatively correlated with gross motor object manipulation play, $r = -.25$, $p < .05$. Engagement in independent activity was significantly positively correlated with fine motor physical behaviors, $r = .29$, $p < .05$. Gross motor locomotor/stability play were significantly positively correlated with gross motor object manipulation play, $r = .48$, $p = .01$ (See Table 2.).

5.2 RM ANOVA 1. Engineering Thinking Play

For this analysis, the Huynh-Feldt-Lecoutre Epsilon was .99, meeting the critical value to ensure the assumption of sphericity was met. Analyses revealed a significant main effect of play setting, in which engineering thinking play occurred most in the Imagination Playground^{TM} (IP), second most in the dramatic play area (DP), and least in the traditional playground (TP), $F(2, 128) = 44.52$, $p < .001$, $\eta_p^2 = .410$; IP, $M = 70.98$, $SD = 38.65$; DP, $M = 49.86$, $SD = 36.77$; TP, $M = 16.46$, $SD = 29.37$. Post hoc tests revealed that each play setting was significantly different from each other play setting; IP vs. DP, $p < .01$; IP vs. TP, $p < .001$; DP vs. TP, $p < .001$. The main effect of gender was not significant. The play setting X gender interaction was not significant (see Figure 1.).

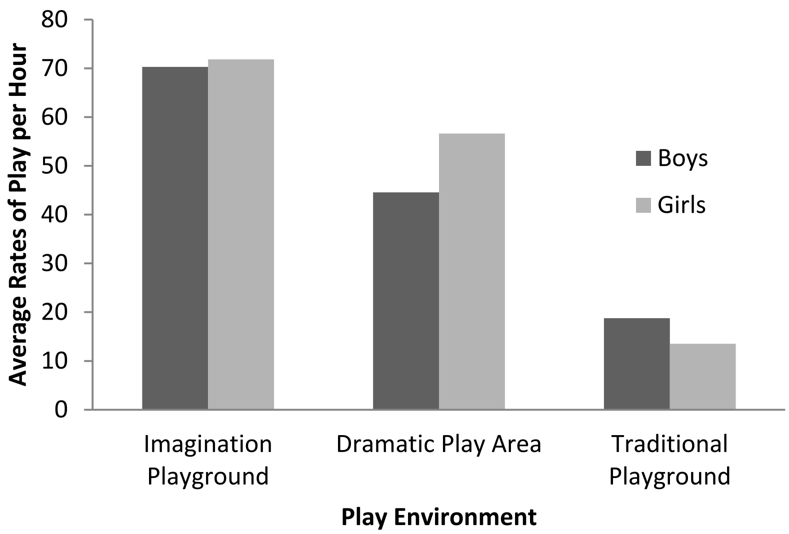

Figure 1. Average Mean Rates per Hour of Engineering Play Behavior by Gender and Play Environment.

5.3 <u>RM ANOVA 2. Positive Social Play</u>

For this analysis, the Huynh-Feldt-Lecoutre Epsilon was .98, meeting the critical value to ensure the assumption of sphericity was met. Analyses revealed a marginal main effect of play setting, in which positive social play occurred most in the TP, second most in the DP, and fewest in the IP, $F(2, 128) = 2.60$, $p < .10$, $\eta_p^2 = .091$; IP, $M = 69.27$, $SD =$

41.64; DP, M = 74.31, SD = 49.72; TP, M = 85.72, SD = 54.27. Post hoc tests revealed that the only significant play setting difference was between the IP and the DP, $p < .05$. There was also a marginal main effect of gender, in which girls engaged in more positive social behaviors than did boys, $F(1, 64) = 3.59$, $p < .10$, $\eta_p^2 = .053$; boys, M = 69.76, SD = 47.69; girls, M = 84.95, SD = 48.80. The play setting X gender interaction was not significant (see Figure 2.).

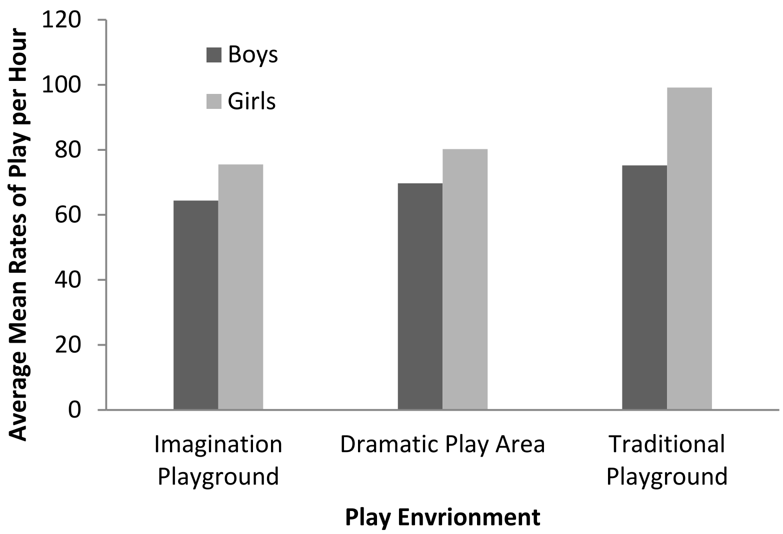

Figure 2. Average Mean Rates per Hour of Positive Social Play Behavior by Gender and Play Environment.

5.4 RM ANOVA 3. Negative Social Play

For this analysis, the Huynh-Feldt-Lecoutre Epsilon was .94, meeting the critical value to ensure the assumption of sphericity was met. Analyses revealed no significant main effects or interactions for negative social play.

5.5 RM ANOVA 4. Engages in Independent Activity

For this analysis, the Huynh-Feldt-Lecoutre Epsilon was .91, meeting the critical value to ensure the assumption of sphericity was met. Analyses revealed a significant main effect of play setting, in which children engaged in the highest frequency of independent play in the IP, second most in the DP, and fewest in the TP, $F(2, 128) = 5.41$, $p < .01$, $\eta_p^2 = .078$; IP, $M = 93.56$, $SD = 42.61$; DP, $M = 92.97$, $SD = 48.00$; TP, $M = 73.08$, $SD = 43.63$. Post hoc tests revealed that significant play setting differences between the TP and each of the other two settings. However, the IP and DP means did not significantly differ, IP vs. TP, $p < .001$; DP vs. TP, $p < .05$. The main effect of gender was not significant. The play setting X gender interaction was not significant (see Figure 3.).

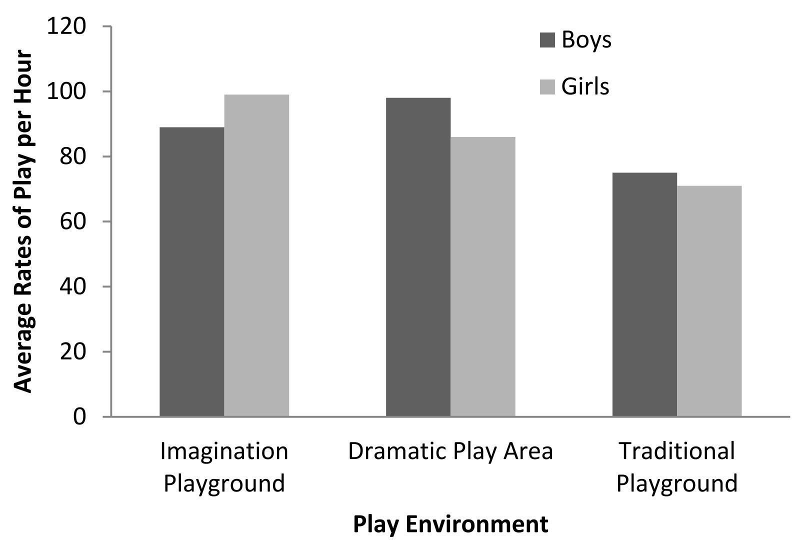

Figure 3. Average Mean Rates per Hour of Engagement in Independent Activity by Gender and Play Environment.

5.6 RM ANOVA 5. Fine Motor Play

For this analysis, the Huynh-Feldt-Lecoutre Epsilon was 1.00, meeting the critical value to ensure the assumption of sphericity was met. Analyses revealed a significant main effect of play setting, in which children engaged in the highest frequency of fine motor play in the DP, second most in the IP, and fewest in the TP, $F(2, 128) = 166.45$, $p < .001$, $\eta_p^2 = .722$; IP, $M = 49.95$, $SD = 34.68$; DP, $M = 130.61$, $SD = 31.79$; TP, $M = 33.84$, $SD = 32.27$. Post hoc tests revealed that each play setting was significantly different from each other play setting; IP vs. DP, $p < .001$; IP vs. TP, $p < .05$; DP vs. TP, $p < .001$. The main effect of gender was not significant. The play setting X gender interaction was not significant (see Figure 4.).

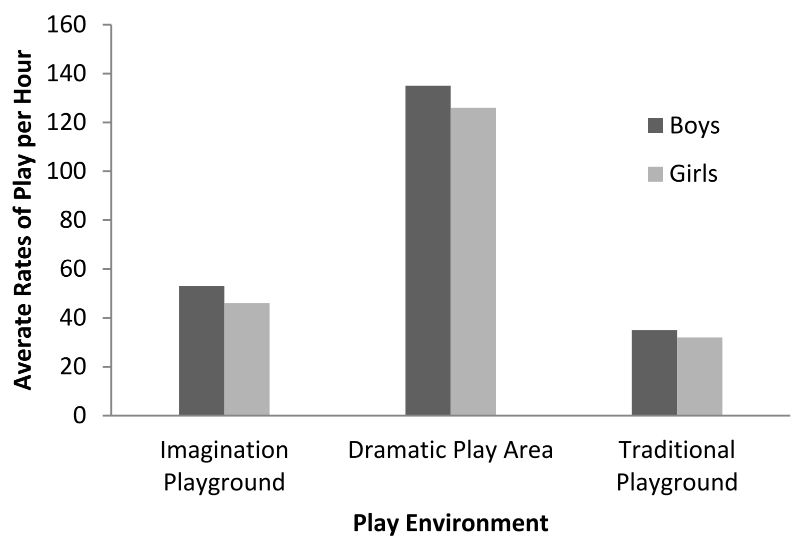

Figure 4. Average Mean Rates per Hour of Fine Motor Play by Gender and Play Environment.

5.7 RM ANOVA 6. Gross Motor Locomotor and Stability Play

For this analysis, the Huynh-Feldt-Lecoutre Epsilon was .99, meeting the critical value to ensure the assumption of sphericity was met. Analyses revealed a significant main effect of play setting, in which children engaged in the highest frequency of gross motor locomotor and stability play in the TP, second most in the IP, and fewest in the DP, $F(2, 128) = 59.93$, $p < .001$, $\eta_p^2 = .484$; IP, $M = 235.61$, $SD = 94.51$; DP, $M = 96.76$, $SD = 57.95$; TP, $M = 237.46$, $SD = 105.43$. Post hoc tests revealed that the IP setting and the TP setting were both significantly different from the DP setting. However, the IP and the TP were not significantly different; IP vs. DP, $p < .001$; DP vs. TP, $p < .001$. The main effect of gender was not significant. The play setting X gender interaction was not significant (see Figure 5.).

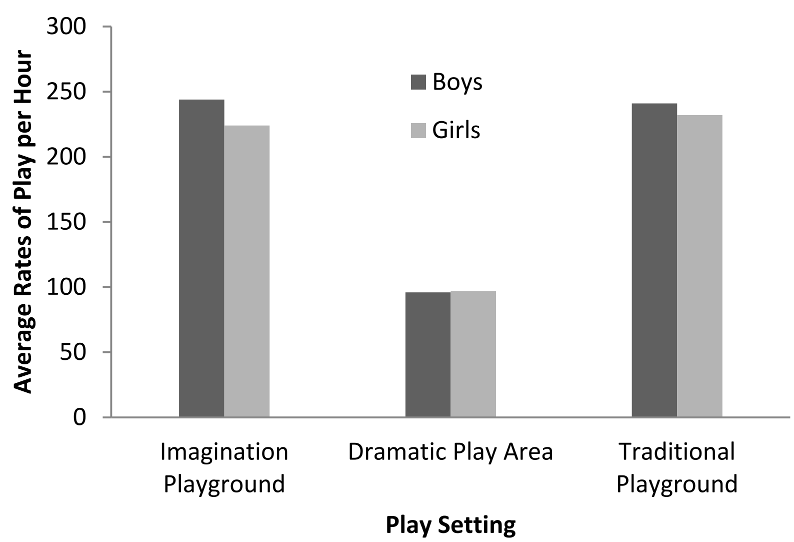

Figure 5. Average Mean Rates per Hour of Gross Motor Locomotor and Stability Play by Gender and Play Environment.

5.8 RM ANOVA 7. Gross Motor Object Manipulation Play

For this analysis, the Huynh-Feldt-Lecoutre Epsilon was 1.00, meeting the critical value to ensure the assumption of sphericity was met. Analyses revealed a significant main effect of play setting, in which children engaged in the highest frequency of gross motor object manipulation play in the IP, second most in the DP, and fewest in the TP, $F(2, 128) = 49.01$, $p < .001$, $\eta_p^2 = .434$; IP, $M = 148.12$, $SD = 71.01$; DP, $M = 89.15$, $SD = 48.94$; TP, $M = 56.06$, $SD = 49.38$. Post hoc tests revealed that each play setting was significantly different from each other play setting; IP vs. DP, $p < .001$; IP vs. TP, $p < .001$; DP vs. TP, $p < .001$. The was also a main effect of gender, in which boys engaged in more gross motor object manipulation play than did girls, $F(1, 64) = 26.12$, $p < .001$, $\eta_p^2 = .290$; boys, $M = 115.52$, $SD = 57.19$; girls, $M = 75.16$, $SD = 46.08$. Finally, there was a significant play setting X gender interaction, in which boys engaged in more gross motor object manipulation play than did girls, within the IP setting. However, there was no gender difference in gross motor object manipulation play in the DP or the TP settings, $F(2, 128) = 3.39$, $p < .05$, $\eta_p^2 = .050$; IP-boys, $M = 177.85$, $SD = 69.74$; IP-girls, $M = 110.20$, $SD = 52.87$; DP-boys, $M = 99.50$, $SD = 48.03$; DP-girls, $M = 75.94$, $SD = 47.66$; TP-boys, $M = 60.20$, $SD = 53.81$; TP-girls, $M = 39.35$, $SD = 37.70$ (see Figure 6.).

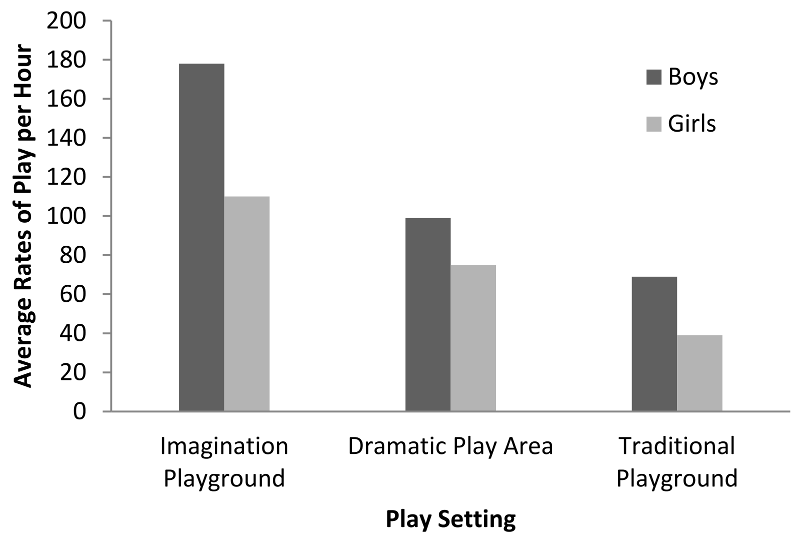

Figure 6. Average Mean Rates per Hour of Gross Motor Object Manipulation Play by Gender and Play Environment.

CHAPTER 6. DISCUSSION

Results in the current study support many of the previous findings about differences in preschool boys' and girls' physical and social play, and also lend support to the notion of free play as undervalued during early childhood exploration, interaction, and learning. Implications can be made about the importance of play as a physical outlet and a means for positive peer social interaction. There were several intriguing play setting effects, some gender effects, and one interesting play setting X gender interaction. However, the most unique core finding of this study pertains to engineering thinking play, particularly during children's play with the Imagination Playground™ blocks, considering both boys' and girls' prevalent display of engineering thinking play.

6.1 Conceptual Group Intercorrelations

Based on the co-occurrence of many of the play behaviors in this study, it was expected that several of the conceptual groups would be significantly correlated. It made sense that engineering thinking play would be positively correlated with engagement in independent activity due to the amount of time children spent engaging in solitary play during play with the Imagination Playground™ blocks. The same can be said about the positive correlation between engineering thinking play and fine motor play, because fine motor play occurred frequently during play with the Imagination Playground™ blocks, which also elicited the highest rate per hour of engineering thinking play. Positive social play was negatively correlated with engagement in independent activities. This made sense, given that positive social play depends on cooperative play with other children. Gross motor object manipulation play was negatively correlated with negative social play. Although there were no significant effects for negative social play, it is possible that gross motor object manipulation play had a less negative affect during play with other children. Engagement in independent activity was positively correlated with fine motor play. This was expected, as fine motor play occurred most often in the dramatic play area, and many of the writing and drawing activities in this play setting may have occurred alone. Finally, gross motor locomotor/stability play and gross motor object manipulation were positively correlated. This was also expected, given that these two groups were both comprised of gross motor physical play.

6.2 Engineering Thinking Play Effects

The most interesting finding of this study was that no significant difference was found between boys' and girls' use of engineering thinking play behaviors. Although the mean difference was non-significant, girls' mean for engineering thinking play was actually slightly higher than boys' mean (girls, $M = 47.34$; boys, $M = 44.54$). Due to the exploratory nature of the study, it is not possible to draw overly bold conclusions from this finding. The study did not examine processes or mechanisms, but rather was meant to describe preschoolers' overall use of engineering thinking play behaviors. Nevertheless, this finding suggests that future research is necessary in order to explore gender in early childhood education, especially in regard to early engineering thinking and the possibility that it includes some mathematical-related concepts. In this regard, Villalobos' (2009) argument that during early childhood, girls may be as capable of demonstrating similar problem-solving abilities as boys, is important to consider in early engineering thinking research, because problem-solving is a part of engineering thinking and could be related to some basic mathematics skills.

Additionally, this finding indicates that encouraging play with the Imagination Playground™ blocks, and potentially other cognitively stimulating play materials, is useful in eliciting engineering play behaviors in both boys and girls. In this regard, questions should be asked in future research about girls' ability to generate ideas, construct, and problem-solve, and evaluate. This finding supports more research exploring early childhood education through play, and the possibility that early education may impact girls' decisions about STEM education and careers later in life.

Regardless of gender, engineering thinking play was significantly different by play setting. Play with the Imagination Playground™ blocks elicited more engineering thinking play behaviors than the dramatic play area and the traditional playground settings. The effect size for this result was rather large. Results indicated that play setting accounted for 41% of variance associated with engineering thinking play, controlling for gender. This suggested that the Imagination Playground™ blocks were successful tools for eliciting preschoolers' engineering thinking play. This finding provided credence to the idea that free play with engaging manipulable materials can be used as an educational tool, providing opportunities for different kinds of thinking than might appear during other types of play or classroom instruction. However, additional research is needed exploring the processes behind engineering thinking, above and beyond the presence or absence of engineering thinking play behaviors. Particularly, it is important to explore to possible connection of engineering thinking with mathematical abilities, as well as the mechanisms that drive engineering thinking, and the language children are using during engineering thinking play. Additionally, it would be beneficial to examine the frequency of different types of early engineering play behaviors, as opposed to the current composite variable, comprised of 9 behaviors. This may allow researchers to examine possible differences in the types of engineering thinking play behaviors in which boys and girls are engaging.

6.3 Social Play

This study found one significant main effect and two marginally significant main effects in preschoolers' use of social play behaviors. Although two of the effects were marginal, it is important to consider the exploratory nature of the study and evaluate these effects as potentially important, requiring further investigation. There was a marginal gender effect of positive social play, in which girls engaged in more positive social play than did boys. Gender accounted for 6.3% of variance in positive social play, controlling for play setting, which is a medium effect size. This result is not surprising, given previous findings about girls' frequency of social play, nurturing interaction styles, and social competencies compared to boys (Blair et al., 2004).

There was also a marginally-significant play setting effect of positive social play, in which the traditional playground was shown to elicit significantly more positive social play behaviors than the Imagination Playground™. The effect size for this result was moderate. 7.8% of variance in positive social play was accounted for by play setting, controlling for gender. This effect is surprising from one perspective, as one might expect that the Imagination Playground™ blocks would promote the kinds of positive social behaviors associated with cooperation, taking turns, sharing, and other behaviors that contribute to teamwork as children are engaging in engineering play behaviors. However, children did engage in frequent positive social play behaviors in both the traditional playground and the Imagination Playground™ settings (Imagination Playground™, M = 69.27; traditional playground, M = 85.72). The distinction in this finding was that more positive social play behaviors occurred in the traditional playground.

One possible explanation for this finding was that there was also a significant main effect for play setting in children's engagement in independent play activity. Children in both the Imagination Playground™ setting and the dramatic play area spent a significant amount of time engaging in independent activity, compared with the traditional playground setting. The effect size for this result was medium. 7.8% of the variance in engagement in independent activity was accounted for by play setting, controlling for gender. This result qualified the play setting effect for positive social play, because it suggested that children were not necessarily less positive in the Imagination Playground™ setting compared to the traditional playground. They simply spent more time engaging in solitary play with the Imagination Playground™ blocks compared to play in the traditional playground. This made sense, given the observers' anecdotal observations of children frequently constructing with the Imagination Playground™ blocks alone. However, the higher degree of solitary play in the Imagination Playground™ setting did not necessarily suggest that play with the blocks was any less cognitively stimulating. Engineering thinking play overall, was significantly more common in the Imagination Playground^{TM} setting than in any other setting. Instead, it was possible that many of the cognitive benefits of engagement in play with these materials simply happened during solitary play.

Finally, there were no significant effects for gender or play setting when exploring negative social play. Unlike previous research (Blair et al., 2004), the current study did not find boys to be more socially negative than girls. Negative social behavior occurred with low frequency in all three of the play settings observed, likely accounting for the absence of any gender effects.

The social play results confirmed some of the previous findings about the prevalence of positive social play in girls. Yet, these findings also helped elucidate the kinds of play naturally elicited by the Imagination Playground^{TM} blocks. Positive social play did occur frequently during play with the blocks. However, our findings showed that much of the time children spent with these engaging materials was solitary. Despite the amount of solitary play that occurred with the Imagination Playground^{TM} blocks, children were still engaging in high levels of engineering thinking play during those times. This suggested that the cognitive benefits of engaging play materials were not necessarily dependent on interactions with other children. Furthermore, it suggested that encouragement of positive social play may be required of teachers more in some play settings than in others. This study did not observe the types and amounts of teacher intervention in children’s play. However, teachers were generally encouraged to take a hands-off approach, allowing children to play freely, intervening only when it was apparent that children needed guidance.

6.4 Physical Play

In this study, results for physical play behaviors were interesting because they drew attention to the interaction between gender and play setting in ways previous research did not. There were three significant play setting main effects, one significant main effect of gender, one important non-significant main effect of gender, and a qualifying interaction between play setting and gender.

First, there was a significant main effect of play setting, in which children engaged in more gross motor locomotor and stability play in the Imagination Playground™ and traditional playground settings than in the dramatic play area. Play setting accounted for 48% of the variance in gross motor locomotor and stability play, controlling for gender. Specifically, this effect was important because the difference in gross motor locomotor and stability play was between the Imagination Playground™ setting and the dramatic play area, and the traditional playground and the dramatic play area. There was no significant difference between gross motor locomotor and stability play in the Imagination Playground™ setting and the traditional playground setting. This was important because it suggested that play with large, manipulable, loose parts elicited the same frequencies in occurrence of large muscle motor-type play as did play in the traditional playground, where children were often given expansive open spaces to run and move. It is important to note that this type of play was conceptualized as play that did not involve manipulating objects. Therefore, none of these play behaviors observed in the Imagination Playground™ setting involved manipulating or moving the play materials. They only involved climbing, crawling, or other non-manipulative methods of using the blocks. This means that when children were engaged in play in the Imagination

Playground™ setting, they engaged in just as much running, walking, jumping, leaping, and other such body movement behaviors as they did in the traditional playground setting.

Additionally, there was no significant gender effect in gross motor locomotor and stability play across play settings. This contrasts with previous findings about boys engaging in more gross motor behaviors than do girls (Jackson et al., 2003). However, there was a significant main effect of gender for gross motor object manipulation play, in which boys engaged in more gross motor object manipulation than did girls. Gender accounted for 29% of the variance in gross motor object manipulation play, controlling for play setting. There was also a significant main effect of play setting for gross motor object manipulation play, in which children engaged in more gross motor object manipulation in the Imagination Playground™ setting, followed by the dramatic play area, and finally the traditional playground. Play setting accounted for 43% of the variance in gross motor object manipulation play, controlling for gender.

Given the Imagination Playground™ blocks' intended purpose of eliciting constructive, physically-active play, in addition to the cognitive benefits, it is not surprising that children manipulated more objects during play in this setting than either the dramatic play area or the traditional playground. These main effects were qualified, however, by a significant play setting X gender interaction, in which gender differences in gross motor object manipulation play were only significant during play in the Imagination Playground™ setting. This means that boys and girls engaged in similar gross motor object manipulation in the dramatic play area and the traditional playground. However, the presence of large, manipulable, loose parts, contributed to boys' more frequent gross motor object manipulation behaviors, compared to girls.

It is possible that this gender effect was only present in the Imagination Playground™ setting, because the blocks elicited different types of physical behaviors in boys and girls. It is possible that both boys and girls climbed, jumped, slid, or crawled on or from the blocks fairly frequently. However, boys' engagement with the blocks may have involved more carrying, stacking, throwing, swinging, or other object-related gross motor movements, that are often associated with boys more than girls. However, further exploration of boys' and girls' frequency of individual play behaviors would be necessary to support this possibility. It is also possible that this finding can be attributed to the size of the blocks. Although the blocks are light-weight and fairly easy for any preschooler to maneuver, it is possible that boys felt more comfortable lifting the blocks and manipulating them than did girls.

Finally, there was a significant main effect of play setting, in which children engaged in the most fine motor play behaviors in the dramatic play area, seconded by the Imagination Playground™ setting, followed by the traditional playground. It was expected that fine motor play behaviors would occur most frequently in the dramatic play area, because this was the only setting in which children were given the opportunity to write, paint, or draw. However, this effect was also interesting because it showed that more fine motor play occurred in the Imagination Playground™ setting than in the traditional playground. In other words, it is important to note that play with large, manipulable, loose parts, was not limited to gross motor play behaviors. Children engaged in an average rate of about 50 fine motor play behaviors per hour during play with the Imagination Playground™ materials, as compared to about 130 per hour in the dramatic play area, and about 35 per hour in the traditional playground.

6.5 Conclusions

The results of this study suggested that some overall differences exist in boys' and girls' physical and social play, as observed in three preschool play settings. In line with previous research, girls engaged in more positive social play than did boys. Boys engaged in more gross motor object manipulation play than did girls. In contrast, we found no evidence of gender differences in gross motor locomotor and stability play or in fine motor play across these settings, which challenges some previous conclusions about gender-related play differences (Jackson et al., 2003). There were also some interesting play setting effects. There was no difference in gross motor locomotor/stability play between the Imagination Playground™ and the traditional playground, a somewhat surprising finding, since the traditional playground was specifically designed to encourage this type of play, whereas the Imagination Playground™ was designed to encourage a wide variety of play behaviors in addition to gross motor play. Additionally, solitary play was observed most often in the Imagination Playground™ setting, suggesting that at least in the early stages of play with these large, loose parts, children often choose to play alone with them. On average, children engaged in independent activity about 95 times per hour, compared to about 70 instances of positive social play, in the Imagination Playground™ setting. Both kinds of gross motor play behaviors and fine motor play behaviors occurred frequently in the Imagination Playground™ setting. Moreover, some positive social play was also observed in the Imagination Playground™ setting.

Most importantly, children engaged in the most engineering thinking play within the Imagination Playground™ setting, and no gender difference was observed in the overall frequency of boys' and girls' engineering thinking play. This result supports the need for further research on gender in early education, specifically related to early engineering thinking and the possible relation of loose parts play to children's understanding of basic mathematical principles. Additionally, results specifically supported the use of engaging play materials and loose parts play as elicitors of physical, social, and engineering thinking play. The use of these blocks for multiple health- and academic-related purposes provides possibilities for teaching strategies or play facilitation that recognizes the use of several kinds of play behaviors in a single activity. For example, teachers may encourage girls to be more social while constructing with the Imagination Playground™ blocks. They may also encourage boys to be more physical during play with the blocks.

Finally, an important aspect of play with the Imagination Playground™ blocks that should be considered, are the social aspects and academic affordances of participating in play with engaging play materials. The current study showed that children spend much time playing with the Imagination Playground™ blocks alone. However, there was frequent use of positive social behaviors, as well. The social benefits of play with loose parts, not simply limited to the Imagination Playground™ blocks (e.g., cardboard boxes, buckets, water toys), could provide teachers with opportunities to encourage group interaction and participation in structured loose parts play activities, with educational goals, in addition to child-initiated free play.

6.6 Limitations and Implications for Future Research

The current study examined a new construct in early engineering thinking play. It was designed as an exploratory study used to describe the general play behaviors elicited in boys and girls through play with a new and engaging material in multiple play settings. Although engineering thinking behaviors have been observed and categorized in preschoolers' play (Bairaktarova et al., 2011), the construct still requires some development. Although Bairaktarova and colleagues' (2011) measure of early engineering thinking play has been validated, the actual definition of the construct may need further focus. In addition, it is possible some of the titles of individual engineering thinking play behaviors need to revision. The current study made an attempt to focus this construct by relating it specifically to observable free play behaviors that engage the engineering design process and construction. Nevertheless, describing preschoolers' displays of numerical knowledge and other mathematics-related concepts as "logical and mathematical thinking," is not accurate given previous research on preschoolers' cognitive development. Further research is needed to focus the construct's definition and revise the titles of engineering thinking play behaviors, as currently the field has but a small number of studies that have actually measured engineering thinking in play.

Additionally, play with bicycles, tricycles, and scooters was not included in the analyses due to an unforeseen error during the data entry process. Anecdotally, data collectors observed children regularly playing with bicycles, specifically in the traditional playground setting, in which bicycles, tricycles, scooters, and wagons were made available. Further development of this project will seek to correct this error in order to include this variable in analyses of physical play.

Furthermore, this study was an exploratory observational project, and was therefore subject to some statistical limitations. The small sample size of 66 participants did not allow for exploratory factor analysis, which would have been ideal in creating conceptual groups of dependent variables. As a result, previous research and some descriptive statistics were used to create conceptual groups.

Another necessary step that would enrich the current study would be parsing out the individual play behaviors that were driving some of the gender and play setting effects found in the combined play categories. For instance, it was clear, based on the results, that boys' and girls' engagement in certain physical play behaviors may have contributed to some of the specific observed gender differences in gross motor locotomor/stability play and gross motor object manipulation play. It was speculated that girls may have spent relatively more time in the Imagination Playground™ setting, crawling, sliding, jumping, and climbing on the blocks compared to manipulating them. It would benefit the study to examine gender differences in some of the individual engineering thinking play behaviors, as well, to explore potential gender differences in specific types of engineering thinking. This could help clarify or qualify the non-significant gender effects we found for engineering thinking play.

Similarly, it should be noted that the Imagination Playground™, the traditional playground, and the dramatic play were each different and provided different affordances and play opportunities, depending on the setting and the play materials available. Although each setting was intended provide different play opportunities, some consideration should be made to these different affordances influencing potential results.

Finally, future research is needed on engineering thinking play, not only because the construct is new, but also because it is unclear what kinds of mechanisms and processes are operating while preschoolers are engaging in engineering thinking play. The current study, and all previous research on engineering thinking, has explored the occurrence of behaviors that are associated with engineering thinking. However, qualitative analyses of children's language while playing would be useful in explaining the occurrence of each engineering thinking behavior in the context of vocabulary and other ways of measuring individual children's cognitive abilities. It is also important for research to consider the relation between engineering thinking play and preschoolers' emerging mathematical abilities. Since engineering thinking play is meant to parallel the ways in which engineers think, but on a preschool level, exploring its connection to mathematics might benefit the development of early childhood educational practices and curriculum, especially using loose parts during play. In summary, the Imagination Playground^{TM} blocks' success in promoting physical, social, and engineering thinking play in preschoolers, supported the notion that loose parts play should be studied further as a means of introducing engineering into the early childhood education literature.

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APPENDICES

Appendix A. Tables

Table 1

Preschoolers' Number of Minutes Observed by School, Play Environment and Gender (N = 66; 29 Girls, 37 Boys)

Variables	Total						Head Start Program						University Laboratory School					
	Boys (N = 37)			Girls (N = 29)			Boys (N = 17)			Girls (N = 20)			Boys (N = 20)			Girls (N = 9)		
	Min	*M*	Rg	Min	*M*	Rg	Min	*M*	Rg	Min	*M*	Rg	Min	*M*	Rg	Min	*M*	Rg
Imagination Playground	317.33	8.58	10.33	220.33	7.60	12.67	115.33	6.78	10.00	140.67	7.03	12.67	202.00	10.10	10.33	79.67	8.85	6.33
Traditional Playground	325.00	8.78	10.00	238.67	8.23	7.67	122.00	7.18	10.00	155.67	7.78	7.67	203.00	10.15	10.00	83.00	9.22	5.00
Dramatic Play Area	295.33	7.98	14.67	219.67	7.84	6.00	107.67	6.33	5.67	162.67	8.13	6.00	187.67	9.38	14.00	57.00	7.13	5.00

Note. Min = Minutes; *M* = Mean; Rg = Range.

Table 2

Summary of Intercorrelations Between Conceptual Groups of Play Behaviors

Group	1	2	3	4	5	6	7
1. Engineering	_	.06	-.01	.25*	.41*	-.04	.01
2. Positive Social	.06	_	-.20	-.45**	-.14	.18	.13
3. Negative Social	-.01	-.20	_	.11	-.20	-.22	-.25*
4. Engages in independent activity	.25*	-.45**	.11	_	.29*	-.06	-.14
5. Fine motor physical	.41*	-.14	-.20	.29*	_	-.15	.13
6. Gross motor locomotor/stability	-.04	.18	-.22	-.06	-.15	_	.48**
7. Gross motor object manipulation	.01	.13	-.25*	-.14	.13	.48**	_

Table 3

Preschoolers' Average Rates of Play per Hour by Conceptual Group (N = 66)

	Imagination Playground™			Dramatic Play Area			Traditional Playground		
Variables	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Boys									
Engineering	70.29	39.76	162.00	44.68	32.69	123.75	18.91	33.28	156.00
Positive social	64.41	44.03	192.00	69.89	46.14	264.00	75.42	51.57	276.00
Negative social	15.39	16.92	52.94	8.29	16.15	84.71	16.00	27.37	144.00
Engages in independent activity	89.21	38.89	132.00	97.94	40.12	156.00	76.36	40.84	156.00
Fine motor physical	52.85	36.43	132.00	133.93	27.61	108.00	34.13	31.72	120.00
Gross motor locomotor/stability	244.04	103.14	492.00	96.56	64.34	216.00	241.34	98.43	372.00
Gross motor object manipulation	177.85	69.74	294.15	99.45	47.37	248.00	71.80	55.44	172.50
Girls									
Engineering	72.66	37.46	156.00	58.94	41.79	156.00	13.63	22.49	114.00
Positive social	77.77	39.58	154.29	79.33	52.79	210.00	98.80	53.77	192.00
Negative social	10.09	13.17	42.00	11.00	25.73	144.00	12.77	19.60	72.00
Engages in independent activity	98.21	46.49	170.00	86.54	55.10	180.00	71.15	47.91	174.00
Fine motor physical	46.29	31.98	132.00	127.41	26.08	144.00	32.84	32.66	120.00
Gross motor locomotor/stability	224.15	81.39	318.00	100.01	49.76	216.00	232.64	111.85	600.00
Gross motor object manipulation	112.92	54.06	228.00	78.21	48.45	162.00	40.19	37.33	156.00

Appendix B. Observation Forms

B.1 Child Observation Forms

Child name: ______________________________
Child gender: Boy _____ Girl _____
Child center/class: MCDLS (________________) Durgan HS (________________)
Setting: Imagination Playground™_____ Dramatic play_____ Outdoor play ground_____
Observer name: ______________________________
Date: ______________________________ **Time:** ______________________________

Motor Skills	Movement pattern	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Gross motor Locom-otor	Walking															
	Running, Galloping, and/or Skipping															
	Jumping & Leaping (landing on both feet)															
	Sliding															
	Ascending/ descending step(s) (using feet)															
	Climbing (using hands & feet)															
	Crawling (using hands or just knees on level surface)															
	Rocking															
Gross motor Manip-ulative	Throwing & Tossing															
	Catching															
	Kicking															
	Striking															
	Lifting large object															
	Dragging or carrying large object (at least 2 steps)															
	Carrying (small object) (at least 2 steps)															
	Bouncing ball															
	Rolling (object or body)															
	Swinging/waving object or body part															
	Riding on bike or scooter															
	Pushing or pushing over															
	Holding > 1 object															
	Handing over (objects to a person)															
	Stacking up (objects)															
Gross motor Stabili-ty	Balances on path or beam															
	Swinging (on swing)															
	Bending (knees or waist 90 degree)															
	Stretching/reaching (extending whole body to reach something)															
Fine	Manipulates small objects (e.g.,															

motor	*cutting, pasting, threading, pulling, pealing, purring, opening/closing, tying, playing with puzzle, etc.)*															
	Drawing/Painting															
	Writing (letter or number)															

Social Skills																
Positive		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Solitary Play	Displays positive affect															
	Engages in independent activity															
	Approaches ongoing activity and gets involved															
Group Play	Displays positive affect directed toward other person (look directly to the person)															
	Leadership															
	Takes turns															
	Cooperates															
	Shares (with intent)															
	Positive or Neutral reaction to conflict															
	Plays with peer of opposite gender															
	Play with peer with special needs															
Negative		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Solitary Play	Displays negative affect															
	Vacant															
	Listless															
	Hits, shoves, knocks over, throws objects (not interpersonal)															
	Engages in no social behavior															
	Dependent on adult															
Group Play	Displays negative affect directed toward other person															
	Displays interpersonal aggression															
	Negative reaction to conflict															
	Displays unprovoked physical interpersonal aggression															

Engineering Skills	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Communicate Goals															
Design and construction															
Problem solving (+ Replication)															
Creative/Innovation idea															
Solution testing/ Evaluating Design															
Explanation of how things are build/ work															
Following patterns and prototypes															
Logical mathematical thinking															
Technical vocabulary															

B.2 Observation Category Definitions

Motor Skills	Movement pattern	Description
Gross motor Locomotor	Walking	Placing one foot in front of the other while maintaining contact with the supporting surface
	Running, Galloping and/or Skipping	Running: A brief period of no contact with the supporting surface Galloping: combines a walk and a leap with the same foot leading throughout Skipping: combines a step and a hop in rhythmic alteration
	Jumping & Leaping	Jumping takes three forms: (1) jumping for distance; (2) jumping for height; & (3) jumping from a height Leaping involves a one- or two-foot takeoff with a landing on both feet
	Sliding	Move along a smooth surface while in contact with it
	Ascending/descending step(s)	Sloping or leading upward/downward using step(s)
	Climbing	Activity of ascending/descending by using the hands & feet
	Crawling	Move on the hands and/or knees or by dragging the body close to the ground
	Rocking	Move in such a way (back and forth)
Gross motor Manipulative	Throws & Tossing	Throwing: imparting force to an object in the general direction or intent Tossing: throw (something) somewhere lightly, easily, or casually
	Catching	Receiving force from an object with the hands, moving from large to progressively smaller balls
	Kicking	Imparting force to an object with the foot
	Striking	Sudden contact to object in an over arm, sidearm, or underhand pattern
	Lifting <u>large</u> object	Lifting: Raise to a higher position or level Large object: (> 9x9x9 inches)
	Dragging and/or carrying <u>large</u> object	Dragging: Pull something along forcefully, roughly, or with difficulty (along ground or floor) Carrying: Move something from one place to another Large object: (> 9x9x9 inches)
	Carrying <u>small</u> object	Move something from one place to another Small object: (< 9x9x9 inches)
	Bouncing ball	Rebounding up and down
	Rolling (object or body)	Move or cause to move in a particular direction by turning over and over on an axis
	Swinging/waving object or body part	Move or cause to move back and forth or from side to side
	Riding on Bike/Scooter	the act or sport of riding a bicycle using the feet to propel forward or to pedal; can include children being towed
	Pushing over	Exert force on (someone or something), typically with one's hand, in order to move them away from oneself or the origin of the force
	Holding > 1 object	Holding more than one object with one or two hands
	Handing over (objects)	Pick (something) up and/or give to (someone)
	Stacking up (objects)	Arrange (a number of things) in a pile, typically a neat one
Gross motor Stability	Balances on path or beam	Dynamic balance involves maintaining one's equilibrium as the center of gravity shift
	Swinging (on swing)	Move or cause to move back and forth or from side to side while or as if suspended on the swing structure
	Bending (body)	Incline the body downwards from the vertical (at least 90 degree) using

		knees or waist
	Stretching/ reaching	Extending one's hand or arm in an attempt to touch or grasp (something); typically using the whole body
Fine motor	Manipulates small object	Handle or control a tool, typically in a skillful manner *e.g., cutting, pasting, threading, pulling, pealing, purring, opening/closing, tying, playing with puzzle etc.*
	Drawing/Painting	Produce (a picture or diagram) by making lines and marks, esp. with a pen or pencil, on paper
	Writing	The activity or skill of marking coherent words on paper and composing text

Social Skills	**Categories**	**Description**
Positive Play	Displays positive affect	Child displays facial, vocal, or bodily emotions e.g., smiling, laughing, singing, dancing, etc.
	Engages in independent activity	The child is involved in an activity that he/she organizes for himself/herself
	Approaches ongoing activity and gets involved	Child seeks out a group of children or child engaged in an activity and gets involved with them. The child does not disrupt or antagonize other children as he/she approaches the activity. Note: active involvement, not just watching, is required.
	Displays positive affect directed toward other person	Child displays facial, vocal, or bodily emotions e.g., smiling, laughing, singing, dancing, etc. towards another child Note: a child <u>must make eye contact with other child</u>
	Leadership	The child plays an organizing role in an activity in which another child or children "follow the lead" and participate Note: This item can include "bossing" another child or children around.
	Takes turns	The child plays with a toy or participates in an activity and then allows another to do the same. A clear beginning and end of each child's turn during an activity must be observed. Note: This can also be coded if the turn taking is teacher-directed.
	Cooperates	The child jointly works with a peer or group of peers to achieve a common goal e.g., holds one end of a jump rope while playing outside
	Shares (with intent)	The child shares toys or other materials. The sharing should be more overt than children utilizing the same materials during parallel play.
	Positive/Neutral reaction to conflict	Promptly verbally expresses feelings arising from a conflict situation OR… Child makes no positive or negative reactions to a conflict situation e.g., walks away, plays with another toy, etc.
	Plays with peer of opposite gender	Child plays with a peer of another gender different than his/her own (can be with one or more children)
	Play with peer with special needs	Child plays with a child of special needs (can be with one or more children)
Negative Play	Displays negative affect	Child displays facial, vocal, or bodily emotions e.g., yelling, crying, frowning, etc.
	Vacant	The child displays a very flat, unexpressive, detached face; shows no involvement in an activity, and looks "emotionally absent."

	Listless	The child looks fidgety and un-invested in the activity but still "emotionally present;" the child stays in one area but shows little/no involvement in activities or social interaction
	Hits, shoves, knocks over, throws objects (**NOT** towards another person)	Child displays any of these negative actions towards self or object, however not towards another peer. Note. Emotionally arousing preceding event must be observed.
	Dependent on adult	Child is overly dependent on the help of an adult.
	Displays negative affect directed toward other person	Child displays facial, vocal, or bodily emotions towards another child e.g., yelling, crying, frowning towards another child
	Displays interpersonal aggression	Someone does something (takes a toy) to which the child responds with verbal or physical aggression Note. emotionally arousing preceding event must be observed
	Negative reaction to conflict	Child has a negative reaction to a conflict situation (fighting over a bike) with another peer e.g., hits, shoves, kicks, etc.
	Displays unprovoked physical interpersonal aggression	child displays verbal or physical aggression towards a peer without an emotionally arousing event occurring first

Early Engineering Skills	**Categories**	**Description**
	Communicate Goals	Child has a goal/purpose and communicates the goal while constructing or using materials.
	Design & construction	Child constructs a model of something, states how to do and make something, and builds an object using materials trying to make this object work in a certain way. -Design: collecting/sketching/describing with intent *(e.g., collecting blocks for purpose)* -Construction: making something/ active building
	Problem solving (+Replication)	Child states intention to change something in order to work better. - Replication: Child is willing to rework, redo, or redesign something in order to improve function of object or process.
	Creative/Innovative idea	Child tries different, not common approach when playing with materials and/or building object in regards to shapes or functionality.
	Solution testing /Evaluating Design	Child stops constructing to evaluate whether the object functions as needed or planed. *e.g., rolling a ball to check whether it actually rolls in the construct*
	Explanation of how things are build/ work	Child explains during or at the end of his/her activity what he/she is making or what he/she has done. (Higher level of thinking)
	Following patterns & prototypes	Child attempts to use his/her new creation in different settings or trying to use/talk about where before he/she have used/seen similar object. *e.g., Knows what works & do it again, Replicates a formal creation, Child use same/diff materials to achieve prototypes*
	Logical mathematical thinking	While playing, the child make references numbers and/or displays math concepts *e.g., estimation, counting numbers, shapes, & sizes*
	Technical vocabulary	Verbal only Child uses accurate technical language. *e.g., "push", "hammer this", "gear"*