

Boys' and Girls' Early Science-Related Experiences and Opportunities

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by

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CHAPTER ONE

INTRODUCTION

This study explored preschool children's science-related experiences and opportunities, specifically focusing on whether and how child gender influences early science-learning. Women are currently underrepresented in science-related careers, enrollment in science-related graduate programs, and participation in high school science courses (NSF, 2010; Andre, Whigman, Henderson, & Chambers, 1999). As a result, it is important to gain an understanding of where the roots of these gender disparities in engagement in science endeavors may have originated. Because children seek knowledge and express interest regarding science-related topics in the context of family interactions, it is important to examine the ways that parents may support or discourage a child's interest in science. In the present study, I investigated preschool-age children's participation in family routines for informal science-learning, the science topics children talk about with their parents, and the types of talk children and parents engage in during naturally occurring science-related conversations. I began by examining the existing literature on gender differences in boys' and girls' early science-related experiences.

Prior literature suggests that there are gender differences in children's interest in and engagement with science during the preschool years. Even before children begin school, parents express gender stereotypical beliefs regarding their child's science abilities and beliefs (Andre et al., 1999). Andre et al. (1999) discovered that parents of young children perceive boys as more capable in science than girls. Additionally, parents often consider science to be more important for boys and expect higher science-related achievement for preschool-age boys than preschool-age girls (Andre et al., 1999). Further research suggests that these gender beliefs are manifested in the ways parents interact with their young children. Conversations with parents are one

important way that children seek science-related information (Frazier, Gelman, & Wellman, 2009), and a child's gender can impact these interactions. Crowley, Callanan, Tenenbaum, and Allen, (2001b) found that at museums, parents offer more explanations for science concepts to boys than girls, regardless of the amount of questions the child asks. This study suggests that acquiring explanatory information about a science phenomenon or concept is an experience that is more likely to occur for boys than girls at the preschool-age. Thus, parents play an important role in shaping their children's early science knowledge.

Opportunities for informal science-learning also vary in relation to a child's gender. Existing literature indicated that parents provide boys with more opportunities than girls to engage in science activities through trips to institutions such as museums, science centers, and zoos (Alexander, Johnson, & Kelley, 2012). When girls exhibit an early interest in science, parents tend to provide them with science-related informal learning opportunities; however, boys receive these opportunities whether or not they express an interest (Alexander et al., 2012). In turn, preschool-aged boys are more likely than girls to express a sustained interest in conceptual domains, most of which fall within the realm of science (Johnson, Alexander, Spencer, Leibham, & Neitzel, 2004).

The present study consisted of two parts, each of which was motivated by information from prior studies. Part One consisted of a survey methodology designed to gather information regarding preschool children's science-learning opportunities. Part Two included a two-week diary study that examined family engagement in conversations about science-related topics. Each of these parts is a component of a larger ongoing investigation of young children's science-related experiences led by Dr. Jennifer Jipson.

Part One of the present study included 54 parents of preschool-age children who completed a survey regarding their family routines for engaging in informal science-learning activities. This 12-item survey contained questions about the frequency with which parents had provided their children with opportunities to experience science-learning activities in the past year including trips to museums, visiting zoos or aquariums, gardening, reading science-related books, and watching science television (see Appendix A). The survey assessed engagement in science learning activities on a four-point scale in which parents had the option to answer (0) Never, (1) Once or Twice, (2) Several Times, or (3) Often. Analyses of the data indicated that the two activities parents reported engaging in most with their children were trips to the “Playground” and the “Beach.” These were followed by reading a “Science Book,” “Gardening,” and watching “Science TV.” Results indicated that, for this sample of families, gender did not significantly impact the frequency with which parents reported providing children with opportunities to engage in informal science-learning activities. Even activities specifically related to science such as visit a science museum, reading a science book, or watching science TV did not significantly vary based on child gender. Thus, parents indicated offering similar early science-learning opportunities to both boys and girls.

Part Two consisted of a diary study including 25 preschool-age children and their families. Participating parents agreed to keep track of their children’s questions, observations, or ideas about the natural world for two weeks. I first analyzed the topics of each of these conversations to explore whether there were gender differences in the topics children discussed with their parents. Researchers examined each reported conversation and classified the topic into one of eight categories (e.g., “Animals,” “Plants,” “Human body,” “Weather,” “Astronomy”). Analyses did not indicate any significant effects of gender on conversational topics. The most

frequently discussed topics for both boys and girls was “Animals,” encompassing almost half of all conversations. The next two topics of conversation that occurred with the highest frequency were “Astronomy” and “Plants.” These results suggest that at the preschool-age children are typically interested in talking about similar science phenomenon with their parents.

I then analyzed the parent-child conversations for the types of utterance that occurred. These categories included: asking questions, offering information, and suggesting activities related to science and nature. The current categories constituted an initial step in a more elaborate coding process that will be used in the near future to further analyze the data. Results suggested that parents were significantly more likely to offer information than to ask questions when engaged in science conversations with their children. Additionally, they were more likely to ask questions than to suggest activities. Next, I analyzed the data to investigate whether parents offered information, asked questions, or suggested activities to different extents based on their child’s gender. None of the three analyses indicated a significant difference for any of the utterance types based on the child’s gender. Similar to parental utterances, analyses of child utterances suggested that children were most likely to offer information, followed by questions asking, with suggesting an activity occurring least frequently. Again, the frequency with which children engaged in these conversational techniques did not significantly vary by child gender.

Findings from analyses of the present study did not indicate widespread gender differences in preschool-aged children’s science-related opportunities or conversational experiences. This is surprising given that prior research suggests gender differences in children’s early experiences with science. There are several possible reasons to explain why this study did not reveal gender differences. First, my measures may not have been sensitive enough. It is possible that gender impacts children’s early experiences with science in a more subtle manner

than was captured by the present study's initial level of exploration. When examining the prior research, it becomes clear that it is not enough to simply examine the frequency with which parents take their children to informal science-learning environments or the amount of science-talk they engage in with their children. The Crowley et al. (2001b) study included parents that were already choosing to provide their children with opportunities to experience science environments, yet once they were there parents offered more explanations to boys than girls. It appears that it is not the amount of information, but the type and quality of information that differs based on the child's gender. Because prior literature indicates that parents play an important role in shaping children's understanding of science concepts and their development of scientific reasoning, the type and amount of explanations a parent provides could be influencing children's future science knowledge and interest. Parents may be unknowingly involved in creating a gender bias in preschool children's science experiences, despite the fact that they are providing their children with informal science learning activities and engaging with their children in science-related conversations. This level of complexity was not identified by the present study's current level of basic coding. Further analyses of the diary study conversations are in progress with the goal of examining gender differences and similarities in causal explanatory talk, specifically.

Second, sampling procedures may have resulted in the recruitment of families who were more egalitarian in their gender-based views than families who participated in previous work. All participants were self-selected and may have chosen to participate because they typically engage in science-learning activities and conversations with their children. Third, all of my measures were self-reported by parents, which could lead to misrepresentations of actual family science practices.

Despite these limitations, it is also important to consider that gender differences may be exaggerated in the existing literature. For example, the Alexander et al. (2012) study provides the only readily available information on gender differences in preschool children's opportunities for informal science-learning. Similarly, the Crowley et al. (2001b) study found gender differences in the number of explanations children received. However, this is, again, only one piece of documented literature that found gender differences in parental explanatory talk. Also, the Crowley et al. (2001b) study took place in a museum, and we cannot necessarily generalize these findings to naturally-occurring conversations that take place in other contexts. Additional research on this topic is necessary before we can be confident enough to draw conclusions about gender disparities in family activities.

CHAPTER TWO

LITERATURE REVIEW

A large disparity exists between the number of men and women employed in science-related careers. According to the 2010 National Science Foundation statistics, women constitute fewer than one-fifth of the scientists in the United States. Similarly, females are underrepresented in high school science courses and women earn fewer science-related graduate degrees than do men (Andre et al., 1999). As a result, it is important to gain an understanding of where the roots of these gender disparities in engagement in scientific endeavors may have originated. Throughout childhood and adolescence there is evidence of gender-typed attitudes about and engagement in science. For example, gender differences in students' perceptions regarding their science competence are apparent in middle school, and gender differences in children's interest in science are expressed by preschool-aged boys and girls (Bhanot & Jovanovic, 2009; Johnson et al., 2004).

Because children and youth seek knowledge and express interest regarding science-related topics in the context of family interactions, it is important to examine the ways that parents may support or discourage a child's interest in science (Frazier et al., 2009). Even before their child begins school, parents express gender stereotypical beliefs regarding their child's science abilities and interests (Andre et al., 1999). These gender-typed beliefs are likely to influence the ways parents interact with children. Research reveals, for example, that parents differ by child gender in their efforts to engage children in informal science learning through visits to such institutions as museums, science centers, and zoos (Alexaner et al., 2012). Further, parents offer more explanations for science-related concepts and phenomena to boys than girls (Crowley et al., 2001b).

In the following sections, prior work on the dynamics of young children's science-related conversations and interactions with parents, in general, is considered. This is followed by examination of existing literature on gender-differences in boys' and girls' science-related interests. Finally, I consider how parents structure their preschool-aged boys' and girls' opportunities for informal science learning.

Parent-Child Conversations as a Context for Young Children's Science Learning

Children are naturally curious about their world and actively seek out information that can help them interpret and understand it (Piaget, 1950). One way learning takes place is through solo, independent inquiry and exploration. However, children also learn a great deal from interactions in social contexts. For example, parent-child interactions allow parents to convey new concepts and help stimulate a child's thinking (Vygotsky, 1978).

Crowley, Callanan, Jipson, Galco, Topping, and Shrager (2001a) demonstrated the important role parents play in children's science learning in their examination of children's experiences at a children's museum. Participants included 91 families with children between the ages of 4 and 8 years old who visited a zoetrope exhibit, a device in which the illusion of motion is produced by spinning the frame of the zoetrope while look through the slots at images of a horse. In addition, this particular zoetrope had a tab above each horse image that could be raised or lowered to trigger the sound of a hoof beat, so children could experiment with constructing a "soundtrack" for the animation of a running horse once they had discovered how to produce the illusion of motion. Crowley et al. (2001a) identified 3 types of interactions: parent-child, peer, and solitary groups, and then coded all data for children's level of engagement across a variety of behaviors, such as: describing evidence, giving directions, and offering explanations. Results indicated that longer, broader, more focused interactions occurred when children engaged the

exhibit with their parents rather than by themselves or with a peer. This suggests that there is something about parent-child interactions that is particularly helpful in supporting scientific inquiry.

One way that parent-child interaction may support children's science learning is that it provides a context within which children have opportunities to ask questions and parents have opportunities to share knowledge. Research indicates that during the preschool years, children often ask questions and actively pursue information to construct initial theories about the world around them. Chouinard (2007) found that children's questions play an important role in their cognitive development. When children encounter a gap in their knowledge, they often seek to fill this deficit by asking a question intended to allow them to receive the information they are seeking. Chouinard analyzed questions taken from four children's transcripts in the CHILDES database, a repository of transcribed audiotapes of verbatim conversations between children and adults that were recorded at regular intervals over several months. In Chouinard's sample, the target children's ages ranged from 1-5 years. Results indicated that children ask many questions that search for information. When children are engaged with a responsive adult, they ask an average of 76 information-seeking questions per hour. This provides an extensive context for parents to engage in the construction of knowledge with their children. Chouinard also found that when children do not receive an informative response, they typically keep asking questions in pursuit of their topic of interest. Thus, children are persistent in their efforts to gain understandings. Further results revealed that adults usually add additional relevant information to their responses beyond what the child asked. Taken together, these findings reveal that children's questions do not simply result in their gain of requested information, rather they open the door for adults to give the child whatever information the adult believes the child needs to

better understand the world (Chouinard, 2007). This study suggests that children's natural desire to ask questions is a powerful tool that works to expand children's cognitive development.

In an investigation of the particular topics that interest children, Callanan and Oakes (1992) asked parents of thirty preschool-aged children, 3-, 4-, and 5-years old, to keep a diary of their children's questions about "*how things work*" and "*why things happen*" for a period of two weeks. Parents' explanations were coded into five categories based on mode of causality: mechanism (procedure-like explanations), prior cause (provided a single event that occurred as a result of a previous event), consequence (provided a purpose or event for a state that will occur later), combined cause-consequence, and non-causal. Analysis of the diaries revealed that children as young as 3 years requested explanations about mechanical, natural, and social phenomena, demonstrating that children's questions extend across several domains. This also indicated that children often ask questions in order to form theories about specific topics of interest, as opposed to simply attempting to prolong social interaction. The majority of parents' responses to children's *how* and *why* questions were causal explanations. At each age, parents answered causal questions most often with a mechanism or prior cause explanation, and explanations increased in complexity as the children got older. These findings support the idea that parent-child conversational exchanges provide a context for the interchange of information and concept construction at the preschool-age.

Further research supports the likelihood that parental responses to children's questions influence children's information gathering approaches. Frazier et al. (2009) examined children's questions as well as their reactions to the answers they receive in conversations with adults. The participants consisted of six children between the ages of 2 - 4 years whose conversations had previously been recorded in a naturalistic setting and made available through the CHILDES data

base. Similar to Callanan and Oakes (1992), Frazier et al. (2009) focused specifically on children's *how* and *why* causal questions. Their coding scheme encompassed three aspects of the parent-child conversation: the initial causal question, the adult's response, and the child's reaction to the adult's response. Each question a child asked was coded as either a simple or complex question. Simple questions consisted of only one or two words (e.g., "Why?" or "How?"), whereas complex questions included a reference to the subject of the *how* or *why* question (e.g., "Why does the bird not talk?"). Additionally, adult responses were coded as explanatory or non-explanatory answers. The results revealed that children respond differently to explanatory versus non-explanatory answers to their questions. When children asked adults causal questions, they were more likely to express verbal agreement with adult responses that provided an explanation as opposed to the parental responses that did not. Even more importantly, explanations seemed to promote further curiosity. Children were significantly more likely to ask a follow-up question to their original inquiry when adults provided a causal explanation. In contrast, when children did not receive a causal explanation, they either re-asked their question or provided their own explanation. This indicates that parental responses are influential in structuring children's approaches to gathering information. Further, these findings suggest that parental responses can foster and extend children's interest.

When focusing specifically on children's science interest, several studies have demonstrated that one pathway for children's development of knowledge regarding science is through family practices including parent-child interactions related to science topics. Whereas Frazier et al. (2009) focused on how children responded to parent explanations in any domain, Luce, Callanan, and Smilovic (2013) explored how parents transmit specifically science-related knowledge to their children. They videotaped 35 parent-child dyads as they read a book together

during a visit to a California children's museum. Children ranged in age from 4 to 8 years. The book was designed to encourage discussion about unresolved scientific issues, with emphasis on the role of scientific evidence. Coding focused on the parents' expression of epistemological stance and children's talk regarding evidence. The results revealed that parents varied in their ways of thinking about science related knowledge, which impacted the information they provided to their children regarding science topics. For example, some parents chose to focus on facts, whereas others sought evidence and used it to back up their explanations. If parents used evidence-based explanations, children were more likely to be persuaded by evidence-based explanations in a follow-up task in which children briefly discussed the book with an interviewer. Also, parents' talk that expressed the value of reasoning with evidence, correlated strongly with the frequency with which children discussed scientific evidence. Results indicated variation across age as well. Parents of 4- to 5-year olds often discussed facts, whereas families with 6-8 year-olds were more likely to use reasoning such as discussing *why* a phenomenon exists. Researchers concluded that children often learn science reasoning and develop techniques to assess the validity of scientific evidence through their conversations with their parents. The messages communicated from parent to child in everyday science-related conversations can impact a child's view regarding the importance of science topics and evidence of knowledge (Crowley et al., 2001a; Luce et al., 2013).

Jipson and Callanan (2003) also advanced the research regarding young children's emerging science knowledge by examining mother-child conversations about and children's understanding of biological concepts. They examined the ways that mothers and children reason about biological and nonbiological objects change in size. Study 1 examined the ways in which mothers talk with their children regarding increases and decreases in size. Mother-child pairs

were videotaped jointly exploring a picture book in a laboratory setting; each book contained ten sets of three pictures in growth sequence. Mothers' talk was coded for different types of references to growth and varying explanations. Findings indicate that although mothers typically concentrate on biological increases in size when discussing growth with their young children, they sometimes talk about nonbiological events as well. This suggests that mothers' may blur domains when discussing scientific evidence with their children; however the contexts in which this occurred were often consistent with the social use of the word *grow*. Study 2 was similar to Study 1, except children explored the book without a parent. However, in this study researchers asked the children three questions: what happened to the object, how did it happen, and why did it happen. Results indicated that, like mothers, children often focused their use of the term *grow* on biological events. Similarly to mothers, they occasionally described nonbiological events as growth. However, mothers' references to nonbiological growth could be seen as coinciding with the social conventional use of the word, whereas children's references were not. An important overall finding from this research is that by the time children have reached preschool age, they have already begun to construct domain-specific understandings. Additionally, mothers play a role in guiding their children's understanding of domain-specific science concepts. Findings indicated that mother's explanations often interacted accurately with the domains they described. For example, when explaining biological events, mothers used biological explanations rather than human cause explanations. This furthers the research which suggests that parents not only provide content knowledge about specific science domains, but also often offer explanations for science-related causes as well.

In sum, research from several studies examining preschool children's interactions with their parents reveals that children have opportunities to acquire knowledge on science-related

topics well before they begin school. An important question about these family interactions is whether they vary based on the child's gender. Although none of the authors of the studies reviewed thus far reported gender differences in parent-child science-related interactions, other studies find that child gender seems to influence children's engagement with science. If such findings are robust, this suggests that family interactions may impact children's interests and opportunities for future science-learning.

Gender Differences in Children's and Parents' Science-Related Attitudes and Interests

Given that parents seem to play a predominant role in shaping and supporting children's scientific thinking, an important open question is whether parents of boys' and girls' support scientific thinking in different ways. Several studies have indicated that gender stereotypes regarding science are already present in the minds of young children and their parents (Andre et al., 1999; Tenenbaum & Leaper, 2003). Andre, Whigman, Hendrickson, and Chambers (1999) examined the attitudes and beliefs about science held by young elementary school students and their parents. Participants consisted of 138 boys and 119 girls in grades K-3rd as well as 171 parents. Both children and parents filled out questionnaires. The student questionnaire consisted of 12 items that focused on four subject areas: mathematics, reading, life science, and physical science. The survey assessed three attitudes or beliefs: perceived self-competence in each subject matter, their degree of liking for the subject, and the degree to which they perceived jobs that used the subject matter to be male or female dominated. The response choices consisted of a smiling face (labeled "Good"), a neutral face (labeled "It's OK"), or a frowning face (labeled "No, I don't like it"). Perceived job occupations response choices consisted of children choosing generic representations of males and/or females. The parents' survey was similar; it assessed each parent's perception of the importance of the subject matter for the child, and how well

parents expected their children to perform in each subject. The results indicated that there was a significant difference in parent perceptions of the abilities of their child based on the child's gender. Parents perceived boys as more capable in science than girls (Andre et al., 1999). They also considered science to be more important for boys and expected higher science-related achievement of boys than girls. Finally, parents demonstrated traditional sex-role stereotyping of occupations. These parental perceptions could potentially impact the approach parents take in discussing science with their child as well as the informal science-learning opportunities they provide for their children.

In contrast to parents' highly gender-typed attitudes, the children's self-reports did not reveal any gender differences in their own competency beliefs or liking of science (Andre et al., 1999). Children did, however, display gender-role stereotypes with regard to occupations. Both boys and girls rated jobs related to math, life science, and physical science as male dominated. This suggests that at a very young age, children already stereotype jobs that related to science as male professions. Although young children do express gender stereotypes regarding science professions, they do not yet exhibit gender differences in their own personal beliefs regarding their science abilities or liking of science.

Tenenbaum and Leaper (2003) extended Andre et al. (1999)'s findings by exploring gender-typed views of science amongst older children and their parents. They found the family to be an important factor in shaping children's beliefs about gender differences in science domains. Fifty-two adolescents between the ages of 11 and 13 years participated with their parents. Parents and children completed questionnaires designed to measure both the parent's and child's attitudes and beliefs regarding the child's science ability and interest. Each parent also engaged their child in four tasks; two of these activities were science related. Researchers

videotaped the activities and then coded for the number of causal explanations, conceptual questions, and vocabulary used by parents and children. They found that parents thought science was less interesting and more challenging for girls than boys. This finding was particularly compelling in that there were no differences in children's science-related behaviors or grades (Tenenbaum & Leaper, 2003). This is consistent with Andre et al. (1999)'s finding that in the lower elementary grades parents perceive boys as more competent in science than girls regardless of their child's ability or beliefs. It also confirms findings from Bhanot and Jovanovic (2009) which indicated that even though there are not typically gender differences in science grades in middle school, parents of boys tend to overestimate their child's science ability more than parents of girls.

Another important finding from Tenenbaum and Leaper (2003) indicated that fathers tended to use more cognitively demanding speech with sons than daughters. In contrast, mothers did not differ in their speech patterns based on their child's gender. This suggests that fathers might be influencing their children's learning environment differently based on the child's gender. If parents assume different attitudes toward their children's science abilities based on the child's gender, this could impact these children's science-related experiences, as the family is an important learning context. However, it is important to note that these beliefs are affecting children much earlier than adolescence. Andre et al. (1999) demonstrated that parental perceptions regarding gender differences in young children's science ability and interest has emerged well before middle school. These findings suggest that the beliefs and attitudes of parents may be contributing to the gender difference in science-related interests that is evident at both the middle school and preschool level.

Jones, Howe, and Rua (2000) demonstrated that gender differences in science-related interests are evident during the middle school years. Jones, Howe, and Rua (2000) determined that not only do boys express greater levels of interest in science than girls, they also express differences in the types of science domains they report as being interesting. A total of 437 sixth grade students from five schools participated in this study. Each student completed a survey designed to elicit his or her perception of science and scientists, out of school experiences, science topic interests, and characteristics of future jobs. Findings demonstrate that males reported significantly more interest in learning about science topics than did females. Further, the topics of interest differed by gender. Males indicated higher levels of interest in physical science areas, whereas girls exhibited greater interest in biological science. Males also reported more extracurricular experiences with a variety of tools including batteries, fuses, microscopes, and pulleys. Females were significantly more likely than males to report that science was difficult to understand, whereas both genders indicated that science was “more suitable” for boys. These findings indicate that by adolescence, children’s science-related interests vary by gender. Males and females exhibited differences regarding their level of interest in science, the types of science domains that were of interest to them, and their beliefs about the difficulty of understanding science concepts. These adolescent science-related perceptions mirror the beliefs that children’s parents typically express regarding their child’s capability in science during the preschool years (Tenenbaum & Leaper, 2003). This shift in perspective from a child’s viewpoint is evident once they reach early adolescence. However, it could have received its foundation earlier in children’s science-related conversations and experiences with parents during the elementary and preschool years.

Most studies of gender differences in children's science-related interests use self-report methodologies. Although less common, observational approaches produce findings that converge with those obtained using self-report methodologies. For example, Greenfield (1995) examined the relative attraction of hands-on, interactive science museum exhibits for boys and girls. Six visits were made to a science museum in Honolulu, Hawaii. During each of these visits Greenfield observed the behaviors of adults and elementary school-aged children, both together and in isolation from each other. The goal was to determine whether participants demonstrated gender differences in their interest in each exhibit. The exhibits observed included 10 that focused on human body, 10 that illustrated physical science concepts, 10 puzzles, and 8 computer games. Overall, Greenfield demonstrated that school-aged boys' and girls' often tend to focus on different aspects of interest in informal science-learning environments. She observed that more boys than girls actively worked with the science exhibits. Further, gender differences were also apparent in children's interest in each exhibit. Girls were more likely than boys to use puzzles and interact with exhibits focusing on the human body, whereas boys were more likely to use computers and exhibits illustrating physical science principles. These findings coincide with Jones et al. (2000) who indicated that early adolescent males tend to express high levels of interest in physical science, whereas girls are often more interested in biological science. Findings also indicated that when children were accompanied by parents, the gender differences were still present but to a lesser extent. Visiting museums with parents may help children broaden their science-related interests. In sum, this study suggests that by the time children reach elementary school, boys and girls often express different interests regarding science topics.

Johnson, Alexander, Leibham, and Neitzal (2004) furthered the Jones et al. (2000) and Greenfield (1995) research regarding children's interest in science concepts. Johnson et al.,

(2004) explored emerging and sustained interest in science domains with young children. Participants in this study included 90 girls and 125 boys all of whom were 4 years old. Each child attended a laboratory testing session with his or her parents. Parents completed the “Play Behavior Questionnaire” which asked questions about their children’s preferred play activities, play interests, and their level of focus on their interests. Parents were then contacted two and four months later by telephone to provide updates on their child’s play interests and the degree to which they were focused. They discovered that there is a complex interplay of factors related to a young child’s sustained interest in conceptual domains. While keeping in mind that many interwoven factors predict preschoolers’ maintenance of interest, findings indicate that preschool-aged boys expressed more interest in science domains than preschool-aged girls. The results indicated that boys were six times more likely than girls to manifest interests in conceptual domains, and that the majority of these conceptual interests fell within the realm of science domains. These science interests included biological and physical domains. For example, interest in these two science domains included concepts such as bugs, dinosaurs, engines, and plant growth. Girls in this study were equally focused in the sustained interests they maintained over the course of four months; however, these interests were generally aligned with the domains of art and social relationships (Johnson et al., 2004). Findings from this study suggest that boys at this age seem to express greater interest in science domains than girls.

How Child Gender Relates to Family Science Practices

As shown in the previous section, there are well-documented gender-related differences in both parents’ and children’s attitudes toward, and interest in, science. As a result, it is important to consider whether parents of boys and girls differ in their provision of opportunities for informal science learning and in the ways they engage science in the opportunities they do

support. Alexander, Johnson, and Kelly (2012) explored whether parents offered opportunities to participate in science-related informal learning environments more frequently to preschool-aged boys than girls. Participants included 215 children who were all 4 years old at the beginning of the study; this longitudinal study continued until the children were 7 years old. Alexander et al. (2012) recruited participants from children's museums, daycare centers, preschools, and pediatrician offices from a community that they report as being ethnically and socioeconomically diverse. Parents and children attended a research lab session where each parent completed a "Community and Home Activities Related to Science Questionnaire" while the children participated in unrelated laboratory assessments. Researchers gathered further data regarding children's science interests through bimonthly telephone calls. The results of this study revealed that boys expressed significantly higher levels of science interest than girls at all ages, and that for both genders interest in science at early ages predicted later science interests. Interestingly, however, whereas boys' levels of interest declined slightly from 4 to 6 years of age, girls' interest levels remained consistent, albeit small, across the age span. Alexander et al. (2009) also discovered that early informal science opportunities predicted later opportunities to engage in science-related experiences for both boys and girls. Researchers found gender differences in terms of frequencies of opportunities for science-learning during all three years. When girls exhibited an interest in science, parents tended to provide more science-learning opportunities. However, boys received opportunities for science learning regardless of whether or not they expressed an interest. This study suggests that the gender differences evident in children's early science interests and informal science opportunities could have important implications for later science learning.

The Alexander et al. (2012) study demonstrates that parents offer preschool boys' more informal science-learning opportunities than girls. However, it is also important to explore whether parents are engaging with boys and girls differently while they are in these environments. Crowley, Callanan, Tenenbaum, and Allen (2001b) videotaped 298 families with children whose ages ranged from 1 to 8 years as they engaged with interactive exhibits at a California children's museum. Coding focused on the following three categories: parents' explanations, parents' direction-giving, or parents' talk about evidence. Coding also indicated who initiated engagement with the exhibit and whether or not the child actively participated with the exhibit. Results revealed that parents were three times more likely to explain science concepts to boys than girls. This finding could not be explained by any gender differences in children's science-related questions as boys and girls did not differ in the number of questions they asked (Crowley et al., 2001b). This important finding suggests that parents may be subtly directing their child's science-related thinking in different ways based on the child's gender. For example, Frazier et al. (2009) demonstrated that parental explanatory responses are more likely than non-explanatory answers to elicit further child questioning and interest regarding the topic. Because children's interactions and experiences involving science often occur with their parents, parent-child conversations can have a strong impact on children's interest in science (Frazier et al., 2009).

Conclusion

The underrepresentation of women employed in science-related careers is evident; research has traced this pipeline to high school and middle school-aged children (Bhanot & Jovanovic, 2009; National Science Foundation [NSF], 2010). However, this disparity may be originating in children's initial experiences with science. In reviewing the existing literature on

preschool children's science learning, it becomes evident that a child's gender might influence their early experiences. Family practices, such as trips to the museum or zoo as well as parent-child conversational interactions, may support or discourage a child's interest regarding science-related topics. Family interaction in the context of naturally-occurring conversations is an area that still needs further exploration. In addition, although it has been demonstrated that gender differences exist in children's opportunities for informal science learning, there is a very limited amount of information on this issue.

The purpose of the present study was to determine whether and how gender influences preschool-age children's science-related opportunities, interest in specific science domains, and conversational interactions involving science. I examined whether preschool-aged boys and girls were offered different opportunities for informal science-learning, as well as whether boys' and girls' science-related conversations with their parents varied based on the child's gender. I chose to explore both parent-child conversations and family routines of informal science-learning because each topic encompasses a different aspect of a child's early science experiences. The focus on informal science-learning opportunities targeted the science activities that parents provided for their children, whereas the emphasis on parent-child conversations offered an example of how parents actually interacted with their child as well as the topics of science children were interested in talking about. It is important to include both of these areas; simply directing attention to one of these facets does not provide a robust understanding of early science experiences.

CHAPTER TWO

METHOD

The methodology of this project is described in two parts. Part One describes a survey approach designed to gather information regarding preschool children's informal science-learning opportunities. Part Two describes a diary study protocol that examined family engagement in conversations about science-related topics. Each of these parts is a component of a larger ongoing investigation of young children's science-related experiences led by Dr. Jennifer Jipson, Cal Poly Associate Professor of Psychology and Child Development.

Part One: Informal Science-Learning Opportunities

Participants. Participants included a total of 54 families with children between the ages of 3- and 5-years old. Parents of 31 girls and 23 boys completed the "Family Routines" survey; this survey asked them to report their children's informal science-learning experiences. This sample of families consisted of children and their parents who visited the San Luis Obispo Children's Museum in California, as well as families who completed this measure as a component of the previously mentioned two week diary study. Researchers recruited families from the museum on three Saturdays when the museum was previewing four new exhibits. Participants from the diary study completed this measure during a visit to their family home as another aspect of the larger project, the "diary study" process. The majority of families were from European-American backgrounds.

Procedure. Upon arrival at the museum, all participating families agreed to allow themselves to be videotaped while interacting with the new exhibits the museum was pilot testing. When leaving the museum, researchers invited parents to complete the survey. Diary

study families responded to the survey during a home visit. This study focused solely on responses to a portion of the survey relevant to family science-learning routines.

Measures. Researchers provided parents with a survey containing items related to their family background and their children's everyday experiences with science. This survey included questions that assessed the frequency with which children engage in science-related informal learning. Parents completed the 12-question survey that focused on the science-learning opportunities their children had experienced during the past year. A four-point scale invited parents to indicate the frequency with which they engaged in various activities with their children, as follows: (0) Never, (1) Once or Twice, (2) Several Times, or (3) Often. Four of the twelve questions were directly related to science activities. Examples included: "In the last year, has your child ever...gone to a science museum? read a science-related book? watched a science-related television program?" The remaining questions also pertained to informal science learning environments. They included question such as, "How often in the past year has your child gone to a zoo or aquarium?" and "How often in the past year has your child gone to a planetarium or observatory?" Further questions referred to the frequency of trips to the beach, national parks, the playground, or an amusement park. For the full survey, please see Appendix A. Although several of these activities were not directly structured to promote science-learning, such as trips to the playground or amusement parks, opportunities to learn about science are still present at these venues. It is possible for children to visit a science museum and not discuss science concepts, yet outdoors at the playground they might engage in science-learning frequently. Thus, each of these activities or venues was classified in the present study as an informal science-learning activity in order to provide a holistic view of opportunities for early science exploration.

Part Two: Parent-Child Conversations About Science

Participants. Participants included 25 preschool-age children and their families. Five 3 year-olds (m = 2, f = 3), thirteen 4 year-olds (m = 3, f = 10), and seven 5 year-olds (m = 3, f = 4) and their parents participated. Researchers recruited families from local preschool and daycare centers. The majority of children were from European-American backgrounds.

Procedure. Researchers conducted home visits with each family to give them instructions regarding the study and videotape the parent and child reading two science-related books. Participating parents agreed to keep track of their child's questions, observations, or ideas about the natural world for two weeks on forms provided for them by the research team. The forms requested that the parents indicate the time and date of the conversation, the person who initiated the conversation (e.g. mother, father, child, friend), how the conversations started (e.g. by someone asking a question or making an observation), the situation in which the conversation occurred, and the child's prior interest in the topic of conversation. It asked the parent to write down as much of the conversation as they could remember; it also instructed them to use direct quotes whenever possible. For a sample form, please see Appendix B.

After a researcher explained the conversation documenting process, one of the parents then read two science-related books with the child, while being videotaped. Researchers left the parents with the binder of forms to record their child's conversations about the natural world for two weeks. In addition, a researcher contacted each family every three days during the two week period to document any additional conversations that had transpired that the parent had been unable to record. At the end of two weeks, researchers contacted each family again to schedule a time for the researcher to pick up the binder of forms from their house.

Topics coding. Researchers examined each reported conversation and classified the topic into eight categories: (1) Plants (e.g. flowers, trees), (2) Animals (e.g. birds, insects, reptiles), (3) Human body (e.g. illness, injuries, health), (4) Ocean (e.g. waves, tides), (5) Astronomy (e.g. moon, stars, constellations), (6) Geology (e.g. rocks), (7) Weather (e.g. fog, rain, wind), (8) Other Physics Concepts (e.g. gravity, energy conservation). Reliability between coders using Cohen's kappa as the agreement statistic was $K = .875$.

Coding of parent-child utterance types. Researchers coded children's conversations for the types of utterances that occurred. As described below, categories included: asking questions, offering information, and suggesting activities related to science or nature. Two coders independently coding 20% of the conversations achieved interrater-reliability of $Kappa = .856$. The current coding categories constituted an initial step in a more elaborate coding process that will be used to further analyze the data. Coding categories consisted of:

<i>Parent Question (PQ)</i>	Parent asks child question relevant to science/nature (e.g. "What makes the moon change shape?" "Do you notice anything different about the trees?").
<i>Child Question (CQ)</i>	Child asks question relevant to science/nature (e.g. "Why do swordfish have long noses?" "What do lions and tigers eat?").
<i>Parent Information (PI)</i>	Consisted of a parental response to a question, a parent offering unsolicited information, parental confirmation of a child's statement, or a parent negates a child's statement. This category included responses such as a simple response to a question (e.g., "yes," or "no"). It also consisted of more complex responses that give a causal explanation for a science phenomenon (e.g., "Plants need light because they turn light from the sun into food."). Describing immediate evidence (e.g., "Tonight there is a full moon."), offering science facts (e.g., "Dinosaurs and animals that ate only plants were called herbivores."), making prediction (e.g., "I think we will see the sun go down behind the hill."), and labeling objects (e.g., "Horses.") were all utterances that were included in the parent information category.

	Thus, the “Parent Information” utterance category consisted of a broad range of parental conversational techniques. An utterance coded as “Parent Information” could vary widely in its level of complexity at this basic level of coding.
<i>Child Information (CI)</i>	<p>Identical to “Parent Information,” this category included a child response to a parental question, child offering unsolicited information, child confirms another’s statement, or child negates another’s statement.</p> <p>This category included responses such as a simple response to a question (e.g., “yes,” or “no”). It also consists of more complex responses that give a causal explanation for a science phenomenon (e.g., “It gets dark because the earth spins around the sun.”). Describing immediate evidence (e.g., “The big pinecones are not open yet.”), offering science facts (e.g., “Electric eels can sting you.”), making predictions (e.g., “I think the moon will get bigger.”), and labeling objects (e.g., “Trees.”) were all utterances included in the child information category. Similar to “Parent Information,” the “Child Information” category included a broad range of approaches to sharing information. In addition, an utterance coded as “Child Information” could vary widely in its level of complexity at this basic level of coding.</p>
<i>Parent Suggests Activity(PA)</i>	Parent suggests an activity related to science/nature. (e.g. “Pick out a pinecone to take home so we can let it dry and see if we can find any seeds inside.”).
<i>Child Suggests Activity (CA)</i>	Child suggests an activity related to science/nature (e.g. “Let’s go watch the sunset.”).

CHAPTER THREE

RESULTS

The results of this study are separated into three sections, each one focused on different aspects of how child gender may relate to early science learning experiences. First, I analyzed family routines regarding children's opportunities for informal science learning using data from the parent surveys. Next, I explored parent-child conversations about science-related topics by examining the diary-reports. Finally, I investigated the parent-child conversational techniques used to discuss science-related concepts.

Family Informal Science-Learning Routines

The parent survey asked parents to report on the frequency with which they engaged in different informal science-learning activities, ratings could range from 0 (Never) to 3 (Often). As illustrated in Figure 1, the two activities that these preschool-aged children engaged in most frequently were trips to the "Playground" ($M= 2.86$) and the "Beach." ($M= 2.76$). These were followed by reading a "Science Book" ($M= 2.26$), "Gardening" ($M= 2.14$), and watching "Science TV" ($M= 1.98$). Other informal science activities that parents reported engaging in with their children included visiting a "Children's Museum" ($M=1.67$) and going to the "Zoo" ($M= 1.67$). Science routines that parents reported less engagement with included attending an "Amusement Park" ($M= .76$) and visiting a "Science Museum" ($M= .49$). Participating parents rarely reported that they visited a "Planetarium" ($M= .09$).

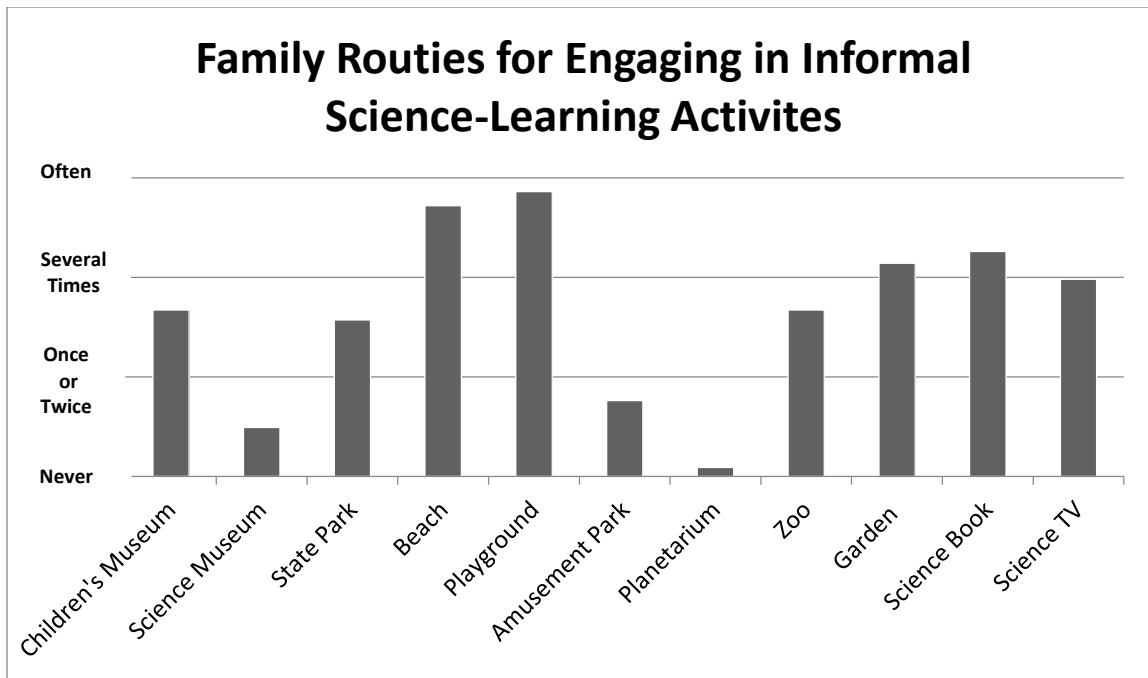


Figure 1: *The means of how frequently families engage in specific informal science-learning activities.*

Informal science-learning opportunities by gender. To explore gender differences in children's opportunities to engage in informal science-learning activities, I compared results from the parent survey responses via a 2(Gender) x 11(Informal Science Activity) repeated measures analysis of variance (ANOVA) with gender as the between-group factor and science-learning environment as the within-group factor. There was not a significant effect of gender, $F(1,54) = 2.32$ $p = n.s.$ Thus, for this sample of families, gender did not impact the informal science-learning opportunities that parents provided their children. However, as illustrated in Figure 2, several trends emerged when examining the mean number of opportunities children were provided for each individual learning activity. Parental responses indicated that girls may be slightly more likely to attend children's museums and zoos than boys, whereas boys might be more likely than girls to visit a science museum, state park, or planetarium. Another emergent

trend suggested that boys might be more likely than girls to engage in reading a science book or in watching science television.

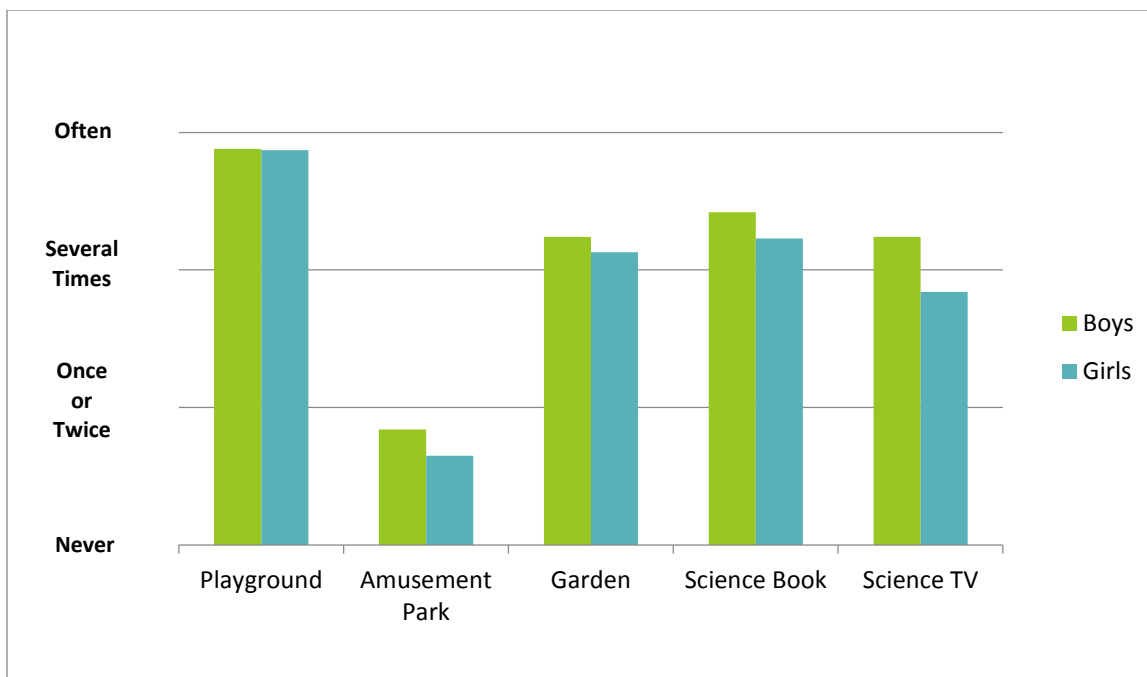
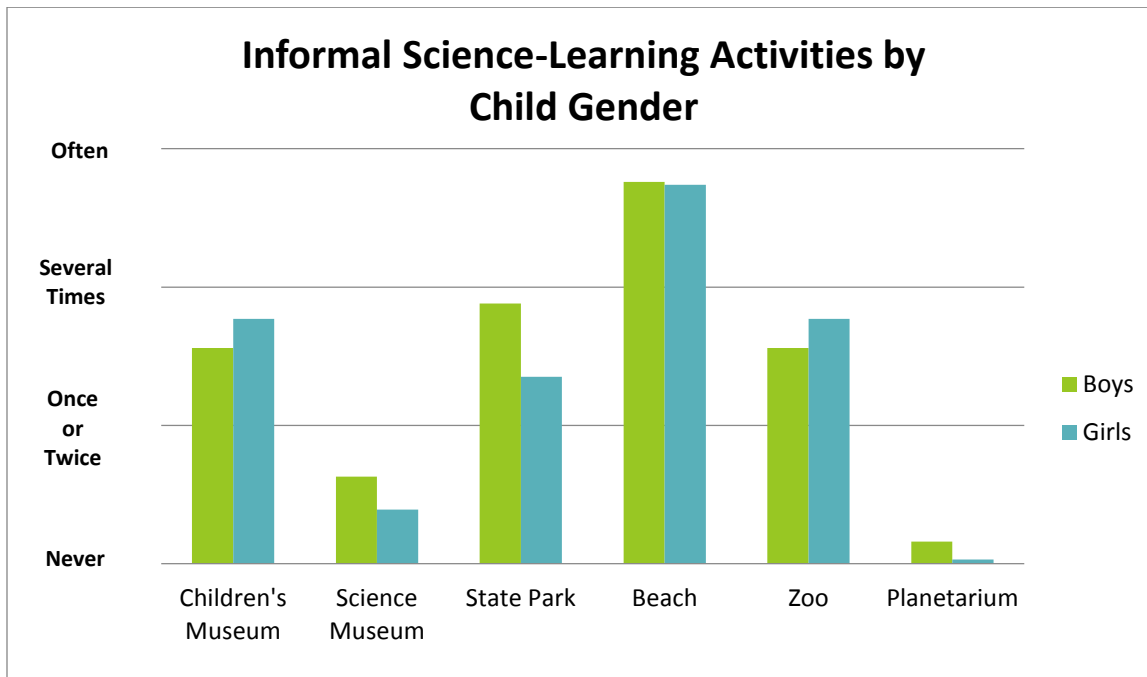


Figure 2: The means of how frequently boys' and girls' experience informal science-learning activities.

Because a trend emerged suggesting that boys might be reading science-related books and watching science television more frequently than girls, I collapsed several categories to create three broad categories of informal science-learning experiences. The category “Designed Informal Science Environment”(children’s museum, science museum, planetarium, and zoo) included learning environments that were specifically designed with the idea of promoting science-learning. “Home Informal Science Environment” (science book and science TV) consisted of science-related activities that parents and children typically engage in at home. The last category, “Natural Informal Science Environment ” (beach, state park, and gardening) included naturally occurring environments that might elicit science-learning. I did not include playground or amusement park in this analyses because these venues seemed the least likely to be specifically designed with the intention of evoking science-learning. I conducted one-way ANOVAs for each category of family science routines to determine if gender impacted their frequency of occurrence. Even after I grouped informal science-learning activities into these categories, there were still not significant differences in parental reports of family practice based on child gender.

Children’s Science Conversations

Frequency of parent-child talk about nature. The total number of recorded interactions for children in this study was 319 conversations. The overall mean number of conversations per family was 12.76. However, the number of conversations families reported ranged widely (range: 4 to 29 conversations). I performed a t-test to discover if parents of preschool-aged boys reported the same amount of conversations as parents of preschool-aged girls. There was not a significant difference in the mean number of boys’ ($M = 10.13$, range: 9 to 27) and girls’ ($M =$

12.11, range: 4 to 29) conversations. Thus, parents are reporting that boys and girls at the preschool age typically engage in conversations about science with similar frequencies.

Conversational topics. I explored family conversations about different topics by first recognizing the variability in the number of conversations each family reported. For each family, I calculated the mean percent score for the number of conversations in each topic category. Findings indicated that the most frequently discussed topic for these children was “Animals” with a mean percent of overall conversation that equaled 44.26%, followed by “Astronomy” (17%), and “Plants” (17%). In addition, families also discussed “Weather”(7.8%), “Other Physics Concepts”(5%), “Natural Water” (3.9%), “Human Body” (3.1%), and “Geology”(1.8%).

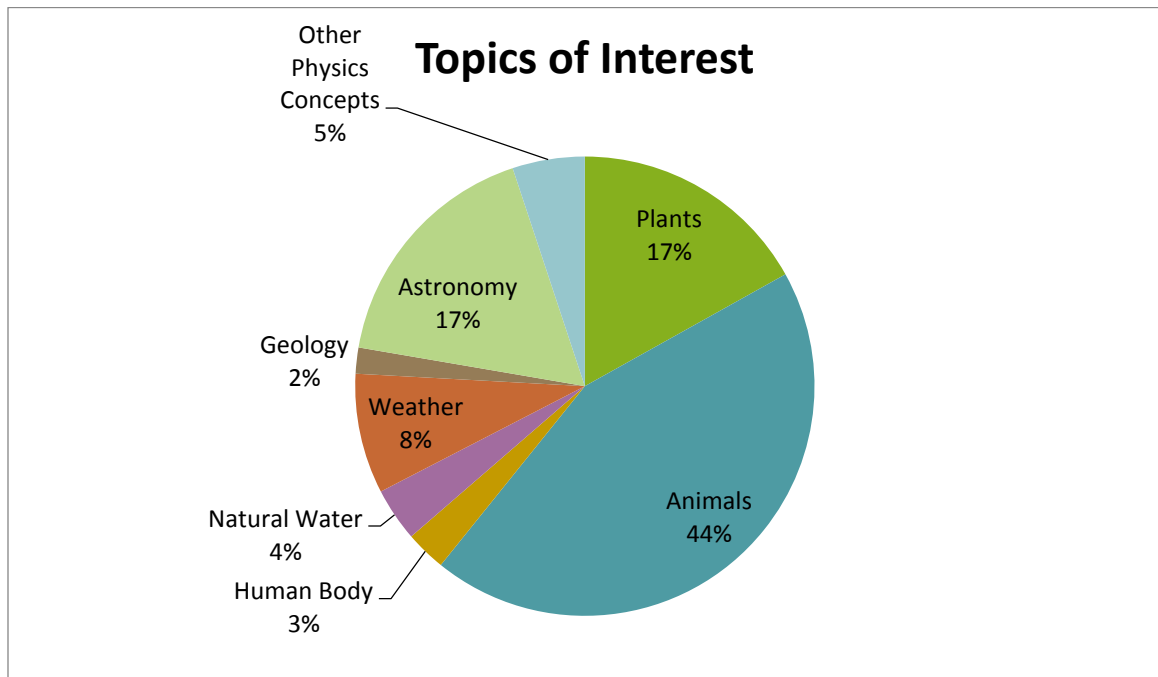


Figure 3: How often children discuss specific topics based on the mean percent of occurrence of each topic in their conversational total.

Topics of children's conversations were then collapsed into categories of "Living"(Animals, Plants, and Human Body) and "Non-Living"(Astronomy, Weather, Natural Water, Geology, and Other Physics Concepts). As illustrated in Figure 4, children's conversations focused on "Living" topics 62% of the time. Examples of specific topics in the "Living" category included conversations that explored: "Where penguins live," "Babies and what they can eat," and "Flower petals needing water to grow." Children's conversations centered on "Non-living" topics 38% of the time. Examples of specific conversational topics that focused on "Non-living" phenomena included conversations that explored: "Why a planet is not a star," "The concept of evaporation," "Clouds and rain," and "The sun making shadows." Thus, it is evident that preschool-aged children are discussing "Living" science phenomena more often than "Non-living" phenomena.

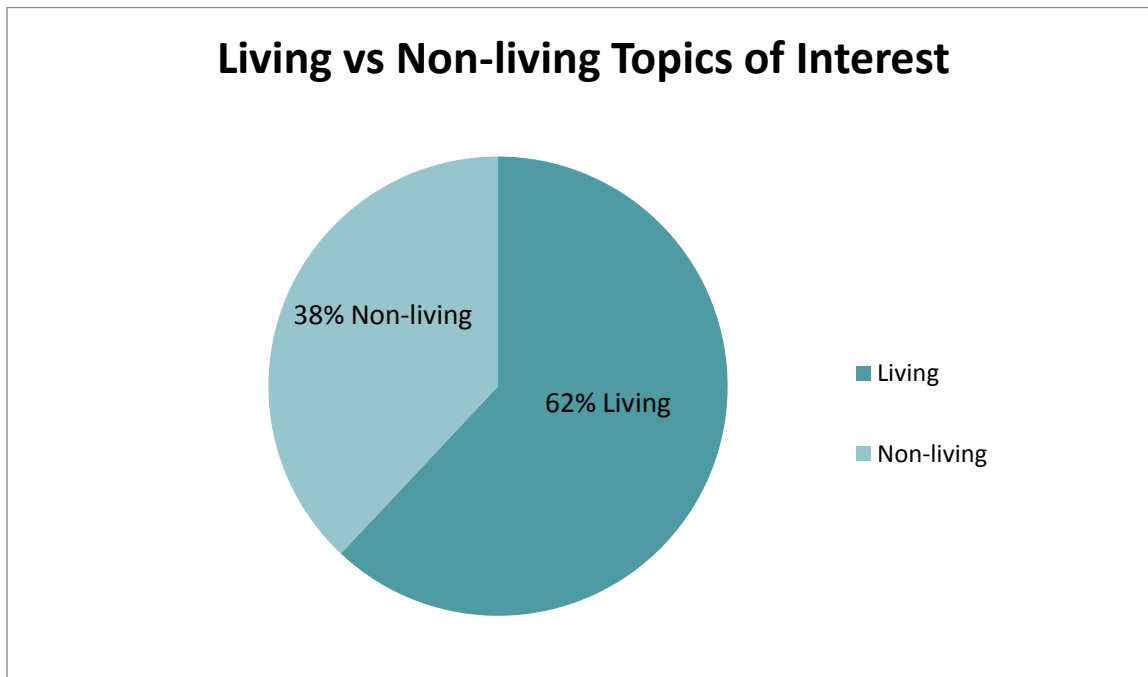


Figure 4: Mean percent of children's conversational topics that focused on "Living" or "Non-living" phenomena.

Conversational topics by gender. I analyzed conversational topics to investigate whether child gender played a role in topics discussed. I compared girls' proportion of talk about each topic and boys' proportion of talk about each topic using individual t-tests for each topic. No significant differences emerged based on the child's gender. Results indicated that preschool-aged children of both genders seem to be talking about each topic with similar frequency (see Figure 5). However, despite the finding that for both boys and girls "Animals" was the most prevalent topic discussed, differences in the proportion of boys' talk versus the proportion of girls talk about "Animals" approached significance. An individual t-test indicated that boys may be more likely to talk about animals than girls, $t(23) = 10.03$, $p = .076$. The topic of "Human Body" also approached significance, with girls discussing this topics more frequently than boys, $t(23) = 16$, $p = .055$. Ongoing analyses of a larger sample of conversations are currently in the process of being coded to examine whether there is further support for these trends suggestive of gender differences in interest in "Animals" and "Human Body" during the preschool years.

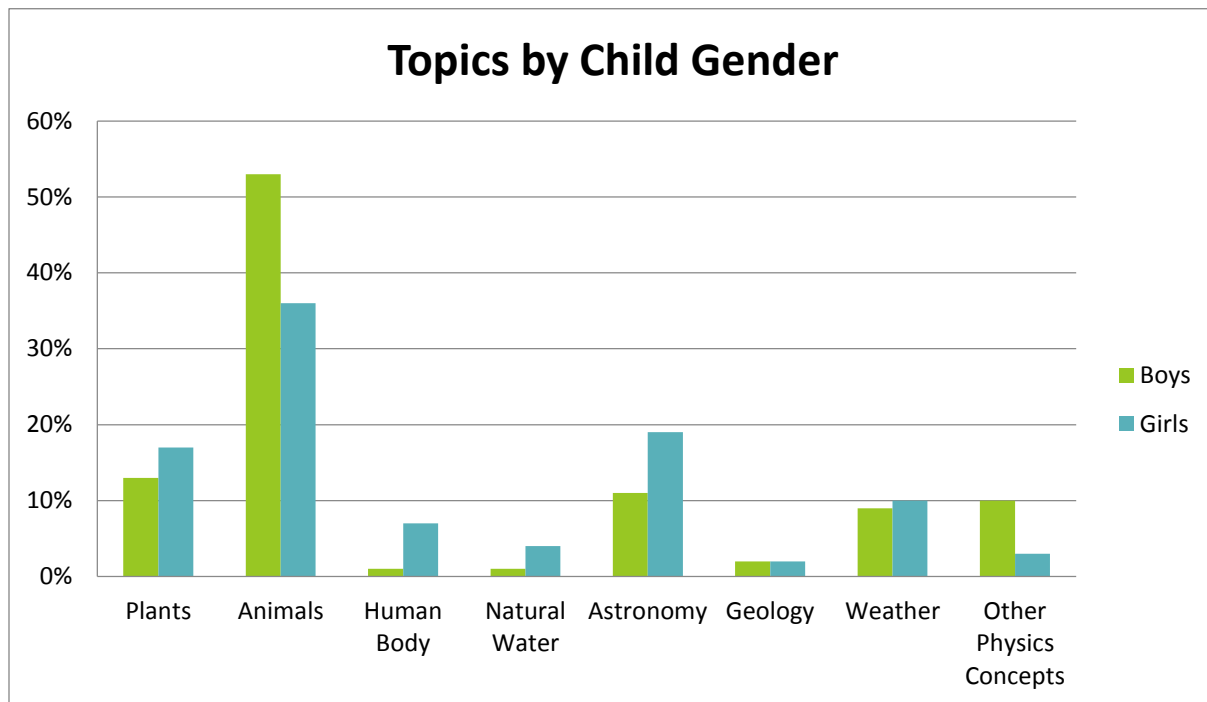


Figure 5: Mean percent of children's talk about science topics by gender.

I next examined the possible effects of child gender on conversational topics by again collapsing topics into “Living” and “Non-living” categories and analyzing these topics by gender. A t-test indicated that there was not a significant effect of gender on conversations about these categories. As illustrated in Figure 6, the mean proportions indicated that boys talked about “Living” science phenomena 67% of the time and girls talked about these topics 60% of the time. “Non-living” science phenomena were discussed in 33% of boys’ conversations and 40% of girls’ conversations. Thus, boys and girls appear to be talking about living and non-living science phenomena with similar frequency.

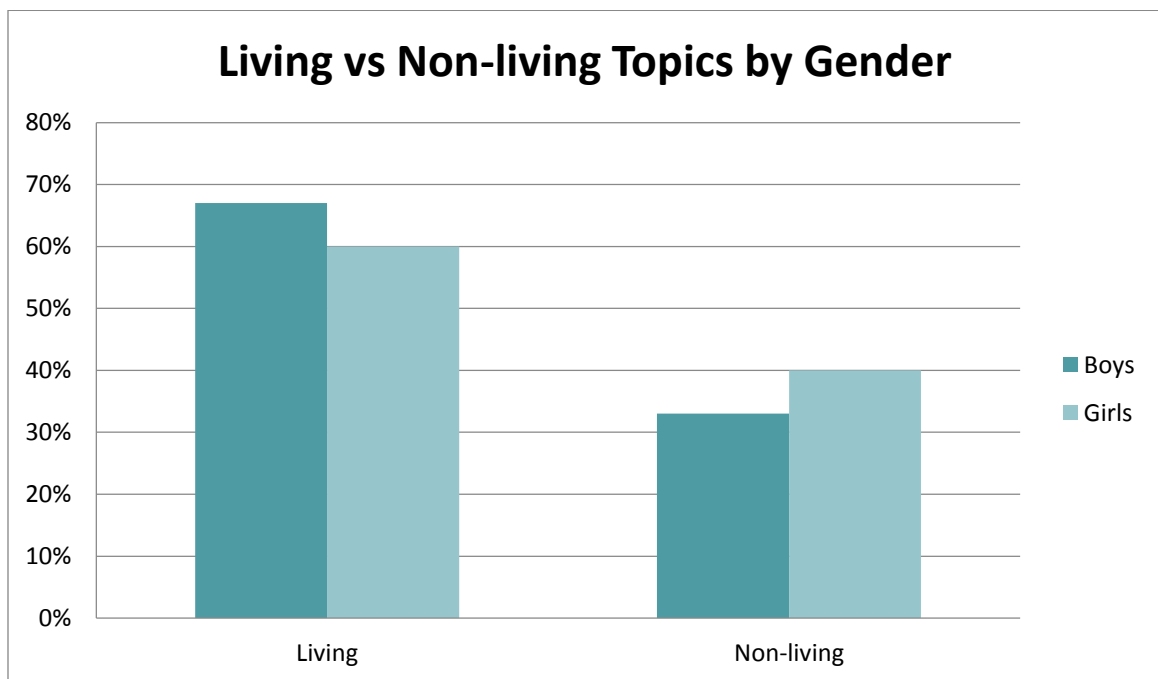


Figure 5: Mean percent of living vs non-living conversational topics by child gender.

Types of Parent-Child Conversational Utterances

Results indicated that the average number of utterances each family reported was 65.16 utterances (range: 17 to 152). This indicated substantial variability between families, suggesting that not all families in this sample discussed science-related topics to the same extent. I then

analyzed the types of utterances that occurred in the parent-child conversations including parent utterances (parent question, parent offers information, parent suggests activity) and child utterances (child question, child offers information, child suggests activity) based on the mean percent of times they occurred for each family. Table 1 gives examples of actual conversational utterances that were coded in each category.

Table 1: *Examples of Utterances from Diary Study Conversations*

Type of Utterance	Examples
Parent Information (PI)	<ul style="list-style-type: none"> • “Plants need light from the sun to make food.” • “Moths are attracted to light.” • “Yes, you’re right.”(Confirmation) • “I don’t know.” • “Tonight there is a full moon.” • “No, those aren’t shells.” (Negates) • “Swordfish have long noses to protect themselves.”
Parent Question (PQ)	<ul style="list-style-type: none"> • “Why do waves go back and forth?” • “Where do you think the moon will be in the sky tomorrow?” • “What’s that?” • “What do the flowers look like?” • “Is that a bumblebee?” • “What will you do with the leaves?”
Parent Suggests Activity (PA)	<ul style="list-style-type: none"> • “Pick out a pinecone to take home so we can let it dry and see if we can find any seeds inside.” • “Look over there!”(Directs attention) • “Let’s go watch the sunset.”
Child Information (CI)	<ul style="list-style-type: none"> • “Eels can shock you.” • “The big flowers aren’t open yet.” • “No, it’s rain.” (Negates) • “I like the big shells.” • “The ants are going down in the hole because they live under the tree in the ground.” • “Horses!” (Labeling)

Child Question (CQ)	<ul style="list-style-type: none"> • “Why is a planet not a star?” • “What do lions and tigers eat?” • “Why?” • “Why do avocados have seeds in the middle?” • “What are the cows doing?” • “Where do penguins live?” • “How do they do that?”
Child Suggests Activity (CA)	<ul style="list-style-type: none"> • “Look!” (Directs attention) • “Let’s follow the frog.” • “I am going to use the binoculars to look for birds.”

Parent conversational utterances. Exploration of parent utterances using a series of t-tests indicated that the percent of talk in which parents offer information ($M = 33\%$, $SD = .15$) is larger than the percent of talk in which parents ask questions ($M = 9\%$, $SD = .07$), which in turn is more likely to occur than parents suggesting activities ($M = 2\%$, $SD = .03$). A series of planned comparisons confirmed that each of these means is significantly different from the others at $p < .016$. The strength of this relationship indicates that in parent-child conversations, parents offer information during most of their speaking time, and ask questions or suggest activities to a lesser extent.

To investigate whether parents offered information, asked questions, or suggested activities to children to different extents based on the child’s gender, I compared the mean percent of each utterance type for parents of boys and parents of girls using a series of independent samples t-test. None of the analyses suggested a significant difference for any of the three types of utterances based on the child’s gender. As illustrated in Figure 6, parents of preschool aged children in this sample reported offering fairly equivalent amounts of information to boys ($M = 31\%$) and girls ($M = 35\%$), asking a similar number of questions to boys ($M =$

9.8%) and girls ($M = 10\%$), and suggesting activities with similar frequency for both boys ($M = 2.6\%$) and girls ($M = 1.5\%$).

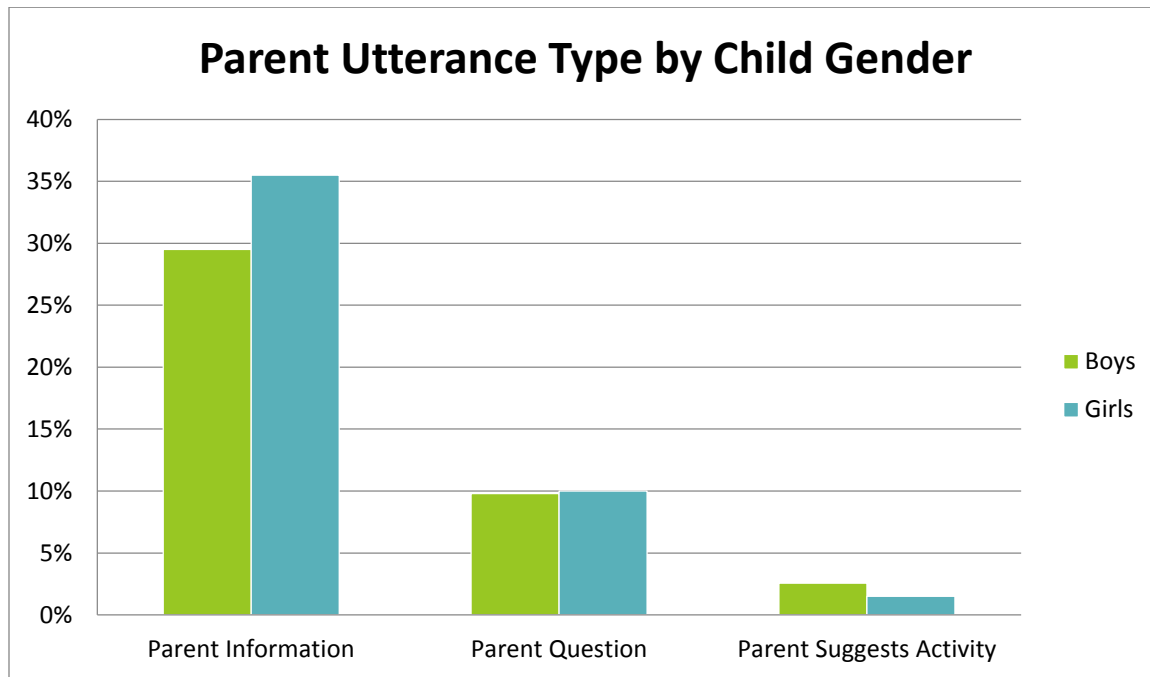


Figure 6: Mean percent of parental talk for boys and girls.

Child conversational utterances. I analyzed the child conversational utterances in an identical manner as the parent utterances. I first calculated the mean percent of each type of child utterance. I then conducted a series of t-tests to compare the means. Results were similar to those of parent utterances. Children were significantly more likely to offer information ($M = 29\%$), than ask questions ($M = 17\%$). Additionally, they were more likely to ask questions than to suggest activities ($M = 5\%$). Thus, both parents and children contribute to conversations in similar ways, offering high levels of information sharing, followed by question asking, and infrequently suggesting activities.

Next, I examined whether a child's gender impacted the types of utterances they used in science conversations. A 2(Gender) x 3 (Utterance Type) ANOVA revealed that there was not a significant effect of gender on the type of utterances children exhibited during conversations

with parents. As indicated in Figure 7, parents reported that boys and girls offered similar amounts of information, asked an equivalent number of questions, and suggested activities with similar frequencies.

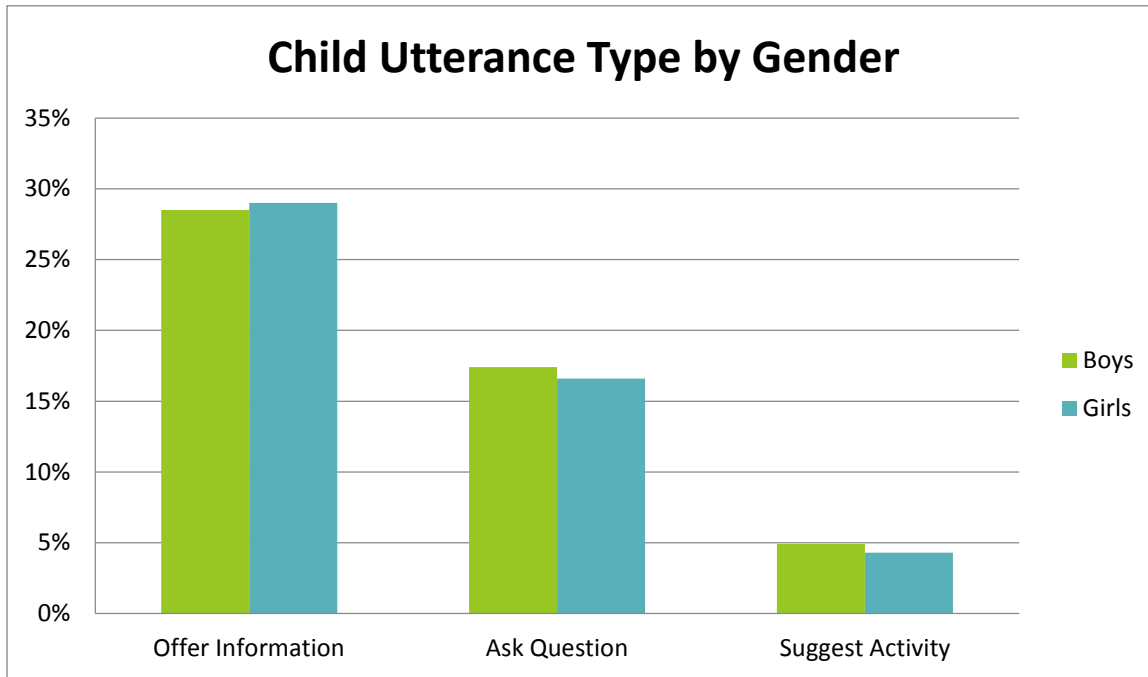


Figure 7: Mean percent of type of child utterance for boys and girls.

It appears that at this broad level of utterance coding, a child's gender does not impact the frequency with which they offer information, ask questions, or suggest activities related to science. Additionally, a child's gender did not have a significant impact on the frequency with which parents offer information, ask questions, or suggest activities in a science-related conversation. It is important to note that this was the first level of coding prior to enacting a more sensitive coding scheme. In the next phase of coding, each utterance category will be further defined in order to explore variations in the types of information provided, types of questions asked, and ideas for suggested activities.

CHAPTER FOUR

DISCUSSION

In these studies, I investigated preschool-aged children's participation in family routines for informal science-learning, the science-related topics children talk about with their parents, and the types of talk that children and parents engage in during naturally occurring conversations involving science. Findings from analyses investigating each of these topics did not indicate widespread gender differences in preschool-aged children's science-related opportunities or conversational experiences. This is surprising given that prior research suggests gender differences in children's experiences with science. There are many possible reasons to explain why this study did not reveal such gender differences. First, my measures might not have been sensitive enough. Second, sampling procedures may have resulted in the recruitment of families who were more egalitarian in their gender-based views than families who participated in prior work. Third, all of the measures were self-reported by parents, which could lead to misrepresentations of actual family science practices. Each of these possibilities is further discussed below as they relate to the particular research question under study.

Family Informal Science-Learning Routines

Part One of this study examined family routines for informal science-learning. Results indicated that the beach and the playground were the most common venues that both boys and girls visited with their families. The activities that occurred with the next highest frequencies were reading a science book, watching science television, and gardening. None of these top five activities included visits to venues specifically designed to teach children about science. Most of these activities were readily available to the participants, as San Luis Obispo, California, is an area near the beach and has a climate that promotes outdoor activities. Additionally, science

book-reading and watching science television are activities that typically take place in the home. This suggests that parents are offering their children informal science-learning opportunities that are inexpensive and close to home. For example, very few parents reported taking their children to a planetarium, yet there is not a planetarium near the location where this study took place. Thus, the availability and proximity of these venues might impact the frequency with which family routines for science-learning include visits to this type of environments.

When looking at the possibility that gender differences might exist in the amount of informal science-learning activities that families engage in with their boys and girls, the parental survey method did not indicate that parents provide boys with significantly more informal learning experiences than girls. Even activities specifically related to science such as visiting a science museum, reading a science book, or watching science television did not significantly vary by child gender. This is in contrast to the Alexander et al. (2012) study that found that preschool-aged boys were provided with more science-related experiences than preschool-aged girls. One reason the current study's data is not consistent with the Alexander et al. (2012) findings could be that the data used to answer this question came from a self-selected sample of families. One set of participating families had already agreed to engage in a two week diary study with their children, so they may have already had a bias in promoting science-learning in their children. The other set of families was surveyed while visiting a children's museum. This could reflect the possibility that the parents who chose to complete the survey were more likely to engage in informal science-learning activities with their children in the first place, as they were already visiting a children's museum. However, a portion of participants from the Alexander et al. (2012) study were also recruited at a children's museum, so this factor alone cannot fully account for the difference in results. Another reason could be that the majority of

parents who completed the survey in the current study were of European-American background, middle to high socioeconomic status, and lived in San Luis Obispo, California, and may have been more egalitarian in promoting gender equality than families in other communities.

These cultural and geographical factors, in combination with the idea that families who completed the survey were already taking steps to enhance their children's science-learning experiences by taking them to a children's museum and participating in a research study about science, could contribute to the lack of evidence of gender differences in this sample. Another explanation for the null findings may be that this study consisted of a smaller sample of families than the Alexander et al. (2012) study. I am in the process of collecting further data on this topic to extend the study's sample size. Finally, because the Alexander et al. (2012) study is the only readily available literature on this phenomenon, the effect of gender on children's opportunities to visit informal science learning environments may not be robust. This could be considered good news. If, in some populations, preschool-aged boys' and girls' opportunities for informal science-learning are equal, then there are opportunities to foster interest in science in preschool-aged girls. If expanded upon, this could form the foundation for female interest in science-related fields later in life. The focus might shift to how we keep girls engaged and interested while visiting these environments or participating in these activities. However, further exploration of this topic is necessary before drawing any definite conclusions regarding preschool-aged boys' and girls' opportunities for informal science-learning.

Although it is possible that parents provide similar opportunities for both boys and girls at the preschool age to experience science-related activities, Jones, Howe, and Rua (2000) demonstrated that by middle school boys have more experience with science-related activities than girls. The results from the current study suggest that this difference may emerge after

children enter school and not during the preschool years. An important extension of the current study would be to analyze the data further to determine if age impacts the frequency in which boys and girls are offered science-learning opportunities. This would aid in determining whether, and at what age, gender differences in opportunities for informal science-learning emerge.

Conversational Topics

Results from the diary study conversation reports indicated that the top three science concepts preschool-age children in this sample most frequently discussed were “Animals,” “Astronomy,” and “Plants.” “Animals” was the most prevalent topic of science-related conversation for children in the 3- to 5- year age range, encompassing almost half of all science-related conversations. Additionally, parents reported that their preschool-aged children are more likely to discuss “Living” as opposed to “Non-Living” topics.

Further analyses indicated that preschool-aged boys and girls in this sample were interested in talking about the same types of science topics. Boys and girls did not differ significantly in the topics they discussed with their parents. However, trends emerged in the current data which indicated that boys talked more about “Animals” than girls, with a frequency that approached significance. Similarly, girls were marginally more likely than boys to discuss the “Human Body.” This early interest in the human body as suggested by the present study might lead to further interest in biological science later in life. Greenfield (1995) found that when visiting a museum, elementary school-aged girls were more likely to be interested in exhibits that focused on the human body versus other exhibits that centered around physical science or computers. Additionally, Jones et al. (2004) demonstrated that by the time children reach middle school, girls indicate higher levels of interest in biological sciences, whereas boys exhibit greater

interest in physical sciences. My sample suggested that this interest is starting to become evident for girls during the preschool years. Further research could explore if this was a topic that parents initiated with girls, or if preschool-aged girls were simply exhibiting a slightly higher level of interest. This would allow us to determine if, and to what extent, parents play a role in children's initial interest in a topic. In contrast to research based on older children, boys in my sample were not more likely to discuss physical or non-living science phenomena than girls. A trend emerged indicating that boys were actually interested in talking about animals. A limited amount of research has been done regarding the development of specific interest in science domains at the preschool age, so it is possible that non-living science domains do not become a prevalent interest for boys until elementary school. An interesting concept to explore further would be at what age this difference in interest in physical science domains develops. A larger sample of conversations is in the process of being coded in order to extend the data in the sample.

Types of Parent-Child Conversational Utterances

Finally, the present study examined the types of talk that parents and children use to discuss science-related concepts. Results suggested that parents were significantly more likely to offer information than ask a question when engaged in science conversations with their children. Additionally, they were significantly more likely to ask questions than suggest activities. Thus, the present sample of parents was not hesitant to share science-related information with their children. This could be a good sign, if parents are sharing knowledge with their children in a manner that promotes further exploration and interest in science topics. However, at this level of analyses it was not possible to explore the depth or quality of information that parents offered their children. A potential area of concern is the low frequency with which parents suggest actually engaging in science activities, such as suggesting an investigation of a science

phenomenon or proposing a way to test an emerging science hypothesis. Actively identifying with a scientific enterprise is one of the “Six Strands of Science-Learning” promoted by the National Research Council report on “Learning Science in Informal Environments.” Through experiencing and conducting everyday science activities, children may begin to view themselves as capable of becoming scientists. Thus, it is important to look more closely at the ways in which parents suggest science-related activities to their children in the context of naturally occurring conversations.

When I analyzed child conversational utterances, I found the results to be similar to those of parent utterances. Children were significantly more likely to offer information than ask questions, and they were more likely to ask questions than suggest activities. This suggests that children are engaging in conversation with their parents beyond simply searching for the answer to a question. Chouinard (2007) found that during the preschool years, children often ask questions to construct initial theories about the world around them. Data from this sample suggest that children may be participating further in science-related conversations with parents by sharing their own knowledge as well as by asking questions. This implies that parent-child conversations are rich and complex interactions that extend beyond a simple question and immediate answer. Thus, it becomes salient to further explore the types of explanations and information both parents and children share during these interactions, in order to discover what types of talk foster deeper science interest and exploration.

Child gender and conversational utterances. I also analyzed the diary-study conversations to explore whether child gender influences the ways in which children and parents discuss science-related concepts. Analyses of the ways that gender may relate to the number of conversations reported by parents failed to reveal any effect of child gender. In addition,

preschool-aged children in this sample asked the same amount of science-related questions regardless of their gender. This finding is consistent with both the Callanan and Oakes (1992) and Chouinard (2007) studies which did not report gender differences in the number of questions children ask. Similarly, when examining questions specifically in the science domain, Crowley et al. (2001b) found that boys and girls typically ask similar amounts of questions when interacting with a science museum exhibit. These prior findings are consistent with the results from the present study and indicate that both preschool-aged boys and girls ask about science phenomena equivalently. This suggests that, at this age, children are naturally curious about everyday occurrences that adults may label as “science.” Also, the diary study reports indicated that children of both genders offered the same amount of science-related information. The “Child Information” category encompassed a large proportion of child utterances, and gender was not found to impact how active children were in engaging in sharing information about science with parents. Because children at this age are not yet exhibiting differences in their level of interest, it becomes important to examine parent responses as an aspect that can further extend or hinder children’s science exploration.

Data from the present study indicated that parents did not differ in the number of questions they asked, amount of information they offered, or number of activities they suggested based on the child’s gender. This is consistent with findings from the Crowley et al. (2001b) study which indicate that parents provide the same amount of information to children, but differ in the type of information they relay. Crowley et al.’s (2001b) findings suggest that it is not enough to simply examine the frequency with which parents take their children to informal science-learning environments or the amount of science-talk they engage in with their children. The present study also implies that gender differences in preschool children’s experiences occur

at a more subtle level; examining only the frequency of opportunities to engage in informal science-learning or the amount of science-information parents provide is not capturing the whole picture. The Crowley et al. (2001b) study included parents that were already choosing to provide their children with opportunities to experience science environments, yet once they were there parents offered more explanations to boys than girls. Because prior literature indicates that parents play an important role in shaping children's understanding of science concepts and their development of scientific reasoning, the type and amount of explanations a parent provides could be influencing children's future science knowledge and interest. Parents may be unknowingly involved in creating a gender bias in preschool children's science experiences, despite the fact that they are engaging with their children as well as offering them informal learning opportunities regardless of their gender. This level of complexity is not addressed by the present study's current level of basic coding.

In order to capture the subtle aspects of parent-child conversational interactions, utterance data from the diary study is currently in the process of being coded at a more detailed level. Utterances that were initially coded as "Parent Information" and "Child Information" are now being coded for different types of conversational approaches including: offering a causal explanation, sharing a science fact, describing immediate evidence, making predictions, and labeling objects. "Parent Question" and "Child Question" will also be further explored to determine if any gender differences emerge in the types of questions asked. "Parent-" or "Child Suggests Activity," which did not vary significantly based on the child's gender and were the least frequently occurring conversational utterance, will also be coded to reflect whether the speaker is suggesting an investigation, experiment, observation, or directing another's attention. Based on prior literature, it appears that this level of coding will allow for detection of more

subtle, yet potentially influential, aspects of parent-child conversations. However, it is important to keep in mind that the diary study conversations were parent reported. Thus, parents might be over- or under-reporting the amount or type of conversation that took place. A parent-child shared book reading event, which took place prior to the two week diary study, could be utilized as a control for this phenomenon. Observational analyses of the parent-child book reading sessions may be helpful in discovering how families actually talk with their children versus how they report talking.

In sum, at the broad level of this study's analyses, there were not significant gender differences present in preschool children's science-learning opportunities or experiences. However, further exploration is needed to determine whether and how gender might subtly influence children's science-related interactions with their parents. It is important to discover when a child's gender begins to impact his or her science experiences in order to help further science interest for children of both genders. Existing evidence indicates that this difference is apparent by middle school. Additionally, there is also proof that in some areas of science-learning at the preschool-age children have different experiences based on their gender. It is also possible, however, that there may not be gender differences in the way parents treat their children in relation to science experiences. One reason could be that researchers are biased to look for differences in the ways parents treat their children based on their child's gender, and may ignore the times when children are treated equivalently. This "file drawer effect" may lead researchers to only publish work in which differences are found, resulting in gender differences in science experiences to be slightly exaggerated in the existing literature. Another possibility is that the null findings of the present study may be due to a cohort effect. Parents in this study may be becoming more aware of gender differences in science-learning and science-related

careers, and thus they may make a pointed effort to encourage science exploration with their female children. This would be a promising outlook for the involvement of women in future STEM careers. Additional work, such as that currently being pursued by additional analyses of this study, is critical to help us understand how to provide girls with the experiences and scaffolding that children need to develop an early and lasting interest in science. This interest could help change females' future career paths, which, in turn, could impact the whole field of STEM and science development.

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Appendix A: Parent Survey

SURVEY: CHILDREN'S INFORMAL LEARNING EXPERIENCES

These questions list different types of activities and ask if these are activities that your child participates in.

In the last year, has your child ever...

	No	Once or twice	Several Times	Often
gone to a children's museum?				
gone to a science museum?				
gone to a state or national park?				
gone to the beach, river or lake?				
gone to a local park or playground?				
gone to an amusement park?				
gone to a planetarium or observatory?				
gone to a zoo or aquarium?				
helped out with gardening?				
read a science-related book?				
watched a science-related television program?				

Use the space below to describe any other experiences your child has had that may contribute to his/her interest in and understanding of science and nature.

Appendix B: Conversation Sheet

Children's Conversations About Nature

Please fill out a separate page for each conversation you and your child have about the natural world.

Date: _____ Time: _____

Please describe as much as you can remember about the whole conversation. Use direct quotes when possible.

What idea or question about nature did your child talk about?

Who started this conversation? (e.g., you, your child, another family member, a friend)

How did this conversation start? (e.g., by someone asking a question, by someone making an observation)

What was your family doing when this conversation started? (e.g., watching TV, just talking, having dinner, playing at the park, etc.)

Is this a topic your child is often interested in discussing? Please briefly explain.