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PARENTAL SUPPORTS FOR THE DEVELOPMENT OF PRESCHOOLERS' SKILLS THROUGH PLAY

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ABSTRACT

This study sought to determine whether parental spatial language use could be enhanced in a play context. The project involved an experimental test of whether giving parents different contexts for play led parents to engage in different kinds of play with their preschoolers. First, spatial skills of both parents and children were tested individually in a pre-test using various spatial tasks. In the experimental trial, parent-child dyads (N= 20) played collaboratively with various toys: a set of jigsaw puzzles, building blocks, LEGO blocks with a booklet of buildings and a Tangrams, each for a given period of time. This play situation fostered an informal learning environment that potentially promotes spatial thinking. Dyads were assigned to conditions in which they were given instructions varying with respect to whether spatial thinking was emphasized (“spatial-play" or experimental vs. "free-play” or control conditions). The experimenter measured whether the quality of parent-child play differs in the two groups, regarding the amount of spatial language exhibited by the mother. The researcher found that mothers in the “spatial-play” condition produced higher proportion of spatial language than did mothers in the “free-play” condition, suggesting that children’s spatial thinking can be promoted during play if parents are aware of the importance of developing spatial skills and how to guide children’s spatial thinking. Such findings will have implications for how parents may be able to enhance children’s spatial understanding.

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Introduction

A particular area of cognitive development that demands further examination is that of spatial thinking. The ability to develop good spatial skills affects numerous areas of life, including success in education, in professions related to the domains of science and mathematics, and success in daily tasks (e.g., understanding maps and graphic instructions). However, research suggests that not all children easily and quickly understand spatial concepts (Liben, 2006), and that many people from youth onwards have a hard time understanding spatial concepts (Aubrey & Dobbs, 1990). This issue is becoming increasingly more important to address as many useful tools are emerging in today's technologically advancing society, such as GPS systems in cars and computer displays of scientific information. Furthermore, a gender disparity is consistently evident where boys tend to perform better on spatial tasks than girls, from infancy onwards (Levine, Huttenlocher & Langrock, 1999; Newcombe & Huttenlocher, 2006, Quinn & Liben, 2008; Watson, 1999). Such findings call for more research to investigate how to improve spatial thinking from a young age.

The research which supports the need for children to develop a much more enhanced set of spatial skills is voluminous. Much research which focuses on adult spatial comprehension demonstrates that adults too have difficulty with spatial concepts. For instance, Aubrey and Dobbs, 1994, found that when 52 younger and older adults had to make decisions about direction based on a simple map of a university campus, with the maps either position aligned with the participant viewing the map or contra-aligned 180 degrees, participants did worse at making directional decisions when the maps were contra-aligned, particularly for older adults. In fact, in addition to the contra-aligned maps causing their decisions to be inaccurate, they also caused participants to take longer amounts of time to make a decision to make a decision. The study also found that women were slower in making decisions for contra-aligned maps than men were, although they were no less accurate than men in their decisions. These results suggest that older people who may need to mentally realign a map in somewhere like a shopping mall or an office building, may have much harder times doing so than their younger counterparts. Also, the research findings suggest that it may take women in such situations longer than men to accurately navigate the environment than it would men.

Findings similar to those discussed above suggest that not only are spatial skills valuable tools for everyday living, but they are tools that continue to affect people throughout their entire lives. Seeing how spatial skills are important enough that they affect people throughout their life-span, it is plausible that such skills are foundational for learning and should be built on as much as possible during development.

Due to the poor spatial ability among adults and how essential they are throughout one's life, a number of researchers have suggested increased instruction and promotion of spatial skills at a young age (Newcombe & Frick, 2010; Krakowski, *et. Al.*, 2010*)*.The fact that adults lack a full understanding of spatial skills suggests that young children are not acquiring spatial thinking as well as they can during development.

One means to address how children may develop better spatial understanding lies in the informal learning experiences that children consistently have with parents and care givers. Only recently (Levine, Ratliff, Huttenlocher & Cannon, 2011; Liben, Tamis-LeMonda, Ng, Kurchiko, Borriello, 2011; Pruden, Levine & Huttenlocher, 2011) have researchers examined how parents may influence the amount of guidance children receive in understanding spatial material. For example, research indicates some parents can guide children's understanding of the spatial relations among different pages of picture books, and that increased parental guidance is associated with more advanced spatial concepts in preschoolers (Szechter & Liben, 2004). Other research has shown that some parents provide greater support for children's jigsaw puzzle play, and that spatial skills appear to vary with these supports (Levine, 2011).

The current research generally aims to study how children's environment affects their acquisition of spatial skills. Additionally, we also seek to examine whether gender differences exist in regards to how a parent interacts with her child and how that varies based on spatial ability. We intend to explore this because past research reveals that gender differences in spatial abilities have been observed starting at a very young age (Johnson & Moore 2008; Quinn and Liben, 2008), While Quinn and Liben, 2008 found that four month old male infants were able to notice novel rotations of images than familiarized rotations of images better as compared to female infants, it is important to not conclude that these gender differences are solely due to innate gender differences. Instead, these differences might be the consequence of the varied experiences of the child and the fact that these experiences may differ based on the gender of the child.

In fact, the effects of gender socialization for spatial development continue to be seen well into adulthood. In 1989, Signorella, Krupa and Jamison examined more closely the relations between gender stereotyping and spatial performance in college students. The researchers were concerned with the associations between gender stereotyping in self- concept and spatial tasks performance (which typically show sex differences where males perform better than females). The main hypothesis the researchers predicted was that better spatial performance would relate to higher ratings on stereotypically masculine traits or lower ratings on stereotypically feminine traits, and a higher amount of activity in space-related activities, especially those that are considered stereotypically masculine (Signorella, Krupa and Jamison, 1989). The results found that sex of the participant had a significant effect on participants' performance in two spatial tasks: the water-level task and the card rotation test. Also, while gender self-concept and participation in spatial activities had significant direct effects on spatial performance, self-concept did not have any significant indirect effect on spatial performance by means of spatial activity. This research is relevant to the research topic at hand because it suggests that a person's gender self-concept, which may be influenced by a person's surrounding environment, is related to the development of one's spatial abilities.

While much research focuses on why gender differences exist at such a young age in children, as well as what these plausibly innate gender differences may mean in terms of spatial acquisition, less research examines how other potential factors may influence differences seen in children's development of spatial abilities (Levine, Vasilyeva, Lourenco, Newcombe &Huttenlocher, 2005; Szechter and Liben, 2004). Increasingly more research suggests that children, particularly at younger ages, do not easily and quickly understand spatial concepts (e.g., spatial-graphic representations) (Szechter and Liben 2004). This implies that other factors in children's environment may very well aid their development of spatial abilities.

While few studies have examined how parents may influence the amount of practice as well as guide children's understanding of spatial-graphic representations (and on a larger scale, spatial abilities), other work has evidenced that parents do help guide children's experience with cognitive concepts and their understanding of other areas that are related to cognitive development (Pruden, Levine & Huttenlocher, 2011; Szechter and Liben, 2004).

In 2004, Szechter and Liben hypothesized that parental social guidance would help children gain a better understanding of spatial-graphic representations which relate to the real world objects they represent. For example, Szechter and Liben suggest that parental social guidance can permit a child to notice the similarity between a drawn rabbit on a page and an actual rabbit in real life. Since parents and other adults understand the connection between a drawn object and the real life object it represents, the researchers suggested that they may be able to aid their children's understandings of spatial-graphic representations of such objects. Ultimately, the researchers aimed to see if children's spatial thinking could be better developed with parental support during a task that required an understanding of spatial-graphic representations.

The experimenters systematically observed interactions between parent-child dyads during play with a spatially salient book, and they also aimed to describe and identify the different teaching strategies parents used to guide children. Children were also given spatial tasks to complete during the study. Parent-child dyads were observed individually while reading a picture book, called *Zoom*, with challenging spatial-graphic representations in it.

The results of the study showed three main strategies (*constant referent*, *attention to depicted size*, and "v*erbal-gestural explanation or physical demonstration of zooming*) were used by parents to aid children's understanding of spatial-graph representations. The findings showed variations within the group of parents, with the extent to which they would try to explain how or why the spatial-graphic depictions of the book were confusing with the children. Some parents explained to their children their confusions with *Zoom* more than other parents. Also, a significant correlation was found between the parents' spatial-graphic behaviors and children's performance on the scene ordering task and photo pairs task, tasks which both require the use of spatial thinking. These findings suggest that children who receive more spatial guidance, regardless of the type of spatial information they are provided with, will likely perform well on subsequent spatial tasks.

The researchers also found that a higher frequency of parent's enjoyment behavior was significantly related to higher scores on the children's *Zoom completion task.* The study again provides increasing evidence that parental supports may affect children's spatial development, and that environmental factors, such as parental guidance, may relate to children's better understanding of spatial thinking. The techniques and strategies parents employ when guiding children's understanding of spatial tasks may also affect children's spatial development.

More recent studies have also examined the role that parents might play in children's spatial development. While many studies have examined early home environments in relations to children's literacy and language abilities (Evans, Shaw & Bell, 2000; Dickinson & Tabors, 2001; Griffin & Morrison, 1997; Hart & Risley, 1995), less research has examined the early home environment in relation to children's mathematics abilities and achievement. Some research, however, has examined factors of the early home environment that may affect children's educational achievement in general in schooling later in life. Baharudin & Luster, 1998, for example, examined factors related to the quality of the home environment and children's educational achievement. The researchers point out that individual differences in parenting are related to child outcomes in cognitive competence and school achievement. Furthermore, they report that children's characteristics, including gender, age, temperament, talents and health also affect the way that parents respond to children. In the study, the researchers examined the home environment of children, aged six to eight years, to see which factors within it are predictors of the individual differences in the home, as well as which factors are predictive of individual differences in children's educational achievement.

It was found that children who scored higher in all achievement measures tended to come from more supportive home environments. Other factors related to children's achievement levels included maternal characteristics. Children with more educated and more intelligent mothers had higher achievement scores. Furthermore, children with higher achievement had mothers with higher levels of self-esteem and also ones who began having children at a later age. Children who performed better on achievement tests also came from families with higher income levels and fewer children in the home. Also related to children's achievement scores was the presence of a father in the home. Finally, children's gender was significantly related to some achievement measures.

A related study by Son and Morrison, 2010, examined changes in the home learning environment as young children approached preschool. They found that many parents improved the quality of the home learning environment they provided for their children as children approached their school years. Furthermore, children's academic skills increased as parents provided children with an environment that offered high quality language and learning materials concurrently. Learning materials, in particular, were found to aid the development of children's academic skills. The researchers also report maternal education as one of the top predictors of the home learning environment and of children's development and learning, as did other studies (Baharudin & Luster, 1998; Korupp, Ganzeboom & van der Lippe, 2002). Furthermore, they found that mothers who worked longer hours or had full-time jobs were typically more educated and received higher salaries than mothers who worked fewer hours. Lastly, maternal depression symptoms negatively associated with changes in the home learning environment.

The few studies which have focused on the home learning environment and children's mathematics, and more specifically, spatial skills, will be discussed here within. Using a case study methodology, Young-Loveridge, 1989, explored the relationship between children's home environment in relation to numeracy skills on entry to school. The researcher examined six preschool aged subjects by conducting open-ended interviews with their mothers at home. Results showed that there was considerable variation with respect to how much children have experiences with mathematical activities at home. Young-Loveridge found that higher SES parents with high achieving children deliberately taught their children counting skills and made sure that their children had ample opportunity to deal with numbers within the home. The same was not true for parents of low achieving children.

Lastly, the researcher found that mothers' negative attitudes towards mathematics was related to their children's low achievement, which is consistent with other studies examining parent attitudes and mathematics achievement (Pederson, Elmore & Bleyer, 1986). Similarly, mothers of low scoring children reported that they avoided working with numbers when solving their own practical problems. Other studies (Melhuish et al., 2008) have also shown that home learning environments are important for children's development of numeracy skills at various points in early education, including preschool, kindergarten and in third grade.

In an attempt to make sense of the individual differences evidenced in young children's mathematical knowledge upon entering preschool, experimenters in a recent study went to children’s homes to estimate the extent to which the early home environment impacts children’s mathematical understanding later in life. Using a naturalistic method, Levine, Suriyakham, Rowe, Huttenlocher and Gunderson (2010), examined longitudinally whether preschool children’s understanding of cardinal meanings of number words is predicted by the amount of “number talk” they hear from caregivers at home. Researchers visited participating children’s home five times, when children were between the ages of 14 to 30 months old. The researchers found that there were considerable amounts of variation in the cumulative number talk of parents and children. Moreover, parents and children who spoke more overall also spoke more about number talk. Parental input to children about number most frequently involved talk about cardinal value and counting. For both parents and children, there was an increase in the use of number words from the 14 to 30 month age period. There was also variation in children’s knowledge of cardinal number words, with children understanding small numbers better. Importantly, it was found that children’s performance on the *point to x* number task was positively related to parent’s cumulative number talk.

More closely related to the present study, Pruden, Levine and Huttenlocher, 2011 also performed similar research in which they examined the parental spatial language input in the home as a predictor of children’s spatial language and ultimately, as a predictor of children’s spatial thinking. Using a longitudinal design, children, aged 14 to 42 months were examined over nine visits while interacting with parents at home. Once again, considerable variation was found in both parents’ and children’s spatial language use, with some dyads using little spatial language, while others used a great deal of talk about spatial concepts. Also, both mothers and children who produced a lot of non spatial language similarly produced greater amounts of spatial language. On one of the three spatial tasks presented to children, a sex difference was found, where boys outperformed girls. Importantly, the amount of parents' spatial tokens was positively correlated to children's performance on spatial tasks. These findings indicate that children who heard more spatial language from their parents performed better on two out of the three spatial tasks. Using a mediation analysis, the researchers were able to show that parental spatial language input influences how well children perform on spatial tasks, and thus how well developed their spatial reasoning skills are.

As the present study will be investigating spatial development during play with building blocks, more research related to mathematics achievement and parent-child play is discussed. Wolfgang, Stannard and Jones, 2003, examined the relationship between the level of sophistication of preschool children's block play and their later mathematics achievement, from elementary to high school. Using the Lunzer (1955) scale, play complexity with LEGO blocks was scored on a five point scale. Although no significant relationship was found between the level of block play and standardized mathematics scores in third and fifth grade, a significant correlation was found for the level of block play and mathematics scores in grade seven. There was also a significant relationship between the level of block play at age three and four and the mathematics achievement in high school, which was measured by the amount of higher level mathematics courses taken in high school. Additionally, the level of block play in preschool years was significantly correlated with the number of honors courses taken in high school. Finally, the level of block play was significantly correlated with grades in mathematics courses in high school.

One last study also analyzed block play along with parent child interactions and specifically examined the occurrence of spatial language during play. Ferrara, Hirsh-Pasek, Golinkoff and Lam, 2011 explored parent-child joint block play with the assumption that spatial language might naturally occur during this particular play experience. In the study, parent-child dyads, with children aged three to six years old, were assigned to three conditions: *free play* condition, where they were given the set of building blocks told to play the way they would at home, the *guided play* condition, where they were given five ordered photographs showing the steps to building a helipad or a garage, and the *preassembled* condition, in which dyads were given already made models, along with the vehicles and figures. The results revealed significant differences in spatial language use across the three conditions. In the *guided play* condition, parents used significantly more spatial language than did parents in both the *free play* and *preassembled* conditions. Not surprisingly, no significant differences in spatial language were found between the *free play* and *preassembled* conditions. Furthermore, children used significantly more spatial language in the *guided play* condition than in the *free play* condition. Lastly, the three block play conditions were compared to other types of play conditions that the researchers had done in previous studies. However the researchers considered the block play conditions to be spatial play, while the other play conditions without blocks were considered to be non-spatial play. The researchers found that when comparing the spatial play conditions to the non-spatial play conditions, there was significantly more spatial language used in all three spatial play conditions than in the non-spatial play conditions.

Since past research such as the studies presented above show evidence that children's environment may influence their acquisition of spatial skills, the current study will focus on how children's interactions with a specific part of their environment— the saliency of spatial instructions to their parents— may affect the development of their spatial abilities. The study will specifically examine how parents may guide children's spatial thinking based on whether or not they receive instructions that highlight what spatial skills are as well as the importance of spatial understanding for children, and finally, it will provide illustrative ways in which a parent could play with their children in order to makes spatial thinking salient.

I hypothesize that mothers given spatial instructions will use more spatial language and encourage more spatial thinking in their children during the play interactions.

I also predict that there will be a relationship between both children's and mother's performance on spatial tasks, where both people's spatial performance are similar, most likely due to environmental factors affecting the attention to such skills. Furthermore, I expect that mother's and/or children who perform better on spatial tasks will be more likely to engage in more spatial thinking and spatial language use. This is at least in part likely because people who may excel in an area may find that subject to be more interesting, fun or may just practice it more often since they are particularly good in that task.

I predict that based on the task being perceived as a typically masculine typed play, parents will expect boys to perform better on the task than girls and as a consequence, mothers who are in the spatial-play condition will likely use more spatial language and try to promote spatial thinking if they are playing with boys rather than girls.

Theoretical Perspectives Related to the Development of Spatial Thinking

In order to address how children can better develop spatial thinking, it is necessary to first examine some major theoretical perspectives related to cognitive development and see how they may tie into children's acquisition of spatial skills. The social, cognitive, and affective aspects of a child's world may all affect how spatial skills develop. Important developmental theorists which play into this discussion include Piaget, and Vygotsky and Bronfenbrenner.

Jean Piaget's theory of development suggests that children develop in stages, and that children's reasoning skills in earlier stages of their development differ from their reasoning skills in later stages. The theory also suggests that children pass along these stages gradually, moving from one stage onto the next as soon as they are ready (Siegler, 29). Piaget suggested that children transition through four developmental stages in a subsequent order, from the sensorimotor period (birth to age 2), to the preoperational period (age 2 to age 6 or 7), to the concrete operational period (age 6 or 7 to age 11 or 12) and finally to the formal operational period (puberty onwards).

In the sensorimotor period, children are very limited at birth to the motor movements they possess, but with experience and time they add to their abilities and within months they can build on their motor reflexes. Eventually they can repeat actions systematically, coordinate actions with other actions, etc. Importantly, children this young interact with the objects around them to stir their development (this includes physical objects as well as people).

During the preoperational period, which is of most relevance to the current study, children are thought to have good language and mental imagery skills (from 4 to 7 years old). During this stage, children can make early symbolic representations by using deferred imitation, where children can imitate an activity hours or even days after the activity has occurred. While during this period, Piaget notes that children have very egocentric communication and ways of seeing the world, their speech actually becomes less egocentric between ages 4 and 7.

Particularly important to the current study is that Piaget believed that the development of mental imagery: the representation of objects and events, reflects the development of language. This is important because it suggests a similar timeline for when mental imagery should be developing. While children make great progress in mental imagery and other domains during this period, Piaget suggests that egocentrism disables them from developing these skills further at this point in their growth. For example, in one of his studies, Piaget & Inhelder, 1969, found that four year olds were unable to take different spatial perspectives when trying to imagine how a person standing in a different position than the child himself would view a model of three different sized mountains. Based on Piaget's theory and his findings about this developmental stage, I posit that children near ages four to six could further their spatial thinking with the proper instruction from parents and other adults.

Another theory, Vygotsky's sociocultural theory, is equally important to mention in reference to developing spatial skills. There are two central themes within Vygotsky's theory: firstly, he notes that cognitive development occurs in social interaction, and secondly, that psychological functioning is mediated by cultural tools, including language (Siegler, 109). Other important themes are that cultural norms and other people influence children's opportunities for learning, and social and cultural learning require particular cognitive abilities on the parts of learners and teachers (Siegler, 109). Essentially, Vygotsky claims that the social interactions children have every day with parents, caregivers, teachers, etc. influence their cognitive development. For the purposes of this research, Vygotsky asserts the idea that the environment, particularly social interactions, can influence children's spatial development. Vygotsky claimed that developmental change occurs through the "internalization of socially shared processes", whereby children develop by learning to perform physiological functions at two levels: the intermental level and next the intramental level. At the intermental level children perform cognitive tasks with the help of social partners (i.e. parents), but over time they internalize how to perform these tasks and are able to do so at the intramental level, where they can perform the cognitive task on their own without any social support.

Also, Vygotsky introduced the concept of the "zone of proximal development", which is the distance between what a child can do independently and what the child can do in interaction with an adult or more advanced peer (Vygotsky, 1978) in order to emphasis that children can reason more complexly when they have aid from adults or other people with more skills in the area than they have. This occurs because the adult or person with more knowledge can pass down this knowledge to the child as he or she tries to solve a problem, which will enable him to internalize how to solve the problem. The idea behind this concept is that with assistance from people who already know how to solve a problem or reason about something accurately, the child can learn more about how to do this skill himself than if he were to try to do so on his own.

Lastly, an important part of Vygotsky's theory relates to how children learn when they interact with adults. Vygotsky suggests the idea of a social "scaffold", in which parents or other caregivers provide support for children as they are trying to perform difficult tasks or solve complex problems. By scaffolding, parents or caregivers help the child if he needs it and thus allow him to perform better than he would if no one were there to assist them in his performance.

Once the child has completed the task, the "scaffold" can be taken away, and the child can now perform the task successfully on his own. The idea again, is that children who are given social scaffolding are given more support as they develop cognitive understanding than children who are given no support, so they may better internalize how to perform activities or tasks, or solve complex problems. Also, adults tailor their support to children's level of skill development when they are scaffolding children (Greenfield, 1984). Particularly relevant to the proposed study, Wood & Middleton, 1975, found that in a task where mothers helped their three and four year old children learn how to construct complex block pyramids, children performed best on an independent posttest if their mother's instruction had been sensitive to the child's skill level.

Lastly, it is important to note not only that the social world influences cognitive development, but that there are different magnitudes to which the social world affects cognitive development. According to Urie Bronfenbrenner's Ecological Systems theory, there are several concentric layers of social and cultural context which each affect children's cognitive development. The social and cultural layers of his theory include the microsystem, the mesosystem, the exosystem, the macrosystem and the chronosystem. The smallest layer, the microsystem, focuses on how family relationships (i.e. parent-child, sibling) influence the developing child; the mesosystem focuses on how extended family, schools, work and the community affect the developing child; the exosystem focuses on how larger social institutions (i.e. government, the law) affect the developing child; the macrosystem focuses on how culture (including cultural norms, values, social roles, etc.), which affects all of the previous layers, affect the developing child and lastly, it is important to note that all of these layers occur within the framework of time, meaning that time affects the developing child overall and on many levels. Thus, Bronfenbrenner purports that a child's cognitive development is affected differently by many different social facets, not just in a holistic sense. This theory's idea most applies to the proposed research in terms of how gender differences may affect spatial development, as the theory takes into account how children are socialized by not only their parents, but also by their extended families, schools, communities, the media, culture etc. It is apparent that all of these different features of society may send different messages to children in terms of spatial development.

Research Goals

The goal of this project is to examine whether spatial language use among parents may be increased during parent-child play with simple instructions to parents. The project involved an experimental manipulation in which parents were provided with an explanation of spatial play and instructed to engage in spatially-oriented play with their children. Specifically, parent-child dyads played collaboratively with LEGOs and other toys, and were provided with a booklet including different constructions of blocks. I will then measure whether the quality of parent-child play differs and whether the amount of mother's spatial language produced differs due to the simple instructions which mothers are given.

Method

Participants

Parent-child dyads were recruited from the Penn State FIRSt Families Database as well as from parents recruited at Penn State's Arts Fest 2007 and Arts Fest 2011. Families from the FIRSt database had provided their contact information and indicated their desire to participate in research studies at the time of their child's birth. In addition to participants recruited from the FIRSt database, families were also recruited through Penn State's Arts Festivals, a community event in the State College area. These participants were approached by a research assistant and the research assistant explained the various research opportunities in the lab. Parents were asked to provide contact information if they were interested in being contacted for future studies.

The final sample included 20 typically developing parent-child dyads (11 boys and 9 girls). Children's age ranged from 4 to 6 years old (M = 61.24 months, SD = 8.02). Only mothers were invited to participate in the study with their children.

Due to the geographical limits of recruitment, almost all of children were of Caucasian ethnicity, and had parents who were highly educated. Three mother-children dyads were Asian-American and one child was adopted and of Hispanic background, although both of his parents were Caucasian. This sample represented the diversity of the region. Children received a gift certificate to Meyer's Dairy for an ice cream cone as a reward for participating, and parents were reimbursed for the parking fee on a campus lot.

Procedural Overview and Materials

Each parent-child dyad was tested individually at a research facility on Penn State's main campus. Participants completed one session which lasted approximately sixty to ninety minutes.

Parent-child dyads remained together for the entirety of the session so that children were comfortable. Once participants were greeted by the experimenter, they were brought to a comfortable room with chairs and a child sized table. While the experimenter went over the consent forms with mothers, children were allowed to draw in order to feel comfortable before testing began. The researcher also obtained verbal assent from children.

Baseline Testing

After providing consent, mothers and children were given two jigsaw puzzles to play with for a five minute period. The researcher instructed the dyads to play together as they would at home with the puzzles so that the researchers could assess the amount of spatial language parents and children normally use when playing together. Dyads played with the puzzles for five minutes. Throughout this session, participants were videotaped.

Spatial Tasks and Other Materials

The researcher then administered spatial tasks to the mother and child. Mothers completed a short survey obtaining basic information about themselves and their child, including education level, race/ethnicity, occupation, child's age, and ages of the child's siblings. Two spatial tasks were administered to the child: the Children's Mental Transformation Task (Levine et. al, 1999) and a child version of the Water Level Task. Each task was administered individually to the child.

Children's Mental Transformation Task

Children were tested with another spatial task, an abbreviated version of the Children's Mental Transformation Task (Levine, Huttenlocher, Taylor & Langrock, 1999). Children were presented with 16 items that assessed their ability to mentally transform two shapes into whole shape. Children were presented each item individually, and for each item they were shown four shapes and two target pieces. Their task was to choose one shape out of the four showed what two target pieces would look like when they came together. Every time children were presented with an item, they were told: “Look at the pieces. Now look at these shapes. If you put the pieces together they will make one of these shapes. Point to the shape the pieces make (Pruden *et al*., 2011).” Some target items required a rotation while other target items required a horizontal or diagonal displacement. Rotation items were rotated from one another at a 45º angle, while translation items had pieces which were translated from each other through a horizontal or diagonal displacement. Children received one point for each correct item. Some children did not fully complete the spatial transformation task or the Water Level Task due to fatigue or because they became upset, thus the proportion of correct items was calculated.

Child Water Level Task

Children received a child version of the Water Level task, which consisted of six multiple choice questions. The experimenter first showed the children an empty jar sitting upright on a table, and explained that the jar had no water in it, and was resting on a table, indicated by a line beneath the jar. Next, the experimenter asked the children to imagine what the jar would look like if it were half filled with water. Participants were subsequently shown six pictures of jars filled with water that were tipped in different horizontal positions on a table, and they had to choose one jar out of the six that had water correctly positioned within it. On subsequent questions, the jar’s position varied, and children had to choose the picture which showed the jar with the water level in the correct position, from six possible choices. Children received one point for each correct response given. Children first had to complete eight out of the sixteen

Levine problems they were given, followed by the Water Level Task, and finally, they completed the remaining part of the Children's Mental Transformation task. The Children's Mental Transformation Task was broken up to ensure that children did not become too fatigued or bored.

One spatial task was administered to the adult: the adult Water Level selection task.

Adult Water Level Task

As stated earlier, parents' and children's spatial task scores will be analyzed to measure spatial performance of individual participants at entry. Mothers were given an adult version of the Water Level Task which consisted of fifteen questions. They were given written instructions explaining that they would see containers with some water in them, and that each container was held by someone in a tipped position on a tabletop. Each container had lines drawn in it, showing where the water might rest in that position. Participants had to decide whether the line shown for each container accurately predicted the water's position by writing down "yes" or "no" on their paper. Mothers received one point for each correct response given. One mother accidentally did not complete the last page of the task, containing three questions, and as a result the proportion of correct responses was calculated based on the number of items each mother completed.

Spatial Instructions and Mother-Child Play Interactions

Upon completion of the spatial tasks, the experimenter provided instructions to the dyads. These instructions varied depending on the condition that dyads were in.

In the control condition, dyads were instructed to play together with the toys as they normally would at home. No further instructions were given to mothers for how to specifically play with their children using the toys.

In the experimental condition, the researcher provided very specific instructions to mothers as to how she should play with her child. Specifically, the researcher emphasized the importance of spatial thinking in developing children. The purpose of the instructions was to define spatial skills, explain how spatial skills are used throughout a child's life, and explain the manner in which mothers can promote spatial thinking in their children. The spatial instructions are as follows:

> "Normally, when talking about children's educational development, most parents are highly aware that literacy and mathematical skills are important foundations for children to build on as they progress through educational school. However, something parents may not be aware of is that there are also spatial thinking skills that are important to develop. Spatial skills are tools that underlie mathematical skills and science skills. The term "spatial skills" is hard to define, but it refers to a person's ability to visualize and manipulate patterns that occur in space. Spatial thinking concerns the location of objects, their shape, their relations to each other, and the paths they take as they move through space. For instance, you do spatial thinking when you try to imagine how a traingle would look if it were flipped upside down, with its pointy top on the bottom. Also, words such as over, under, above, around, corner and edge are linguistic ways to signify spatial thinking. For example, when a preschool child visualizes a cow jumping **over** the moon instead of under it or through it, that child is using a spatial toolbox.
>
> Down the road, spatial skills are important in school. For example, they help children do well in math and science classes. For example, in an algebra class they will

have to understand the meaning of points on a graph, and know how to find them; in a geography class they will have to understand different geometric figures such as triangles, hexagons, and quadrilaterals, and also be able to understand the different angles they create. In a chemistry class students must understand how to picture the bonds of chemical compounds; in an Earth Science class they'll have to understand cross-sections of Earth; and in social studies, history or geography classes children will have to understand how to read maps. Children will also draw on these spatial skills in art classes when they have to draw figures from certain perspectives. They will also draw on spatial skills in everyday life, for example, when they are using maps to figure out how to get from place to place, when looking at different objects in a picture, like a flower and a bird, and how they relate to one another, knowing how to backtrack to a hotel after getting dinner in a strange city, knowing the shortest route to the grocery store or which grocery store in your area is nearest to your home, when searching for your car in a parking lot, when finding a store in a mall, when walking around one's home during the night with the lights turned off in search of the bathroom, and not knocking into furniture along the way, knowing that Florida is south of New York and that New York is east of California, etc. Also, simply putting a jigsaw puzzle together requires spatial skills. Furthermore, if a person had to rearrange the furniture in a room, put together a desk or a bunk bed using a diagram on an instruction sheet, or play the video game Tetris, they would have to use spatial thinking.

Later on in life, such spatial skills will aid children if they choose to progress in fields such as architecture, engineering, computer programming, cartography and many more. In fact, spatial training has been found to improve educational outcomes, such as helping college students to complete engineering degrees (Sorby, 2005). With this in mind, we are trying to see if it is possible to encourage parents to try to help encourage their children's spatial skills in the curse of playing with toys like those your child already plays with. Jigsaw puzzles, building blocks, Legos, and others are games that your child might already have, which can help him/her build spatial skills.

For example, if your child plays with a jigsaw puzzle, there are many ways that you could play with your child and the blocks to promote your child's spatial thinking. For example, thinking and talking about the shape of the puzzle pieces and how they are different, talking about the outside puzzle pieces versus the inside puzzle pieces, talking about pieces that have corners and edges verses pieces that are curved, talking about how if you turn or flip the puzzle pieces in a certain direction, the puzzle pieces will fit together, but if the pieces are turned in a different direction, the pieces will not fit together. Thinking about the kind of angles that certain pieces might make with another piece, or about how a single piece, like a corner puzzle piece has a 90 degree angle in itself, talking about all of the puzzle pieces in relation to each other and how the pieces are all different from each other, and finally, making your child understand that if the singular pieces are fitted together in the right way they are able to create a bigger picture, or the puzzle, are all ways that a jigsaw puzzle can be used to encourage a child's spatial thinking.

Following the spatial or free-play instructions, dyads in both conditions were told that they would be given some toys to play with, and they were then successively presented with the toys. Each time that dyads were given a new toy with which to play, mothers in the experimental group were reminded to keep in mind what they had previously been told about spatial thinking. Dyads were video recorded as they played collaboratively with the various toys.

Dyads were first presented with a set of LEGO blocks that also included various sized blocks, cars, and people. Next, they were presented with a booklet of structures to accompany the set of LEGO blocks. The booklet contained pictures of ten structures built with the same LEGO blocks. Each structure in the booklet was displayed from four different camera angles: eye level from the front side of the structure, eye level from the back side of the structure, an oblique angle, and a bird's eye view. Dyads were instructed to play together and to try to build the structures. These structures varied in difficulty level. If in the experimental condition, the researcher reminded the parent about the spatial instructions before exiting the room. The parent

Measure of Spatial Thinking during Play Interactions

While I recognize that there are multiple possible ways to index spatial thinking and the spatial guidance that parents may provide children, for the purposes of this study I am currently only examining the linguistic aspect of spatial guidance. Furthermore, I chose to only focus on one play period, that which involved the LEGO blocks and the booklet.

Parent and children's speech from the LEGO block and booklet period was transcribed by trained undergraduate research assistants. Reliability procedures were modeled after those reported by Cannon, Levine & Huttenlocher, 1999. In order to ensure that transcriptions were reliable, second coders independently transcribed 20% of speech for each dyad's block and booklet session. Average reliability of all coded video sessions reached 90%. Second coders had to go through the segment they had coded and note any discrepancies. Furthermore, third coders compared the discrepancies coder 1 and coder 2 had for each dyad and watched the video in order to make a final decision as to which coder's interpretation was correct.

Once the LEGO block and booklet sessions were transcribed, they were coded in order to assess the amount of spatial language mothers and children used in reference to the LEGO block and booklet play. Transcriptions were analyzed using the program CHILDES. Words such as "it", "here", "where" and "there" were not considered a part of spatial language and thus not coded because they did not explicitly reference spatial properties or features of objects, and were often used in a non-spatial manner. Excluding these words was consistent with the coding procedures that other studies have used when examining spatial language (Cannon, Levine & Huttenlocher, 1999).

The researcher used the *System for Analyzing Children's Language about* Space (Cannon, *et Al.*, 2007) in order to determine which types of speech terms would fall under spatial language. Coders identified terms and phrases that fell within the following spatial categories:

(1) *Shape terms*– words which describe the mathematical names of two- and three-dimensional objects and spaces. For example: shape, triangle, circle, rectangle, octagon etc.

(2) Dimensional adjectives- words that emphasize the size of objects, people or spaces. For example: size, small, long, tall, big, tiny etc.

(3) Spatial features terms- words that describe the features and properties of two- and three-dimensional objects, people and spaces. For example: bent line, curvy, edge, side etc.

(4) Spatial orientation- words that describe the direction of two- and three-dimensional

objects, people and spaces. For example: direction, turn, flip, facing etc.

(5) Spatial locations- words that describe the location of two- and three-dimensional objects, people or spaces. For example: up, down, between etc.

The number of *spatial tokens* as well as the cumulative number of *non-spatial tokens* were counted for each mother during the LEGO block and booklet task. *Non-spatial tokens* were obtained by subtracting the number of *spatial tokens* and from the total number of words that each mother produced. *Spatial tokens* consisted of all of the times that specific words which fit under the 5 different spatial language categories occur. For example, a person who said the word "long" ten times would have ten *spatial tokens* for that particular word.

RESULTS

Overview

As explained earlier, the primary purpose of this study was to examine whether mothers who receive spatial instructions before playing with children will use more spatial language than mothers who do not receive these instructions. Thus, the dependent measure was the amount of the mother's spatial language, not the amount of the child's spatial language. Although the latter is also of interest, the current focus was on whether mothers would increase their spatial behaviors (here indexed by their use of spatial language) as a direct result of having heard about the importance of spatial thinking and having been given some general examples about how that thinking might be facilitated through play.

Quantitative Analyses of Language by Condition

A one-way repeated measures ANOVA examined the effect that group conditions had on the types of spatial language used by mothers. The results showed a significant main effect of group condition on the mother’s total proportion of spatial words produced, $F(1,18) = 5.56$, $p = .030$,. As seen in Table 1, mothers who received the spatial instructions condition had a higher proportion of spatial words produced (M = .10) than did mothers in the control condition (M = .08). These results confirm our hypothesis that being provided with instructions that stress the importance of spatial thinking in children’s development and with examples of how to do so will enhance the amount of spatial thinking parents both encourage and guide in their children.

A two-way repeated measures ANOVA was also conducted to examine whether the amount of spatial language mothers produced for each spatial language category differed based on their child’s gender. I found that with mothers' spatial language in each category as the dependent variable, no interaction was found between child's gender and the condition group.

Quantitative Data on Mothers' Spatial Language

Table 1 shows the mean occurrences of the different categories of spatial language that mothers used. Over the five different spatial categories, the mean amount of mothers' use of spatial category words was 15.90. Spatial location terms were used the most amount (M = 42.05) while spatial orientation terms were used the least amount (M = 2.65, SD = 3.28).

As seen in table 2, a one-way repeated measures ANOVA found no significant differences for the different types of spatial language between group conditions

Correlations

Finally, correlations were conducted to assess the potential relationship between the amount of spatial language mothers used and their performance on a spatial task (i.e. Adult version of the Water Level Task) given to them during the study. No significant correlation was found between the amount of mothers' use of spatial language and their scores on the Water Level Task. When split by condition group, a significant difference between the amount of spatial language used and spatial performance were still not significantly correlated.

DISCUSSION

In sum, this study sought to determine whether providing parents with definitions and examples of spatial thinking would result in a greater use of spatial language during parent child interaction. We hypothesized that mothers in the spatial-play condition would use more spatial language than mothers in the free-play condition during structured play activities with their children. Analyses provided evidence in support of this hypothesis. Mothers in the spatial-play condition did in fact use a greater proportion of spatial language with their children during play as compared to mothers in the control condition. Thus, these results reveal that parents will employ more spatial language with their children when provided with a description of spatial abilities and the advantages that these abilities provide.

Parents' amount of spatial language produced may be influenced by their understanding of spatial skills and by being made aware of the importance of spatial thinking in children's development. In this manner, the current research implies that informal learning environments may be able to influence, to some degree, the development of spatial abilities in children. Adults become increasingly able to provide spatial guidance to children as spatial thinking becomes more salient to them.

A second hypothesis of this study was that there would be an interaction effect between the amount of a mother's spatial language and the child's gender, as well as an interaction effect between group conditions and children's gender. However, no such interactions were found. This absence of an effect may be a consequence of the small sample size. Future research might benefit from utilizing a greater number of participants when testing these hypotheses. Lastly, we expected to find a positive relationship between mothers' spatial language use and performance on the adult version of the Water Level Task. This correlation was also expected to remain when mothers' spatial language was split by condition group. Once again, neither of these correlations was found to be significant. Although the lack of a significant relationship may be due to a small sample size, it is promising. The lack of a correlation between spatial ability and spatial language among mothers indicates that even mothers with poor spatial ability, spatial language usage can be increased through simple instruction.

This research also suggests that playing with toys available in most homes, such as LEGOS, is an excellent context in which spatial language can be utilized. Thus, through this study, one can infer that spatial language use can be easily increased with little effort and materials needed.

This study is limited in several regards. First and foremost, there are limitations in regard to the sample. The sample size for this study is small and results should be interpreted with caution until replicated with a larger sample size. Additionally, these results might not be generalizable to the larger population, as the sample was homogenous in regards to race/ethnicity and socioeconomic status. As Table 4 shows, many parents of participating children were highly educated, as they had completed at least some college up to graduate school, and may thus also be more intelligent than a sample of people from a different population.

Other potential limitations related to the study procedures. The participants were videotaped, and the presence of a camera may have altered their behavior. Also, mothers realize that their behavior is being evaluated based on their own and also their children's performance on the spatial tasks, as well as during the play period with the LEGO blocks and booklet. Mothers may thus try to encourage the children to complete the tasks and build the LEGO structures more so than they normally would, which would not be similar to a real life situation.

Further studies might investigate if children whose parents utilize more spatial language develop better spatial reasoning skills, as spatial thinking would be more salient. These present findings suggest that parents' spatial language can be increased when they are made aware of the importance of spatial skills. how this may directly affect children's spatial language and spatial thinking skills.

Future studies might also examine whether spatial language use varies among different cultures and whether the pattern observed in this study (an increase in spatial language use among those in the experimental condition) is observed among different cultures. This study lacked sufficient diversity among ethnic backgrounds to examine this.

In considering the relationship between gender and spatial language use, there was evidence from video recordings of the dyads that gender may in fact play an important role in the salience of spatial thinking during play. Although results did not show statistically significant effects or correlations between gender and spatial language use, there were numerous times in which mothers made gender-salient remarks to their children in regard to spatial thinking. For example, a few mothers who had daughters mentioned that either they themselves were not as good at playing with one game, the Tangram as their husband would be, or that one of their sons, would be better at completing the Tangram than their daughter was. For example, the mother from one dyad told her daughter: boy, your brother should be here, he would have figured this out in two seconds."

Thus, future research might explore how spatial language use varies among mothers and fathers, and how parents' gender might interact with children's gender. A possible study might manipulate the assignment of parents' gender to children's gender, so that there could be eight group conditions: Same-sex spatial-play (Mothers-daughters; Fathers-sons), mixed-sex spatial-play (Mothers-sons; Fathers-daughters, same-sex free-play (Mothers-daughters; Fathers-sons) and mixed-sex free-play (Mothers-sons; Fathers-daughters. In this manner, the interaction of parents' and children's gender and spatial language could be examined.

Observations from the current study found two things of particular interest. The first one was that in the spatial-play condition, some mothers admitted to not knowing what spatial skills were at all. Interestingly, other mothers stated that they knew what spatial skills were rather well, and said that the spatial instructions were very clear to them. Even still, the researcher noted that some of these mothers did not convey much spatial information to their children during the play periods. This led the researcher to wonder whether the spatial instructions needed to be even more explicit about how to play in a spatial manner with children. More studies should examine possible ways to teach parents what spatial thinking is, and focus on how to make parents understand different ways they could guide their children's spatial thinking.

The experimenter also noted that when mothers in the spatial-play condition did play spatially with their children and use a rich amount of spatial language, children, in general, were not responsive. Additionally, some children seemed to be more inherently interested in spatial typed play than others. Thus, future studies should also focus on how to get children engaged in and to enjoy spatially directed play, whether they are spatially inclined or not.

Two final things that the current study did not do are presented here within. First, the experimenter could have gotten information from parents about how much their children tend to play with spatially geared toys, such as jigsaw puzzles at home. This could have given the researcher more insight as to children's inherent liking of spatial thinking. Finally, the study could have gotten parents' expectations about their children's spatial skills, so this could have been compared to parents' and children's spatial performance. Both of these factors may influence the amount of spatial guidance parents give their children. Future studies may want to consider these factors when thinking about which data to collect on participants. Gender differences may also be evidenced in these two variables.

The results of this study can be used as evidence that informal play with parents can lead children to have more experience with spatial language and potentially, spatial concepts.. This study's findings not only have implications for ways in which children's spatial reasoning skills can be improved in the home, but they have similar implications for how these skills can be enhanced in schools. Based on the results this study has shown, educational interventions should follow so that researchers can examine how to transfer these results to a classroom setting. If parents can aid children's understanding of spatial thinking in the home by means of informal play with everyday toys, surely, teachers can implement similar strategies with toys way so that children can not only gain early exposure to spatial concepts at home, but they can also learn about spatial thinking at school.

The development of spatial abilities is very important, as spatial concepts are presented as challenges to people every day. Spatial skills are essential tools to develop because they enable people to make much needed representations of the world they live in and use those representations to live effectively. The development of these skills is pertinent for a person to live in a three dimensional world, and interact with objects that are used frequently to help people better function in the world. By studying the development of spatial abilities in children, researchers can continue to unravel how people acquire the skills they use each day to interact with the world around them.

Appendix A

Table 1 Descriptive Statistics about Mothers' Mean Use of Spatial Language						
Spatial Language	Condition					
	Control		Spatial		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Shape Terms	5.56	11.55	10.64	14.51	8.35	12.92
Dimensional Adjectives	7.44	5.98	10.55	9.04	9.15	7.78
Spatial Feature Terms	16.44	11.07	18.09	7.69	17.35	9.13
Spatial Orientation	2.44	2.13	2.82	4.01	2.65	3.28
Spatial Locations	34.00	16.06	48.64	26.07	42.05	22.85
Proportion of Spatial Words	.08	.02	.10	.02	.09	.03

Table 2
ANOVA of Spatial Language between Group Conditions

	Between Group Analyses		
Spatial Language	*df*	*F*	*p*
Shape Terms	1	.76	.40
Dimensional Adjectives	1	.7	.39
Spatial Features Terms	1	.154	.70
Spatial Orientation	1	.061	.81
Spatial Locations	1	2.15	.17
Proportion of Spatial Words	1	5.56	.030*

$p \leq 0.05$

Table 3
Descriptive Statistics of Mothers' Spatial Language by Group Condition and Children's Gender

	Children's Gender								
	Female			Male			Total		
Group Condition	M	SD	N	M	SD	N	M	SD	N
Control	31.75	13.77	4	35.80	19.10	5	34.00	16.06	9
Spatial	52.60	19.31	5	45.33	32.12	6	48.4	26.07	11
Total	43.33	19.44	9	41.00	26.20	11	42.05	22.85	20

Table 4
Descriptive Statistics on Parents Gender and Education Level

	Parent's Education Level					
Parent's Gender	No High School Diploma	High School Diploma	Some College	4 Year College	Graduate School	Total
Mothers	0	0	5	9	8	22
Fathers	0	3	1	8	10	22
Total	0	3	6	17	18	44

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