AN ABSTRACT OF THE DISSERTATION OF

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Title: Exploring the Foundations of Science Interest Development in Early Childhood

Abstract approved: ____

Lynn D. Dierking

There is growing evidence that children develop science-related interests in early childhood, before they enter school, and that these interests may have long-term implications for science participation and achievement. Although researchers have made headway in describing interest development in the preschool years, little is currently known about the proximal processes influencing early childhood interests and how these relate to other more distal factors, such as parent beliefs and attitudes. To address this gap, I conducted a two-phase, mixed-method study, involving an initial cross-sectional survey of Head Start parents and caregivers, followed by an in-depth, qualitative investigation of seven Head Start mothers and their four-year-old daughters. The goal of the study was to systematically document the ongoing proximal processes potentially driving young children's developing science-related interests, as well as the contextual factors shaping these processes. Over the course of two to three months, mothers in phase 2 were interviewed twice and videotaped interacting with their daughters in four different science-rich contexts, inside and outside the home. Analysis of data from both phases was used to develop a revised co-regulation model of early childhood science-related interest development. Building on prior work, the revised model explicates the proximal processes during parent-child interactions that likely drive interest development, draws attention to important distal and contextual factors, and posits four critical feedback loops previously implicit in other theories. The model outlines important hypotheses for future research and suggests promising strategies for Head Start and low-income families to support their young children's developing science-related interests.

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EXPLORING THE FOUNDATIONS OF SCIENCE INTEREST DEVELOPMENT IN EARLY CHILDHOOD

by

Scott A. Pattison

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APPROVED:

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Major Professor, representing Science Education

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Dean of the College of Education

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Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

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Scott A. Pattison, Author

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To preserve the confidentiality of the parents and families that participated in phase 2 of the study, I unfortunately cannot thank them by name. During the months we spent together, these parents were willing to open up their homes and share their perspectives, struggles, and dreams as caregivers of young children. Their passion and commitment, often in the face of numerous challenges and hardships, inspired me throughout the project and reaffirmed my belief that parents are the key to shaping our nation’s future. I hope this dissertation, and future work inspired by it, will serve as a small token of thanks for the many hours and ideas these families freely gave to me.

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PREFACE

This dissertation is written in manuscript format, following the guidelines of the Oregon State University Graduate School.[1] Chapter 1 is a general introduction to the study, outlining the context and issues that motivated the research, reviewing and synthesizing prior literature, introducing the theoretical frameworks that guided the investigation as a whole, and articulating the major research questions. Chapter 2 is a manuscript describing methods and findings from phase 1 of the dissertation study and the exploratory analyses I conducted with these data to identify predictors of parents' and caregivers' science interests and learning behaviors. This chapter also provides context and background for understanding the results of the qualitative study conducted in phase 2. The manuscript will be submitted to the *Public Understanding of Science* journal for publication. Chapter 3 is the second manuscript in the dissertation, written for the *Journal of Research in Science Teaching*, describing methods and findings from the phase 2 in-depth qualitative study with seven Head Start mother-daughter dyads. Both Chapter 1 and 2 manuscripts review, in abbreviated form, the prior literature from the general introduction relevant to each phase of the study. Finally, Chapter 4 is a general conclusion to the overall dissertation, in which I summarize key findings from both phases, outline a revised co-regulation model of early childhood science interest development, and suggest future directions for research and practice. I will be the first author for the final submissions of both the Chapter 2 and Chapter 3 manuscripts and my major advisor, Lynn D. Dierking, will be a co-author.

[1] http://oregonstate.edu/dept/grad_school/docs/thesis/Thesis%20Formatting%20Guide.pdf

CHAPTER 1:
GENERAL INTRODUCTION

Science, and the related areas of technology, mathematics, and engineering, is increasingly a central aspect of our society, our work, and our everyday lives (National Research Council, 2009; National Science Board, 2012). Educators, policymakers, and researchers from a wide variety of fields are focusing on ensuring that we continue to develop a robust and diverse science workforce and, more broadly, a scientifically literate and engaged citizenry (National Science Board, 2012, 2014). Although the science workforce in the US has continued to grow over the last decades (National Science Board, 2014), there is increasing concern that children and youth today are not prepared for the future. For example, based on recent national proficiency tests, few elementary, middle, and high school students are meeting their grade level proficiencies in science and the US high school graduation rate is below that of most developed countries (National Science Board, 2014). Furthermore, there is evidence of a decrease in young people's interest in pursuing scientific careers and numerous studies have documented a decline in attitudes toward science as children get older (Osborne, Simon, & Collins, 2003).

There also continues to be persistent disparities in science-related academic achievement and workforce participation between men and woman and across racial, ethnic, and socioeconomic groups. This is an issue of both practical and ethical concern, since it is broadly recognized that in order to maintain a strong and innovative scientific community in the US, all communities must have access to opportunities to learn about and engage with science and, ultimately, be equitably represented in the science workforce (Hill, Corbett, St. Rose, & American Association of University Women, 2010; National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2011; National Science Board, 2010). According to the National Science Board (2014), the substantial gaps across racial and ethnic groups in science and math school achievement, the proportion of students earning advanced mathematics and science credits, and high school graduation rates remain persistent challenges in K 12 education. Despite some positive trends, Hispanics, Blacks, and American Indians/Alaska Natives make up a disproportionately small share of college graduates with science-related degrees and professionals in the science workforce. And although women are beginning to achieve parity in science school achievement, they continue to be underrepresented in science-related careers, and especially in the fields of engineering and computer and mathematical sciences (Hill et al., 2010; National Science Board, 2014). In the United States, like many other countries across the world, socioeconomic status is a significant predictor of science literacy and achievement in school (Ainley & Ainley, 2011a; Gershenson, 2013; Organization for Economic Cooperation and Developmen, 2014).

In the ongoing effort to address these issues, researchers from a variety of fields have worked to understand how individuals and groups learn about and engage with science, both inside and outside of school, and identify effective strategies for supporting science learning (National Research Council, 2000b, 2005, 2009; National Science Board, 2010; US Department of Education, 2007). Many research, education, and policy efforts have focused on science skills and knowledge (e.g., Klahr, Zimmerman, & Jirout, 2011). However, there is broad recognition that helping children develop lifelong science interests is equally important(National Research Council, 2005, 2009).

Interest, often defined as a heightened emotional state of engagement as well as a predisposition to reengage with a particular object, event, or topic (Hidi & Renninger, 2006), is a critical component to successful learning, motivating individuals to engage with particular topics, objects, and activities and supporting skill development, knowledge gains, cognitive processing, persistence and attention, and use of effective learning strategies (Alexander, Johnson, & Leibham, 2013; Fisher, Dobbs-Oates, Doctoroff, & Arnold, 2012; Hidi & Renninger, 2006; National Research Council, 2009; Renninger, 2007; Renninger & Hidi, 2011; Renninger & Su, 2012; Silvia, 2006). As Hidi and Renninger (2006) argued, "findings from studies of interest suggest that it impacts attention, goal setting, and learning strategies in ways that make it a particularly relevant variable for those focused on improving educational practice" (p. 121). The strong emotional arousal associated with interest in a specific moment and context has been repeatedly associated with increased comprehension, knowledge gains and information integration, focused attention and engagement, perseverance during complex and challenging tasks, increased self-regulation behaviors, and buffering against unfavorable learning conditions (Hidi & Renninger, 2006; Kang, Scharmann, Kang, & Noh, 2010; Lewalter & Scholta, 2009; National Research Council, 2000b; Renninger & Su, 2012; Silvia, 2006). Interest triggered in a particular moment also sets the stage for the development of more enduring individual interests

(Hidi & Renninger, 2006), which extend beyond a specific situation or context and can lead to identity development (Alexander, Johnson, & Kelley, 2012; Renninger, 2007) and career pathways (Archer et al., 2012; Brickhouse, Lowery, & Schultz, 2000; Hughes, 2001; Packard & Nguyen, 2003; Silvia, 2006; Watt & Eccles, 2008). Scholars have argued that individual interest is critical for science learning and achievement in particular, motivating individuals to focus attention on science topics and activities, identify and seek answers to meaningful science questions, engage and persevere in science learning experiences, and develop positive attitudes toward science (Renninger, 2007; Renninger & Su, 2012).

Although relatively little research has been done to understand interest in early childhood (Alexander et al., 2012; Fisher et al., 2012), there is growing evidence that before they enter school, children do indeed develop enduring interests, including science-related interests, that persist over time and have implications for long-term learning trajectories (Alexander et al., 2012, 2013; Alexander, Johnson, Leibham, & Kelley, 2008; DeLoache, Simcock, & Macari, 2007; Fisher et al., 2012; Patrick, Mantzicopoulos, Samarapungavan, & French, 2008). In their pioneering studies of early childhood interest, Renninger and colleagues provided evidence that preschool children exhibit strong, individualized, gender-differentiated interests focused around specific objects or themes and that these interests are associated with differences in attention, cognition, temperament, persistence, and social play behaviors (Renninger, 1989; Renninger & Leckrone, 1991; Renninger & Wozniak, 1985). Subsequent research indicates that these interests often persist and have implications for children's attitudes, behaviors, and achievement in kindergarten and beyond (Alexander et al., 2013; Leibham, Alexander, & Johnson, 2013; Neitzel, Alexander, & Johnson, 2008).

As these findings emerge, researchers are just beginning to turn their attention to understanding the factors and processes that influence early childhood interest development. From a developmental, ecological perspective (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007), young children's science-related interests are expected to be directly shaped by ongoing, proximal processes in those children's lives, and especially interactions between children and their caregivers, and indirectly influenced by more distal processes, such as science-related cultural values and norms, caregiver beliefs, and the availability of science engagement opportunities and learning resources. Researchers have documented the many ways that preschool children and their families engage in scientific activities and learning practices in a variety of settings (Callanan & Jipson, 2001; Callanan & Oakes, 1992; Callanan, Siegel, & Luce, 2007; Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; National Research Council, 2009; Rigney & Callanan, 2011; Valle & Callanan, 2006). To date, however, there has been almost no research to understand the proximal processes influencing children's developing science-related interests.

Purpose statement

Recognizing the current state of the field, the goal of this study was to systematically document the ongoing proximal processes potentially driving young children's developing science-related interests, as well as the contextual factors shaping these processes. Ultimately, as described in Chapter 4, I used the descriptive findings from the study to develop a revised theoretical model of early childhood science interest development, which can be empirically tested in future research. The study followed a mixed-method design, with an initial cross-sectional survey of caregivers of preschool children used to recruit a small sample of families for an in-depth, qualitative investigation. This second phase of qualitative, inductive research was particularly appropriate given the lack of prior literature on caregiver-child proximal processes related to interest development and the recognized need to capture the complexity of children's learning and developmental ecologies (Alexander et al., 2012, 2013; Barron, 2006; Bricker & Bell, 2014; Falk et al., 2014; Renninger & Hidi, 2011). A qualitative approach is also aligned with the discovery-oriented research advocated by Bronfenbrenner and Morris (2007) in order to develop hypotheses about the complex distal and proximal processes that shape children's development.

Prior Research

Interest is a concept that cuts across topic domains and research fields. In reviewing the prior literature below, I begin by outlining research on interest in general and identifying the particular theoretical perspectives that will inform my own study. I then synthesize the literature on interest development in early childhood, for interest broadly and science interests specifically, including what is known about individual differences in interest before children enter school, the relations between early interest and later developmental and academic outcomes, and the factors that influence early interest development. Finally, I describe the bioecological model of human development (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007) that has framed my own perspective on interest development. Throughout, I primarily draw from research in the fields of developmental psychology and informal science education and learning.

Studying interest

Although interest is often described as an important outcome and motivator of learning (National Research Council, 2009), many scholars argue that the study of interest is still in its infancy (Alexander et al., 2012; Falk et al., 2014; Fisher et al., 2012; Renninger & Su, 2012). Broadly, researchers generally agree that interest is a motivational variable that includes both cognitive and affective components, has a physiological and neurological basis, and, unlike some other more general psychological dispositions or temperaments, such as achievement motivation, is always specific to a topic, object, event, or idea (Renninger & Hidi, 2011). Most researchers also distinguish two types of interest: (1) situational interest, as an emotional response to a particular activity or situation; and (2) individual interest, as a more enduring, domain-specific aspect of motivation (Alexander et al., 2012; Fisher et al., 2012; Hidi & Renninger, 2006; Renninger, 2009; Silvia, 2006).

Most interest researchers agree that situational interest is an emotion, similar to but not the same as enjoyment (Hidi & Renninger, 2006; Renninger & Su, 2012; Silvia, 2006). Hidi and Renninger (2006) defined situational interest as "focused attention and the affective reaction that is triggered in the moment by environmental stimuli" (p. 113). According to appraisal theory, “cognitive appraisals of events cause and constitute emotional experience” (Silvia, 2006, p. 55). In the case of interest, appraisal theorists have argued that positive emotional arousal is elicited through a process of individuals assessing the novelty of a situation, as well as their ability to understand and cope with it. In other words, “the events that people find interesting can probably be described thematically as events that are not understood but understandable” (p. 58). As an emotion, situational interest has both valence (i.e., positive and negative directions) and intensity (Silvia, 2006). However, Hidi and Renninger (2006) argued that positive interest is particularly likely to lead to motivation, learning, and more enduring interest development. Either explicitly or implicitly, interest and enjoyment are often combined by researchers as aspects of positive affect (Hidi & Renninger, 2006).

There is less consensus around the notion of individual interest (Renninger & Hidi, 2011). As reviewed by Renninger and Hidi (2011), researchers have conceptualized and studied interest as a developmental process, an emotion and emotional memory, a task- or environment-specific phenomenon, an aspect of value, and a central component of vocational choice. Understanding interest, and especially enduring individual interest, is further complicated by the overlap within the literature of interest theories and other related perspectives on learning and development, such as self-efficacy (Bandura, 1999), motivation (Wigfield, Eccles, Jacquelynne S., Schiefele, Roeser, & Davis-Kean, 2006), and attitudes (Osborne et al., 2003). For example, Eccles and colleagues, as part of their expectancy-value theory, defined interest as how much an individual "likes" an activity and identified it as one of several constructs, including utility beliefs and attainment value, that motivate behavior and choices (Renninger & Hidi, 2011; Wigfield et al., 2006). Osborne and colleagues (2003) described interest as one aspect of attitude, which they defined broadly as "the feelings, beliefs and values held about an object" (p. 1053). Common across most these perspectives is a shared understanding that there is a constellation of cognitive and affective constructs that influence and motivate behavior and that interest, however defined, is an important component of motivation and a central contributor to learning; is always linked to particular disciplinary content, objects, events, or ideas; and includes affect or feeling (Renninger & Hidi, 2011; Renninger & Su, 2012).

In light of these diverse perspectives, Renninger and Hidi (2011) recommended that researchers be explicit about the theoretical perspective underlying their approach to studying interest and the implications for measurement and design (see also Falk et al., 2014). Within the field of science education and learning, Renninger and Hidi (Hidi & Renninger, 2006; Renninger & Hidi, 2011) have developed the most broadly used and empirically supported theoretical conceptualization of science interest and interest development. In their model, they defined interest broadly as "the psychological state of engaging or the predisposition to reengage with particular classes of objects, events, or ideas over time" (Hidi & Renninger, 2006, p. 112) and individual interest, specifically, as a "a person's relatively enduring predisposition to reengage particular content over time as well as to the immediate psychological state when this predisposition has been activated" (p. 113). They also argued that interest involves “a particular relation between a person and the environment and is sustained through interaction” (Renninger & Hidi, 2011, p. 169).

This theoretical perspective places individual interest as one aspect of a four-phase model of interest development (Hidi & Renninger, 2006). Based on prior research, the model specifies four distinct and sequential phases of interest development, including two phases of situational interest (triggered and maintained) and two phases of individual interest (emerging and well-developed). Hidi and Renninger argued that each phase is a prerequisite for subsequent phases and that the characteristics of each phase are mediators of subsequent interest development. The phases are characterized by varying amounts of affect, knowledge, and value, with earlier phases of interest primarily consisting of focused attention and positive feelings, while later phases incorporate stored knowledge and value. For example, an individual may have a strong, positive affective response toward science while watching a demonstration at a science center. However, for that interest to be maintained and to continue to develop, the individual must, according to Hidi and Renninger, develop deeper knowledge of and an increased value for science. Therefore, as the researchers argued, support and opportunities to continuing to engage with the topic are necessary for individual interest to develop. Recently, Renninger has further refined the model to highlight how different configurations of the interest development phase, achievement demands of the learning environment, and metacognitive awareness require different supports for interest development (Renninger & Su, 2012).

Interest, as conceptualized in the four-phase model, is closely related to but distinct from other aspects of motivation. For example, Renninger (Renninger, 2007) argued that “whereas motivation is used to describe the will to succeed across multiple contexts (see Eccles, Wigfield, & Schiefele, 1998), interest is not necessarily focused on achievement and is always linked to a particular class of objects, events, or ideas, such of science” (p. 1). In the four-phase model of interest development, each stage of interest is expected to be characterized by "differing levels of effort, self-efficacy, goal setting, and ability to self-regulate behavior" (Hidi & Renninger, 2006, p. 114).

A variety of studies, often descriptive or qualitative, have documented these different phases (Hidi & Renninger, 2006). Recently, several quantitative investigations have provided direct empirical support for Renninger and colleagues’ multi-construct conceptualization of interest. Ainley and Ainley (2011a, 2011b) used cross-sectional data from the 2006 Programme for International Student Assessment (PISA) to evaluate the relations between 15-year-old students' science knowledge, current participation in science-related activities, and their self-reported personal value and enjoyment of science, interest in science, and future-oriented motivation to learn science. Using structural equation modeling, the authors found that the best fit model for US students connected "personal value through enjoyment of science to general interest in science and to current and future participation variables" (Ainley & Ainley, 2011a, p. 65), with science knowledge also being an important predictor of enjoyment (p. 67). In other words, aligned with the four-phase model, personal value, affect, and knowledge were all important contributors to students' current engagement with science activities and their expressed interest in continuing to learn more about science. The researchers did find cultural variation in this pattern. Specifically, for one of the four countries included in the study (Columbia), knowledge was not a significant contributor to the network of interest-related variables.

In a second analysis (Ainley & Ainley, 2011b), the researchers focused on students' expressed interest in learning more about the specific science topics included in the PISA assessment ("embedded interest"). Similar to before, they found good fit for the model specifying a path from socioeconomic status through both science knowledge and personal value of science and to enjoyment of science, interest in learning science in general, and finally predicted embedded interest. Across the four countries, "the strongest path in the model links personal value with enjoyment which in turn is linked to embedded interest through interest in learning science" (p. 9). Enjoyment of science and interest in learning science were both important mediators in the chain of relations. As in their previous study, the relative importance of science knowledge depended on the country. Overall, the model explained between 22% and 46% of the variance in the embedded interest scores, depending on the country, providing strong evidence that the four-phase model captures the critical components of individual science interest. The findings are also aligned with emotion-attribution theory (Silvia, 2006), which posits a central role of enjoyment, and the memory and attribution of enjoyment, to the development of interest.

Individual interest in early childhood

Historically, many scholars have argued that there is little evidence of preschool children showing enduring, stable interests (Alexander et al., 2012). To date, much of the research on interest and interest development has been conducted with older children (Alexander et al., 2013; President's Council of Advisors on Science and Technology, 2010). However, in the last two decades, research has indicated that many young children do indeed develop domain-specific interests that persist for months and even years (Alexander et al., 2013, 2008; Leibham et al., 2013; Neitzel et al., 2008; Renninger & Su, 2012). For example, in a four-month study with 211 four-year-olds, primarily using data from caregiver questionnaires, Johnson, Alexander, Spencer, Leibham, & Neitzel (2004) found that at the majority of time points at which caregivers were contacted (66% of the time for girls, 72% the time for boys), children showed evidence of focused conceptual interests, defined based on whether caregivers felt children tended to "keep the same play interest for more than one week at a time" (p. 330), and that 42 of the children, primarily boys, maintained the same conceptual interests throughout the study. Similarly, surveying 117 caregivers with children between the ages of 11 months and six years, DeLoache and colleagues (2007) found that 37% of caregivers reported that children had moderate interest in specific activities or objects, such as vehicles, balls, dolls, or dinosaurs, and that 29% reported that children had developed "extremely intense interests." These were defined as "relatively long-lasting, shown in several different contexts (home, friends' homes, daycare, etc.), directed toward multiple objects/activities within the category of interest (real objects, replicas, pictures, videos, etc.), and independently noticed by people outside the immediate family (friends, extended family, teachers, etc.)" (pp. 1579–1580). The average age at which caregivers self-reported that children had developed extremely intense interests was 18 months, with 90% of the interests having emerged by 24 months (p. 1581). Caregivers reported that extremely intense interests lasted between 6 to 36 months, with an average of 22 months (p. 1584). Similarly, in a two-year longitudinal study with families of four-year-olds, Alexander and colleagues (2008) found that approximately 50% of the children were reported by caregivers to have an interest in a conceptual domain at some point during the study and 20% were reported to have developed a long-term interest.

Not only do preschool children exhibit stable individual interests but growing evidence suggests that these early interests have implications for children's behavior and learning before and after they enter school. In a series of studies on interest and learning with preschool children, Renninger and colleagues provided evidence that children as young as three have strong and individualized interests focused around activities, objects, themes, or topic domains, such as playdough, bears, horses, or fire. More importantly, they found that there were often clear differences in interest between boys and girls at an early age and that the interests of young children were associated with attention, level of recognition of previously encountered images and pictures, recall of previously presented objects, length of and variation in play activities with interest objects, the nature of play with other preschoolers, and temperament and persistence during play with objects of interest (Fink, 1994; Renninger, 1989; Renninger & Leckrone, 1991; Renninger & Wozniak, 1985). In a year-long, qualitative study of 11 two- and three-year-old children at a childcare center, Rowe and Neitzel (2010) identified distinct, consistent “personal interest orientations” across the children and found evidence that these interest orientations exhibited during play were associated with distinct approaches to engaging with writing activities in the classroom.

Studying the connections between interest before school and in kindergarten, Neitzel and colleagues (Neitzel et al., 2008) identified associations between the types of activities young children appeared to prefer before they entered school and how they later participated in the classroom. At the age of four, 109 children were classified into four interest groups, based on the types of activities parents reported and the frequency of those activities: conceptual, procedural, creative, and socially oriented. A year later, when the children entered kindergarten, they were observed and assessed for the frequency and nature of information contribution behaviors (e.g., providing elaborations or extensions, sharing suggestions or rationales, and generating connections or associations) and information pursuing behaviors (e.g., additional information, task-process information, and normative information). Controlling for gender, cognitive skills, and temperament, there were statistically significant differences in the types of information children contributed and pursued across the four groups, but not in the frequency of contributions. The authors argued that “young children’s early interests are not insignificant and may provide the fundamental contexts and processes for academic preparation” (p. 793).

Early childhood science interest

Emerging evidence also supports the notion that young children are developing science-related interests before they enter school and that these are associated with later interests, opportunities to engage with science, skill and knowledge development, and science self-concepts. Several studies have documented how young children develop strong science interests specifically related to the topics of birds and dinosaurs (DeLoache et al., 2007). In a three-year, longitudinal study with families of four-year-old children (Alexander et al., 2012), many caregivers reported their children showed evidence of science-related interests at the beginning of the study. Specifically, families with boys reported that children had science-related interests in an average of 47% of the six telephone interviews conducted across the year, while families with girls reported children had science-related interests in an average of 16% of the telephone interviews. These caregiver-reported interests predicted both later science interests and opportunities afforded by caregivers to engage with science, with the connection between early science interest and caregiver support being particularly strong for girls. Focused on the related topic of mathematics, in a five-month longitudinal study with four-year-olds, Fisher and colleagues (2012) found that math interest at the beginning of the study, assessed both through semi-naturalistic observations and teacher reports, predicted later math skills. Findings indicated a mediational path between early and later interest through skill development and vice versa.

Several studies have found meaningful differences in children's science interests at kindergarten. Using a developmentally appropriate, puppet interview, Mantzicopoulos, Patrick, and Samarapungavan (2008) explored the science-related motivations and self-concept beliefs of 113 kindergarten children. Exploratory factor analysis of the data indicated a three factor structure of the 17 interview items: science competence, science liking, and ease of learning science. Internal consistency of the three subscales was reasonable, ranging from 0.64 to 0.79. Additional validity evidence included significant correlations between the subscales and science academic achievement, applied problem-solving, and passage comprehension measures; significant differences in science competence and liking of science for groups of students who had participated in two different kindergarten science learning intervention programs; and similarity in the structure of the science interests, motivations, and beliefs measured with the puppet interview and the dimensionality of children's beliefs in other academic domains. In a related study, through a cluster analysis of science-related motivations of 110 kindergarten children, assessed through an age-appropriate, puppet activity, Patrick and colleagues (2008) identified three different motivational profiles. The majority of students (72%) held positive motivational beliefs across all three scales. However, some children (15%) "said they liked science but it was difficult and they were not good at it" (p. 139) and a small group of children (14%) "reported not liking science even though they were somewhat good at it and it was easy" (p. 139).

These studies suggest that although most young children typically enter school with positive attitudes and motivations related to learning (Institute of Medicine & National Research Council, 2012; National Research Council, 2000a), important individual differences in science interests may already be developing by kindergarten. Based on the broader interest literature, these differences may influence children's motivation to engage with science, their science-related knowledge and skill development, use of effective learning strategies, and caregivers' provision of learning opportunities. Preliminary evidence of these relations comes from a prospective, longitudinal study of early science interest development in preschool and elementary school (Alexander et al., 2013; Leibham et al., 2013). Beginning when children were four years old, the researchers tracked the interests, as well as environmental and distal factors potentially influencing interest development, of 116 children over the course of four years, primarily through ongoing phone calls and emails with parents. When the children were eight, researchers used standardized measures to assess science knowledge, science self-concept, and general reading ability. Controlling for reading ability, intense science-related interests when children were in preschool predicted science self-concept and knowledge when children were eight. However this relation was only significant for girls. Furthermore, early science interest appeared to be a stronger predictor of self-concept and knowledge than current science interests (Leibham et al., 2013). This work provides the strongest evidence to date that early childhood interests have important implications for long-term development and learning.

Early childhood interest development

Despite growing evidence that preschool children exhibit individual differences in enduring, science-related interests before they enter school, little research has been done to understand how interests develop, especially with young children (Alexander et al., 2012; Fisher et al., 2012; Renninger, 2007). In general, researchers often assume that enduring, individual interests build on and develop from situational interests. Although the four-phase model of interest development (Hidi & Renninger, 2006) is helpful for describing levels of interest and appropriate supports for learners at different levels, it provides few details about the mechanisms underlying interest development (Renninger, 2007). Furthermore, the model is based almost exclusively on research with school-age children and so may or may not be useful for understanding early childhood processes. As outlined below, there is indirect evidence that before children enter school, gender, caregiver-child interactions, children's interests and questions, and caregivers' attitudes and beliefs are important proximal processes and contextual factors shaping the development of young children's science-related interests.

Gender

There is substantial evidence that gender differences exist in science-related interests for children in middle school, high school, and beyond (Alexander et al., 2013). Gender is also one of the few personal and demographic factors potentially influencing early childhood interest development that has been studied in any detail. In general, consistent findings indicate that boys and girls exhibit different interests in preschool (Alexander et al., 2013, 2008; DeLoache et al., 2007). For example, in a two-year, longitudinal study with four-year-olds and their families, Alexander and colleagues (2008) found strong differences in the types of individual interests boys and girls exhibited (p. 328). However, boys and girls were similar in the likelihood of exhibiting focused interests, the length of time interests persisted, and the variety of interests. Research on caregivers' socialization of boys and girls has found significant differences "in terms of the degree to which caregivers encouraged sex stereotypes in play activities and household chores" (Alexander et al., 2012, p. 71). Analyzing the activity preference profiles of four-year-olds, based on parent interviews, Neitzel and colleagues (2008) found significant gender differences. Boys were more likely to be classified as having concept-oriented or procedural activity interests, while girls were more likely to have creative or socially oriented interests. Using data from the same study, the researchers also found that boys were approximately six times more likely than girls to show conceptual interests across three time points over the course of four months based on caregiver questionnaires (Johnson et al., 2004).

Findings are more mixed for science-related interests specifically. Alexander and colleagues (2012) found that boys were more interested in science than girls at four years of age and that these differences persisted until children were eight years old (Leibham et al., 2013). Boys' reported science interest declined in elementary school, while girls' interest remained relatively low and stable (Alexander et al., 2012, p. 781). Furthermore, as noted above, early science interests in preschool were found to predict later science self-concept and knowledge for girls but not for boys (Leibham et al., 2013).

However, several other studies have not found significant differences in science and math interests before school (Fisher et al., 2012; Mantzicopoulos et al., 2008; Patrick et al., 2008). For example, in their study of science interest, motivations, and beliefs of kindergarten children described above, Mantzicopoulos and colleagues (2008) found no statistically significant differences by gender. However, as they noted, all the children in the study had participated in innovative kindergarten science learning programs, which may have mitigated gender differences. The discrepant findings across studies may also be due to caregivers' tendency to self-report interest based on cultural stereotypes. Recent studies using caregiver self-report methods (Alexander et al., 2012) have shown significant gender differences, while studies using observation or child interview methods (Fisher et al., 2012; Mantzicopoulos et al., 2008; Patrick et al., 2008) have not. Research in both informal learning contexts and classrooms indicates that adults often provide more scientific explanations to boys than girls (Crowley, Callanan, Tenenbaum, & Allen, 2001), although these findings have not been linked directly with interest or motivation.

Caregiver-child interactions

As Renninger and Su (2012) argued, interaction with others is critical for interest development, both helping to spark interest and supporting the provision of information and experiences that leads to the deepening of interest. From a developmental perspective, the daily experiences and social interactions of young children, and particularly interactions with their primary caregivers, are seen as central drivers of learning and development (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007; Institute of Medicine & National Research Council, 2012; National Research Council, 2000a). Evidence suggests that preschool children and their caregivers from a diversity of communities frequently engage in scientific activities and learning practices that may offer an important context for science-related interest development (Callanan & Jipson, 2001; Callanan & Oakes, 1992; Callanan et al., 2007; Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; National Research Council, 2009; Rigney & Callanan, 2011; Valle & Callanan, 2006).

During these interactions, caregivers may help spark and maintain children's interests by scaffolding learning and tailoring the relative challenge of a learning task or situation to children's individual needs. As described above, according to appraisal theory, situational interest is an emotional response influenced by both the degree of novelty and understandability of a situation (Silvia, 2006). For example, an activity that is highly novel to an individual but incomprehensible or overly challenging will likely not spark situational interest, while an activity that is both highly novel and potentially understandable to that individual likely will. Based on this theory, and aligned with sociocultural perspectives on learning (e.g., Vygotskiĭ, 1978), caregivers can help foster situational interest by using their understanding of children's prior knowledge and experiences to tailor the level of comprehensibility of an activity or topic, either by scaffolding or providing an additional level of challenge. Scholars have also speculated that caregivers influence interest development by (a) communicating important messages about attitudes, beliefs, and values through modeling interest and enthusiasm and providing opportunities for involvement, including making interest-related materials available; (b) regulating family time and activities; (c) answering curiosity questions, co-constructing knowledge, and engaging in conversations; and (d) providing encouragement and motivation (Alexander et al., 2013; Barron, Martin, Takeuchi, & Fithian, 2009; Frenzel, Goetz, Pekrun, & Watt, 2010; Leibham, Alexander, Johnson, Neitzel, & Reis-Henrie, 2005; Tenenbaum & Leaper, 2003).

Only a few studies have directly examined the influence of caregivers on the development of young children's interest before they enter school and these studies have primarily focused on distal, rather than proximal, factors and processes. Leibham, Alexander, Johnson, Neitzel, and Reis-Henrie (2005) conducted a prospective, longitudinal study to examine correlations between parenting and home environment factors when children were four and the development of young children's enduring conceptual interests measured two years later. Participants were 51 children and their caregivers who were part of a larger longitudinal study and had been identified, based on caregiver interviews, as having sustained an interest in a conceptual domain, such as dinosaurs, rocks, cars, or horses, for at least four months. Only a few factors appeared to distinguish children with individual interests, defined by the authors as children having “a small number of specific interests with longer durations,” and children with stabilized situational interests, or a “larger number of specific interests with shorter durations” (p. 401). Caregivers of children who eventually sustained individual interests on average reported placing more emphasis on academic stimulation and satisfying their children’s curiosity and were more likely to report providing interest-related materials and learning opportunities.

Based on a logistic regression comparing children who were and were not classified as sustaining a conceptual interest across three time points over the course of four months, beginning when the children were four years old, Johnson and colleagues (2004) found that gender, cognitive ability, and parent-reported beliefs about consistency and structure were significant predictors of sustained conceptual interests. There was also evidence of a moderating effect of the degree to which families were classified as “high communication.” Caregiver beliefs about free play and educational emphasis were significantly and positively associated with sustained conceptual interests in young children but only for families in which parents reported placing a relatively higher value on communication with their children, supporting Bronfenbrenner’s assertion that distal processes influence individual development through more proximal processes. Based on subsequent longitudinal work (Alexander et al., in press), the researchers developed a co-regulation model of early interest development, positing that caregivers facilitate interest development by noticing interest, regulating activities, supporting questions, and controlling the environment, while children facilitate interest development by expressing interest, seeking out opportunities, asking questions, and developing self-awareness.

The literature on caregiver-child interactions related to science more broadly supports aspects of this model. In particular, research indicates that caregivers frequently use explanations as a scaffolding tool that may help spark situational interest and, ultimately, long-term interest development. There is strong evidence that caregiver explanations, commonly conceptualized as talk describing causal connections, links to prior experiences, analogies, and general scientific principles, are a regular part of caregiver-child conversations in the context of children's museums and science centers, even before children enter school (Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; Valle & Callanan, 2006). When recruited by researchers to interact with their children at a specific exhibit, caregivers are frequently observed providing explanations to guide their children's learning (Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007). For example, in one study in a children's museum, over half of the caregivers (24 of 41) recruited to interact with their young children at an animation exhibit spontaneously gave at least one explanation, with 12 providing causal explanations, five providing connection explanations, and seven providing both (Fender & Crowley, 2007). In a more naturalistic context, such as when researchers recruit families to participate in a study as they enter the museum without indicating specifically which exhibit interactions will be observed, caregivers still provide spontaneous explanations, although less frequently (Callanan & Braswell, 2006; Valle & Callanan, 2006). In a study in a children's museum exhibition focused on magnification and size, about a quarter of the videotaped interactions between caregivers and their young children included explanations about science concepts (Callanan & Braswell, 2006).

There is also some evidence that caregivers offer preschool children explanations in other contexts, such as the home (Callanan & Jipson, 2001; Callanan & Oakes, 1992). In a two-week diary study, caregivers frequently reported that children asked questions related to scientific concepts and that these questions elicited both causal and non-causal explanations from adults (Callanan & Oakes, 1992). In the study, children's questions reflected curiosity about social and physical phenomena and the majority of caregivers' responses to "why" and "how" questions were causal in nature. Some research suggests that the nature of caregiver-child interactions and scientific practices may be different in everyday contexts compared to designed settings. Specifically, several studies have found that caregivers may be more likely to offer spontaneous explanations during a visit to a children's museum or science center (Callanan & Jipson, 2001; Crowley, Callanan, Jipson, et al., 2001; Valle & Callanan, 2006), while explanations outside of designed settings may be more frequently prompted by children's questions (Callanan & Jipson, 2001).

Regardless of the setting, studies to date suggest that caregivers primarily provide partial, concrete, situation-specific explanations, rather than more abstract or general principles. For example, at an animation exhibit, caregiver explanations usually focused on specific causal links between actions and effects at the exhibit or analogies between the exhibit and other animation devices, rather than general scientific principles about motion or perception (Crowley, Callanan, Jipson, et al., 2001). Callanan and Jipson (2001) found a similar pattern for caregiver-child conversations both inside and outside museums. Crowley, Callanan, Jipson, and colleagues (2001) speculated on the role of these "explanatoids", which they defined as "brief prompts thrown into ongoing collaborative exploration or problem solving strategy." The authors argued that these prompts "are not sufficient to teach complete concepts or strategies. Instead, we think of them as 'just-in-time' explanatory nuggets that are offered when relevant evidence is the focus of joint caregiver-child attention and that serve the function of providing children an on-line structure for parsing, storing, and making inferences about evidence as it is encountered" (p. 730).

The context-specific nature of these explanations may be particularly appropriate for sparking situational interest. Several studies have indicated a connection between caregiver explanations and preschool children's engagement and conceptual learning (Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; Valle & Callanan, 2006). The mechanisms underlying this connection have not been explored but researchers have speculated that explanations may help focus children's attention on salient aspects of an experience, prompt children to identify and compare relevant evidence, motivate children to spend longer at an activity, or enculturate children into specific ways of interpreting evidence (Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; Valle & Callanan, 2006).). In other words, caregiver explanations may be an important support for triggering situational interests. In addition, caregiver explanations may foster situational interest in a topic or activity by helping to balance novelty and comprehensibility and may be critical for supporting the shift from situational interest to individual interest by increasing children's knowledge of the topic.

Children's interests and questions

Children are not simply passive participants during interactions with caregivers. In general, developmental research strongly emphasizes that young children are active agents in their learning processes, influencing their own developmental and learning outcomes (Institute of Medicine & National Research Council, 2012; National Research Council, 2000a, 2009). In particular, children's questions, focused around their own interests, may be an important mechanism through which young children elicit caregiver discourse and shape their own development (Alexander et al., 2013; Callanan & Oakes, 1992; Callanan, Rigney, Nolan-Reyes, &

Solis, 2012; Chouinard & Imberi-Olivares, 2011; Hidi & Renninger, 2006). Although relatively few studies have been conducted on children's questions, the existing research indicates that these questions are a frequent part of caregiver-child conversations and that the majority appear to be intended to elicit factual or causal information, rather than, for example, attention or permission (Callanan & Oakes, 1992; Chouinard, Harris, & Maratsos, 2007; Frazier, Gelman, & Wellman, 2009; Kelemen, Callanan, Casler, & Pérez-Granados, 2005; Mills, Legare, Grant, & Landrum, 2011). Several studies have been focused on cause-related questions, indicating that children frequently ask such questions related to physical, biological, and social phenomena (Callanan & Oakes, 1992; Kelemen et al., 2005).

Furthermore, those questions appear to be an effective tool for eliciting caregiver responses and discourse (Callanan & Oakes, 1992; Chouinard et al., 2007; Kelemen et al., 2005). For example, based on a detailed analysis of longitudinal transcripts of four young children and their caregivers, Chouinard and colleagues (2007) found that the majority of questions that children asked were part of a series of "building exchanges" (p. 34), eliciting rich interchanges between caregivers and children. As noted above, several diary studies have indicated that the majority of caregivers' responses to children's "why" and "how" questions are causal explanations (Callanan & Oakes, 1992; Kelemen et al., 2005). For example, Kelemen and colleagues (2005) documented children's questions related to why the sky gets dark, why it rains, why we have birthday parties, or why parents go to work. As with other studies of family learning (e.g., National Research Council, 2009), Kemler Nelson and O'Neil (2005) found that caregivers' responses to their children's questions appeared to be sensitive to children's prior experience.

Some studies have begun to directly connect children's questions with interest development. In a study of the "extremely intense interests" of young children between the ages of 11 months and six years (DeLoache et al., 2007), caregivers reported that these interests pervaded their children's lives and that children as they got older, "constantly talked about the object of interest" and also "asked endless questions" (p. 1583). The vast majority (92%) of caregivers reported that they felt positive about their children's interests and actively supported those interests, such as by purchasing books, objects, or videos or engaging their children in relevant activities (p. 1583). This may partially explain why, as described above, Alexander and colleagues (2012) found evidence for a "child-driven" model of interest development, in which early science interest was a strong predictor of later opportunities afforded by caregivers to engage with science.

Researchers have speculated that developing interests may motivate children to ask “curiosity questions” (Hidi & Renninger, 2006), which in turn elicit interactions with caregivers and other adults and supports further interest development (e.g., Alexander et al., 2008; Hidi & Renninger, 2006; Renninger, 2007). Similarly, the combination of both motivation and ability to ask questions may be critical for self-driven learning (Renninger, 2007). Evidence suggests that as preschool children get older, they are better able to make distinctions between knowledgeable, ignorant, and inaccurate sources of information; ask effective and appropriately worded questions; determine when they have gathered sufficient information to address their questions; and coordinate this information to support problem solving (Chouinard et al., 2007; Mills et al., 2011). Children may ask a greater proportion of explanation and cause seeking, rather than fact seeking, questions as they get older (Chouinard et al., 2007). Overall, children’s interest-driven questions may be an important input and outcome of interest development that is reciprocally related to caregiver support.

Child-rearing beliefs

Another factor potentially shaping the development of early childhood science interest is caregivers’ own interests and attitudes related to science. In general, caregivers internalize an array of beliefs, values, and attitudes related to child-rearing and early childhood development that, in turn, influence their interactions with their own children (Holden & Miller, 1999; Huang, O’Brien Caughy, Genevro, & Miller, 2005; Institute of Medicine & National Research Council, 2012; Keels, 2009; National Research Council, 2000a; Rogoff, Paradise, Arauz, Correa-Chávez, & Angelillo, 2003; Tazouti, Malarde, & Michea, 2010). These relations are not simple, however. Social psychological theory suggests that individual and social group characteristics influence the strength of the relationship between beliefs and behaviors (Ajzen, 2001; Barnett, Shanahan, Deng, Haskett, & Cox, 2010). In a meta-analysis of 87 empirical studies that examined how parental beliefs and behaviors vary across time, setting, and child, Holden and Miller (1999) found evidence for both the stability and dynamism of beliefs and behaviors. Across-situation data showed the most variation, suggesting the "person-situation interaction is a better unit of analysis for understanding patterns of behavior than personality characteristics alone" (p. 243).

In other words, the relation between an individual's beliefs and actions, such as beliefs about discipline and disciplinary actions towards children, might be expected to be relatively consistent within a specific context, such as a visit to a science center, but vary across contexts, such as between a science center visit and the home.

Researchers have yet to specifically examine caregivers' beliefs related to science interest development in early childhood and the relationship between these beliefs and child-rearing behaviors and discourse. However, scholars have generally argued for the importance of child-rearing beliefs as a factor influencing caregiver-child interactions and, consequently, child development (Holden & Miller, 1999; Huang et al., 2005; Tazouti et al., 2010). Studies have documented significant variation in child-rearing beliefs, often associated with socioeconomic status, caregiver education, and ethnicity and cultural background. In cross-cultural studies, for example, investigators have identified broad patterns of child-rearing beliefs focused on promoting either individualism or collectivism (Achhpal, Goldman, & Rohner, 2007; Institute of Medicine & National Research Council, 2012; National Research Council, 2000a; Suizzo et al., 2008). Suizzo and colleagues (2008) used exploratory factor analysis to identify three broad child-rearing beliefs constructs, conformity, autonomy, and prosocial beliefs, among 310 caregivers of infants and toddlers from Latino, European-American, African-American, and Asian backgrounds. In the study, conformity beliefs were associated with caregiver education and ethnicity. In a review of 71 child-rearing beliefs studies published between 1980 and 1985 (Hirsjärvi & Perälä-Littunen, 2001), investigators found evidence of variation in child-rearing beliefs related to the relative importance of parenting versus other external factors, what constitutes normal development, and the relative importance of effort and self-improvement.

Given this variation in child-rearing beliefs, researchers have also worked to understand the relationship between beliefs, child-rearing practices, and early childhood development. Several studies have documented a direct link between caregiver beliefs and behaviors (Barnett et al., 2010; Barnyak, 2011; Plowman, McPake, & Stephen, 2008; Tazouti et al., 2010), as well as an indirect link between child-rearing beliefs and early childhood developmental outcomes, mediated by child-rearing behaviors (Barnett et al., 2010; Tazouti et al., 2010). For example, using data from 1198 early head start families from diverse ethnic backgrounds, Keels (2009) found that maternal cognitive skills mediated between ethnic group differences in child-rearing beliefs, which in turn mediated between ethnic group differences in child-rearing behaviors, although these patterns varied across ethnic groups. Several studies have actually found a direct link between child-rearing beliefs and child development outcomes (Barnett et al., 2010; Cottone, 2012). These beliefs may subtly influence the nature of caregiver-child interactions, such as encouragement or caregivers' communication of affect and value (Cottone, 2012). Specific to early childhood and interest, Leibham and colleagues (2005) found correlations between caregivers' perceptions of the importance of academic stimulation and satisfying children's curiosity and the likelihood that children sustained interests for at least four months. Similarly, as noted above, researchers have found associations between the emergence and maintenance of conceptual interests and caregiver beliefs about the importance of education and communication, consistency and time for unstructured play, and supporting children's interests to help satisfy their curiosity (Alexander et al., 2013).

Only a few studies have explored variation in child-rearing beliefs related to science. In a cross-sectional survey of 509 caregivers with children between the ages of three and seven (Braswell, Rosengren, & Berenbaum, 2012), investigators found significant variation in child-rearing beliefs related to learning about science, as well as a negative correlation between adult religious beliefs and beliefs about encouraging science learning. On average, caregivers felt the children should begin learning about science at 5.9 years of age. Related to science, Plowman and colleagues (2008) documented a range in child-rearing beliefs about how young children learn to use technology, including beliefs about the relative importance of demonstrations, being self-taught, using trial and error, and copying. Interviews with caregivers suggested that these beliefs were influenced by "parents' earlier experiences with technology at school, further education or work, as well as public debate about the role of technology in the lives of young children" (p. 311).

Some evidence suggests that caregivers with strongly positive science-related attitudes and interests may interact differently with their children in specific contexts compared to caregivers with less positive attitudes and interests. For example, Andre, Whigham, Hendrickson, and Chambers (1999) identified correlations between caregiver beliefs about children's science abilities and about the value of science, and children's liking of and perceived abilities related to science. More recently, Tenenbaum and Leaper (2003) found significant correlations between parents' and children's beliefs related to science. Analyzing longitudinal data with German adolescents, Frenzel and colleagues (2010) found that parent and classmate values and teacher enthusiasm were all positively and uniquely related to the level of students' mathematics interest, although not to the trajectory of interest development. As noted above, researchers have speculated that caregivers communicate important messages about attitudes, beliefs, values, and interest through modeling and providing opportunities for involvement; showing interest and enthusiasm related to particular topics, objects, or domains; and providing encouragement and motivation (Barron et al., 2009; Frenzel et al., 2010; Leibham et al., 2005; Tenenbaum & Leaper, 2003). These aspects of caregiver-child discourse may mediate the link between the distal factor of caregiver interest and beliefs and children’s own interest development.

An ecological perspective on early childhood interest development

Long-term, developmental perspectives are often missing from research on family and early childhood science engagement and learning. For example, many of the studies of how preschool children and their families engage in scientific activities and learning practices are cross-sectional in nature, focusing on a few, short interactions between caregivers and children across families (Alexander et al., 2013; Callanan et al., 2012). However, in order to address critical social issues and needs, it is important to understand how these short-term interactions and processes relate to long-term developmental and learning outcomes. Bronfenbrenner’s bioecological model of human development (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007) provides a detailed, research-based framework for studying these long-term processes, including the development of children’s science-related interests.

The bioecological model, defined as a “theoretical system for the scientific study of human development over time" (Bronfenbrenner & Morris, 2007, p. 753), makes two central claims: (1) proximal processes, or the ongoing, direct experiences of an individual with his or her environment, including other individuals, are the primary engines of development; and (2) the impact of these proximal processes are indirectly influenced by personal, environmental, and temporal factors that are more or less distal to the direct experiences of the individual. From an analytic perspective, these claims can be translated to mean that proximal processes, such as caregiver-child interactions, should have a direct association with developmental outcomes, while other contextual factors, such as availability of learning resources or child-rearing beliefs, should be indirectly associated with those outcomes, either mediated through proximal processes or moderating the relationship between those processes and associated developmental outcomes. Bronfenbrenner and Morris also posited that in order to have a significant influence on an individual's development, proximal processes must be fairly regular and ongoing.

Since the original ecological model of development was formulated (Bronfenbrenner, 1979), Bronfenbrenner has developed more specific recommendations for research designs and approaches intended to study development from a bioecological perspective. Bronfenbrenner and Morris (2007) defined research designs that permit the holistic study of development as "process-person-context-time (PPCT)" models (p. 798). These designs attempt to operationalize and measure proximal processes appropriate to the developmental outcomes of interest; personal characteristics of study participants and contextual factors that likely influence those processes; and the cross-context, longitudinal influence of those processes on development.

This theoretical framework and research model has several implications for the study of young children's developing science-related interests. First, proximal processes, and particularly caregiver-child interactions (Bronfenbrenner & Morris, 2007; National Research Council, 2000a), are expected to be the primary influence on children's situational interests and developing individual, enduring interests. To date, the few studies of young children's science-related interests have primarily focused on more distal factors, such as opportunities to engage with science (e.g., Alexander et al., 2012). While these factors are no doubt important, the bioecological model suggests that they should influence development only to the degree to which they afford or constrain more direct, proximal processes. Notably, almost no research has been conducted to identify and understand the proximal processes that support or hinder young children's science-related interest development.

Second, in order to have a strong impact on interest development, these proximal processes must be regular and ongoing. As noted above, many of the existing studies on interactions between preschool children and their caregivers have been cross-sectional and focused on particular, unique situations, such as a visit to a children's museum or science center. These studies provide little insight into the ongoing, regular aspects of caregiver discourse and caregiver-child interactions that slowly but surely guide children's developing interests. Research to identify such processes, therefore, must be both longitudinal, capturing interactions and discourse over time and across settings, and also detailed and naturalistic, focusing not on indirect indicators of interest development but on the day-to-day talk, behaviors, and experiences of young children.

Finally, in order to develop a holistic, ecological model of interest development, research studies must be sensitive to the personal and contextual factors that shape the more direct, proximal mechanisms of interest development. As Bronfenbrenner and Morris (2007) noted, researchers must not leave these discoveries to chance but must strategically design studies to reveal interactions and indirect effects. Based on the limited research described above, an important personal factor shaping the proximal processes of interest development may be young children's questions and especially those that elicit caregiver discourse and deeper caregiver-child interactions. Similarly, although findings are mixed, children's gender may influence the nature of caregiver discourse, based on social and cultural stereotypes. Studies also suggest that child-rearing beliefs and values may be an important influence on caregiving behaviors and thus, an indirect influence on interest development.

Research Questions

Many of the leading interest researchers have emphasized the need to better understand the proximal processes influencing interest development (Alexander et al., 2013; Falk et al., 2014; Renninger & Hidi, 2011). Guided by the bioecological model and the literature described above, I used a mixed-method approach, with an initial quantitative survey followed by a more extensive qualitative investigation, to document the proximal processes of caregiver-child interactions that potentially contribute to early childhood science interest development and begin to identify important contextual factors influencing those processes. The study was guided by two research questions:

1) What are common, ongoing patterns of caregiver and child discourse and caregiver-child interactions that potentially influence the development of preschool children's early science-related interests?
2) What contextual factors potentially influence these proximal processes and contribute to or hinder the development of preschool children's early science-related interests?

Based on the four-phase model of interest development (Hidi & Renninger, 2006), I focused on reoccurring proximal processes during parent-child interactions related to supporting positive affect, personal value for science, importance of science, and science-related knowledge. I paid particular attention to discourse and interactions associated with children's enjoyment and situational interest, since research indicates that this is a central component to all stages of interest development (Ainley & Ainley, 2011a, 2011b; Hidi & Renninger, 2006). In addition, based on the studies reviewed above, I took note of caregiver explanations and scaffolding and child questions as potential indicators of interest-supporting discourse. Finally, Renninger and Su (2012) drew on findings from several studies to argue that metacognitive awareness of a particular interest is also critical for ongoing interest development. This suggests that caregiver-child discourse making a child's interest, or perceived interest, explicit may be important.

Although the focus of this study is not measuring early childhood science interest, it was important for me to have a working definition of this concept to guide data analysis. Following Hidi and Renninger (2006), I began the study conceptualizing early childhood science interest as positive affect towards science-related topics, objects, and activities, as well as a predisposition to reengage with these focus areas. Following the coding scheme of Leibham and colleagues (2013), science-related interest areas included life science and nature, such as dinosaurs and horses; earth science, such as rocks and space; mechanics, such as cars; and technology, such as computers (p. 12). As Alexander and colleagues (2013) noted, preschoolers likely do not associate their emerging interests with science. However, the researchers argued that "parents and teachers may well be sensitive to these relations and take advantages of opportunities to support the interests through books, videos, and exhibits that scaffold linkages between the topic of interest and more traditional science content" (p. 5).

Methods Overview

To answer the research questions outlined above, I conducted a two-phase, mixed method study in collaboration with the Mt. Hood Community College Head Start program and the Oregon Museum of Science and Industry. Table 1 outlines the design, sampling and recruitment strategies, data collection methods, and timing for each of these phases. The first phase of the study involved a cross-sectional survey with 138 parents and caregivers of Head Start children, recruited with the help of Head Start staff members between November 2013 and January 2014. In phase two, seven mothers and their four-year-old daughters were recruited from the overall sample to participate in an in-depth, qualitative investigation involving videotaped observations of parent-child interactions and parent interviews. Mother-daughter dyads were videotaped in three everyday, science-rich contexts: (1) reading science-related books together at home, (2) visiting the early childhood learning space at a science center, and (3) engaging with a science-related activity at home. Families were also videotaped in one context that they themselves identified as science related, such as a walk to a botanical garden. After the first two sessions and after the final session, I conducted in-depth interviews with the mothers in order to elicit their perspectives on the interactions and explore parent beliefs and other distal factors potentially influencing children's interest development.

Table 1. Overview of phase 1 and 2 research methods

Phase	Design	Sampling and recruitment	Data collection	Dates
Phase 1	Quantitative, cross-sectional	138 Head Start parents and caregivers recruited with the help of Head Start staff members	Paper questionnaire focused on parent science interests and activities, child-rearing beliefs, and demographics	November 2013-January 2014
Phase 2	Qualitative, short-term longitudinal	Seven mother-daughter dyads, recruited from the phase 1 sample	Videotaped observations in four science-rich contexts, two in-depth parent interviews	January-August 2014

This mixed-method approach allowed me to capitalize on the inductive and deductive strengths of qualitative and quantitative research (Morgan, 1998, 2014). For example, as described in Chapter 2, I used the data from the phase 1 survey to deductively test relationships between parent interests in science and the frequency that they engage in different types of science learning activities with a broad, representative group of Head Start parents and caregivers. In contrast, the in-depth, inductive coding of data from the phase 2 qualitative study with a small sample of mother-daughter dyads from Phase 1 was used to develop novel hypotheses about the proximal and distal processes that support or hinder science-related interest development in early childhood. In the general conclusion to the dissertation (Chapter 4), I build on findings from both phases to develop a revised model of early childhood emerging science interest that can be tested in future research.

As noted in the preface, I will be the first author for the final submissions of both the Chapter 2 and 3 manuscripts and my major advisor, Lynn D. Dierking, will be a co-author.

CHAPTER 2:
PERSPECTIVES ON SCIENCE AND CHILD-REARING: A CROSS-SECTIONAL SURVEY WITH HEAD START PARENTS

Parents and caregivers are widely recognized as having a central influence on children's developing knowledge, skills, and motivations, including those related to science. However, very little work has been done to understand parents' science-related perspectives and interests and how these might shape their children's understanding of and engagement with science. As part of a larger project investigating the foundations of science interest development in early childhood, we surveyed 138 parents and caregivers of Head Start children and collected information on child-rearing beliefs and science-related attitudes, interests, and learning behaviors. In general, parents had positive views of science, which was often associated with active practices, such as experimenting, inventing, discovering, exploring, and learning. Many participants also associated science specifically with the outdoors and biology-related topics, suggesting an opportunity to broaden awareness and appreciation of the variety of science fields. Multivariate analyses indicated that personal value for and enjoyment of science were key predictors of the overall frequency of science learning behaviors. These results provide a foundation for efforts to increase parents' understanding of and interest in science topics and practices in order to ultimately support children's science engagement and learning.

Introduction

Fostering a robust science workforce and a scientifically literate citizenry is critical in today's society (Langdon, McKittrick, Beede, Khan, & Doms, 2011; National Academy of Sciences et al., 2011; National Science Board, 2010, 2012, 2014; Osborne et al., 2003). Although researchers, educators, and policymakers have long agreed that achieving this goal requires that individuals from all backgrounds and communities participate in science, persistent disparities exist, especially for women, minorities, and individuals from low socioeconomic backgrounds (Gershenson, 2013; Hill et al., 2010; National Science Board, 2014). For example, based on the most recent science and engineering indicators from the National Science Board (2014), women currently account for only 28% of employed individuals in science and engineering occupations, with these differences particularly apparent in the fields of engineering and computer and mathematical sciences. Similarly, although Hispanics, Blacks, and American Indians and Alaska Natives together make up approximately 26% of the US population age 21 and older, these groups collectively represent only 10% of workers in science and engineering occupations and only 13% of science and engineering highest degree holders.

Many efforts to increase the diversity of individuals interested and engaged in science in their daily lives, graduating with science-related degrees, and pursuing science-related careers have focused on schools. However, it is widely understood that parents and families play a critical role in supporting children’s learning and development (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007; Gershenson, 2013; Institute of Medicine & National Research Council, 2012; National Research Council, 2000a, 2009; Weiss, H., Little, P., Bouffard, S., Deschenes, S., & Malone, H., 2009), ultimately guiding children towards and preparing them for different career pathways. Parents support their children by laying the foundations of positive developmental pathways; fostering basic literacy skills and learning capacities; engaging in rich learning discussions and promoting curiosity questions; providing access to new experiences and resources; enculturating children in particular beliefs, values, and practices; supporting children’s engagement and success in school, and more (Institute of Medicine & National Research Council, 2012; National Research Council, 2000a, 2009). Specific to science, there is strong research evidence that parents regularly engage their children in science-rich conversations; facilitate science learning experiences, both in the home and in other settings, such as museums and science centers; and support the development of science-related interests (e.g., Alexander et al., 2013; Harackiewicz, Rozek, Hulleman, & Hyde, 2012; National Research Council, 2009; Renninger & Hidi, 2011).

Despite the broad recognition of the important role that parents play in children’s development, learning, and career preparation, surprisingly little research has been done to understand parents’ science-related knowledge, beliefs, and interests and how these might relate to children’s engagement with and participation in science (Dabney, Chakraverty, & Tai, 2013). In general, most adult Americans have a positive view of science, although many adults have trouble answering basic science questions and have a limited or narrow perception of science fields and practices (DeWitt & Pegram, 2014; National Science Board, 2014). Only a few studies have explored variation in child-rearing beliefs related to science. In a cross-sectional survey of 509 caregivers with children between the ages of three and seven (Braswell et al., 2012), investigators found significant variation in child-rearing beliefs related to learning about science, as well as a negative correlation between adult religious beliefs and beliefs about encouraging science learning. On average, caregivers felt the children should begin learning about science at 5.9 years of age. Related to science, Plowman and colleagues (2008) documented a range in child-rearing beliefs about how young children learn to use technology, including beliefs about the relative importance of demonstrations, being self-taught, using trial and error, and copying. Interviews with caregivers suggested that these beliefs were influenced by "parents' earlier experiences with technology at school, further education or work, as well as public debate about the role of technology in the lives of young children" (p. 311).

Some evidence supports the hypothesis that parents' science-related knowledge, beliefs, and interests influence their children's engagement with science (Andre et al., 1999; Dabney et al., 2013; Frenzel et al., 2010; Hidi & Harackiewicz, 2000; Simpkins, Davis-Kean, & Eccles, 2006; Tenenbaum & Leaper, 2003). For example, Andre and colleagues (1999) identified correlations between caregiver beliefs about children's science abilities and about the value of science, and children's liking of and perceived abilities related to science. Analyzing longitudinal data with German adolescents, Frenzel and colleagues (2010) found that parent and classmate values and teacher enthusiasm were all positively and uniquely related to the level of students' mathematics interest, although not to the trajectory of interest development. Analysis of a national retrospective survey with 4285 physical science doctoral students and scientists indicated that family interest in science, including parent occupation, diversions and hobbies, and encouragement, were significantly associated with early science interest development (Dabney et al., 2013). These studies indicate the promise of better understanding parent science-related interests, values, and beliefs, and the mechanisms through which they influence children's engagement with science.

Research purpose

The goal of this study was to extend existing literature on the role of parents in children's engagement with science by exploring parents' beliefs, values, and interests related to science in more detail and identifying potential predictors of these variables. The analyses reported in this article draw from data collected as part of a larger study investigating the role of parents in supporting children's developing science-related interests in early childhood. In this larger, mixed-method study, we used an initial questionnaire with parents and caregivers of Head Start families to recruit a smaller sample of mother-child dyads for a follow-up, qualitative investigation and to provide context for interpreting the qualitative findings. This article describes the secondary analysis of data from this initial recruitment questionnaire. Although this secondary analysis was exploratory, we believe it provides a strong foundation for guiding future research on the role parents play in supporting children's developing science interests and knowledge and identifying possible intervention strategies for educational programs and community organizations.

In particular, through the analysis we hoped to better theorize parents' beliefs, values, and interests related to science, using the four-phase model of interest development (Hidi & Renninger, 2006; Renninger & Hidi, 2011). Although this model has primarily been used to study interest development in children and youth, it provided a strong framework for conceptualizing and measuring adult science-related beliefs, values, and interests and exploring how these might motivate science learning behaviors and ultimately parent support for their children's science-related learning and development. The model defines interest broadly as "the psychological state of engaging or the predisposition to reengage with particular classes of objects, events, or ideas over time" (Hidi & Renninger, 2006, p. 112). Based on prior research, the researchers specified four distinct and sequential phases of interest development, characterized by varying amounts of affect, knowledge, and value, with earlier phases of interest primarily consisting of focused attention and positive affect toward the subject, while later phases incorporate knowledge and value built over time. In other words, in order to capture a holistic understanding of individuals' interests, it is important to attend psychological and behavioral indicators of affect and emotion, knowledge, and value. In this study, we used the four-phase model as a framework for identifying measures to capture these various aspects of parents' science-related interests.

Methods

During phase 1 of the broader research study, a paper questionnaire was administered to parents and caregivers of Head Start children participating in the Mt. Hood Community College (MHCC) Head Start program in East Portland, Oregon. The questionnaire was developed and administered in close collaboration with the MHCC program. Prior to the development of the instrument, we met with senior staff members at the program several times to discuss project goals, understand staff member concerns, and collect ideas for questions and information that would be of interest to the Head Start program. An initial version of the questionnaire was then drafted and we again met with senior staff members to review, discuss, and revise the instrument format and questions. To the extent possible, survey questions were drawn from previously developed measures with strong evidence of internal reliability and validity, such as the Programme for International Student Assessment.

Because a large proportion of MHCC Head Start parents speak Spanish as their primarily language, a Spanish version of the questionnaire was developed in collaboration with a bilingual, bicultural researcher and evaluator at the Oregon Museum of Science and Industry (OMSI). The first author compiled the updated English version and sent it to the bilingual researcher, along with Spanish versions of the questions from the PISA international parent survey, as administered in Colombia in 2006 (http://www.oei.es/evaluacioneducativa/Colombia_en_PISA_2006.pdf), and the Spanish-version of the American Community Survey (http://www.census.gov/acs/www/). The bilingual researcher made an initial translation of the entire questionnaire and identified potential issues and challenges with the questions, including concepts and vocabulary difficult to translate or culturally specific. We subsequently revised both versions in collaboration with the bilingual researcher, adapting both the Spanish and English to be as similar and culturally transferable as possible. Finally, both versions were reviewed by two bilingual and bicultural staff members at MHCC and final revisions were incorporated. (See Appendices A and B for final versions of the Spanish and English questionnaires.)

Questionnaire construction

The questionnaire included demographic questions and measures of child-rearing beliefs and practices, associations with science, importance of science, personal value for science, enjoyment of science, and frequency of science learning behaviors. Each of these measures is discussed below. Combined, the measures were intended to provide a holistic picture of parents' and caregivers' interest in science, including positive affect, value, knowledge, and behavior (Hidi & Renninger, 2006; Renninger & Hidi, 2011), as well as their general beliefs and values about parenting.

Science interest scales

Four scales related to science values and interest were used from the 2006 Program for International Assessment parent and student questionnaires (Organization for Economic Cooperation and Development, 2009): importance of science, personal value of science, enjoyment of science, and frequency of science activities. Table 2 summarizes these four scales, including the number of items per scale, how index values were constructed, internal consistency for the phase 1 sample, and example items.

The importance of science, personal value of science, and enjoyment of science scales all consisted of four statements, each with a four-point agreement response scale, ranging from strongly agree to strongly disagree. The enjoyment of science scale, which was taken from the student questionnaire, was modified from the original five-item version to eliminate one school-specific item ("I'm happy doing science problems"). The original science activity scale included six activities, with six-point frequency rating responses ranging from very often to never. For this study, we added one additional item ("visit a science museum like OMSI") in order to provide information specifically to the science center about visit frequency. All four scales showed strong internal consistency, with Cronbach's alpha levels ranging from 0.79 to 0.88. Internal consistency for the English- and Spanish-versions of the questionnaires was nearly identical.

The PISA instrument and measures are developed through an intensive, iterative process, with close attention to reliability and validity (Organization for Economic Cooperation and Development, 2009). Unfortunately, the parent questionnaire designed for the 2006 study was optional and only 16 countries, not including the US, chose to administer it. However, based on the 2006 data, internal consistency was high (greater than 0.70) for the importance of science and personal value of science scales across nearly all of the countries which administered the questionnaire (Organization for Economic Cooperation and Development, 2009, p. 345). Although confirmatory factor analyses (CFA) have not been reported for the parent questionnaire items, modeling of the nearly identical measures using student data provided strong evidence that each captured a unidimensional construct.

Table 2. Science interest indices

Scale	No. of items	Index construction	Cronbach's alpha	Example item
Importance of science	4	Average score across four items, with a minimum of two valid responses. 4 = Strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree.	0.789 (English = 0.775, Spanish = 0.796)	*It is important to have good scientific knowledge and skills in order to get any good job in today's world.*
Personal value of science	4	Average score across four items, with a minimum of two valid responses. 4 = Strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree.	0.806 (English = 0.852, Spanish = 0.760)	*There are many opportunities for me to use science in my everyday life.*
Enjoyment of science	4	Average score across four items, with a minimum of two valid responses. 4 = Strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree.	0.880 (English = 0.900, Spanish = 0.849)	*I generally have fun when I am learning science topics.*
Science activities	7	Average score across seven items, with a minimum of four valid responses. 5 = Very often, 4 = regularly, 3 = sometimes, 2 = hardly ever, 1 = never.	0.860 (English = 0.849, Spanish = 0.850)	*Watch TV programs about science*

Note. Questions based on the 2006 Program for International Assessment parent and student questionnaires(Organization for Economic Cooperation and Development, 2009). Cronbach's alpha values show internal consistency for all responses, English questionnaire responses, and Spanish questionnaire responses.

The enjoyment of science and frequency of science activities scales were only included in the 2006 student questionnaire. A CFA of the two-factor model including the five-point version of the science interest scale and one additional scale not included in the study (interest in science learning across a variety of topics) indicated a poor fit. However, the researchers argued that this was primarily due to correlated error terms among interest items about similar topics, such as biology of plants and human biology (Organization for Economic Cooperation and Development, 2009, p. 319). Internal reliability of this scale was 0.93 for US students and 0.92 across all OECD participating countries (Organization for Economic Cooperation and Development, 2009, p. 320). For the frequency of science activities scale, which was also not included in the parent questionnaire, Cronbach's alpha was 0.80 for the US student sample and 0.78 across all participating OECD countries (Organization for Economic Cooperation and Development, 2009, p. 327). Using the student data from the 2006 assessment, Ainley and Ainley (Ainley & Ainley, 2011a, 2011b) conducted a series of analyses using structural equation modeling and found that the relations among the science attitudes and interest measures aligned with the four-phase model of interest development.

Associations with science

Participants' associations with science were evaluated by asking the open-ended question: "When you hear the word 'science,' what does it mean to you?" English and Spanish responses to open-ended questions were reviewed and coded by the first author in collaboration with a bilingual researcher at OMSI. The first author began by reviewing all the responses and developing preliminary codes and code categories inductively. He then created a code book for each of the two questions, with code definitions and example responses, and systematically applied the codes to the responses. The bilingual researcher then used the same code books to code responses for both questions from the first 58 questionnaires, after meeting and discussing the coding protocol in detail with the first author.

Complete agreement, meaning coding for each response matched exactly even when multiple codes were applied to the same response, excluding missing responses, was 39.1%, with an average of 0.9 non-matching codes per response. Mean percent agreement, meaning the average percent of matching codes for each response out of the 16 total codes included in the agreement a check, was 94.4%. The two coders discussed and reconciled all discrepancies and then clarified and updated the code book. The bilingual researcher subsequently coded responses for the next 53 responses. Complete agreement and mean percent agreement during this round were 56.1% and 96.2%, with an average of 0.6 non-matching codes per response. All discrepancies were again discussed and resolved. Finally, the bilingual researcher coded the remaining 27 responses, with a complete agreement and mean percent agreement of 58.3% and 96.4%, respectively, and an average of 0.6 non-matching codes per response. All final discrepancies were discussed and resolved. Overall, across all the questionnaires, the average percent agreement between the two coders was 95.5%.

Child-rearing beliefs

To measure general child-rearing beliefs that have previously been reported to relate to young children's interest development, measures developed by and used with permission from Johnson and colleagues (Alexander et al., 2008; Johnson et al., 2004). As summarized in Table 3, these included scales measuring value of consistency and structure and value of communication. The measure of value of consistency and structure consisted of five words related to consistency and structure in parenting. Participants were asked to rate the importance of each word using a five-point response scale, ranging from very important to not at all important. Similarly, the value of communication scale included five words related to communication and parenting, with participants asked to rate the importance of each word using a five-point response scale. Because of concerns that the words from the original scales, which were developed in English only, would be interpreted differently among Spanish speakers, brief definitions of each of the words were developed in collaboration with the original researchers. These definitions were then translated into Spanish, as described above. Despite this modification, internal consistency for both items was high (above 7.5), with internal consistency for the English and Spanish versions nearly identical. In their original research, Johnson and colleagues (2004) found evidence that these indices represent distinct factors, based on principal axis factor analysis with promax rotation, with all items loading on the expected factors.

Two additional measures of parenting beliefs, focused on educational emphasis and value for free play, were included in the questionnaire. However, internal consistency within the sample was unacceptably low (below 0.6), therefore the scales were not included in the analyses.

Table 3. Parenting beliefs indices

Factor name	Number of items	Items words	Index construction	Cronbach's alpha
Value of consistency and structure	5	*Consistency, order, structure, organization, routine*	Average of scores for all items (minimum of three items complete)	0.773 (English = 0.797, Spanish = 0.751)
Value of communication	5	*Exploration of new ideas, exchange of information, family discussions, expression of personal opinions, exploring controversial issues*	Average of scores for all items (minimum of three items complete)	0.763 (English = 0.806, Spanish = 0.734)

Note. Questions based on unpublished measures developed by and used with permission from Kathy E. Johnson and colleagues (Alexander et al., 2008; Johnson et al., 2004). Cronbach's alpha values show internal consistency for all responses, English questionnaire responses, and Spanish questionnaire responses.

Data collection

The final version of the questionnaire was administered to parents and caregivers at Head Start family meetings between November 2013 and January 2014. To identify the best family meetings for recruitment, the first author attended a monthly Head Start family worker meeting. During this time, Head Start staff members had a chance to review the instrument and volunteer to allocate time during an upcoming family meeting to the questionnaire. Staff members also shared thoughts and concerns that ultimately helped guide the protocol for recruiting families and administering the questionnaire during the family meetings. The first researcher attended eight family meetings during this time period, introducing the project to attending parents and caregivers and providing time for those who wished to participate to complete the questionnaire. A bilingual staff member from the MHCC program also provided introductory information in Spanish. Parents that completed the questionnaire were given two free passes to OMSI. In order to recruit additional families and better represent participants in the MHCC Head Start program, between January and March 2014, seven home-based program family workers also distributed questionnaires to caregivers during home visits.

Participants

In total, 138 completed questionnaires were included in the analysis, with an overall response rate of 78.9% across the eight family meetings. The majority of participants were from Head Start meetings (78%), with the remainder recruited during home visits. Table 4 summarizes general participant characteristics. The majority were women (76.7%) between the ages of 26 and 35 (56.7%). Over half (54.3%) of the caregivers opted to complete the Spanish version of the questionnaire and an even larger percent (66.2%) identified as Hispanic/Latino. The majority of participants identified their race as white (57.4%), with a few caregivers identifying as Black (13.9%) or American Indian/Alaska Native (6.9%). Other identified races included Chinese (*n* = 1), other Pacific Islander (*n* = 1), Vietnamese (*n* = 1), Cambodian (*n* = 1), Russian (*n* = 2), Mestizo (*n* = 1), unspecified other race (*n* = 2), and participants who checked the "other race" box and wrote Hispanic, Latino, or Mexican (*n* = 20). The most common education level (40.9%) was a high school diploma or equivalent. According to MHCC senior staff members, this group was slightly older and slightly more educated than the entire population of MHCC Head Start families, potentially because of differences between families who do and do not choose to attend monthly family meetings. Although socioeconomic data were not collected, all families were low income based on their eligibility for the Head Start program.[2]

Five questionnaires were excluded because the participant was not a Head Start parent (*n* = 1), the questionnaire was identical to another and appeared to be a duplicate filled out by a spouse for his or her partner (*n* = 1), or the participant was under 18 years of age (*n* = 3).

[2] Families are eligible to participate in the Head Start program if their household income is below 100% of the federal poverty line; they receive income-based public assistance, such as through Oregon's Temporary Assistance for Needy Families (TANF) program or the federal Supplemental Security Income (SSI) program; they are enrolling a foster child; or they are classified as homeless.

Table 4. Head Start phase 1 participant characteristics

	Proportion (%)
Sex (*n* = 133)	
Male	23.3%
Female	76.7%
Age (*n* = 134)	
18–25	22.4%
26–35	56.7%
36–45	15.7%
> 45	5.2%
Questionnaire language (*n* = 138)	
Spanish	54.3%
English	45.7%
Ethnicity (*n* = 130)	
Hispanic/Latino	66.2%
Not Hispanic/Latino	33.8%
Race (*n* = 101)	
White	57.4%
Black	13.9%
American Indian/Native Alaskan	6.9%
Other	28.7%
Education level (*n* = 127)	
Less than HS diploma	28.3%
HS diploma or equivalent	40.9%
Some college	18.9%
Associate's degree or above	11.8%
Age of children (*n* = 134)	
0–3	73.9%
4	51.5%
5	24.6%
6–9	42.5%
10–12	13.4%
13–15	9.0%
16–18	5.2%

Note. HS = high school. The mean participant age was 31.2 years (*SD* = 7.27, 95% *CI*: 30.0–32.5, Median = 29.5, Range: 20–57). Participants could indicate multiple races. Age of child indicates proportion of families with at least one child in the corresponding age group. The mean number of children was 2.50 (*SD* = 0.974, 95% *CI*: 2.34–2.67, Median = 2.00, Range: 1–5).

Data analysis

Data were analyzed with descriptive and inferential statistics using SPSS™ 22.0. For the multivariate analyses, we used multiple linear regression to assess the degree to which parent characteristics uniquely contributed to the variance in expressed science interests and the frequency in which they engaged in of science activities. Based on a review of residual plots, distance, leverage, influence measures, and collinearity diagnostics, there was no indication of outliers or violations of the assumptions of the regression models (Tabachnick & Fidell, 2007). All significance tests were two-tailed unless specified, using a critical value of 0.05. When data met the appropriate assumptions, such as normal distribution and homogeneity of variance, we used parametric statistics. In other cases, we used the equivalent nonparametric tests.

In analyzing participant responses, there was some evidence of satisficing, or answering questions without thinking deeply about the responses (Groves, Fowler, Couper, Lepkowski, & Singer, 2009), such as participants marking very important for all question six and seven items. Responses were more varied for the behavior-based questions, perhaps indicating that caregivers were more willing or more able to thoughtfully answer these questions.

Findings

We begin by reporting on descriptive and correlational findings from the questionnaire. We then describe results from the multivariate analyses.

Descriptive analyses

To measure the value of parenting beliefs, such as consistency and structure and the value of communication, the questionnaire provided caregivers with a series of parenting values words, along with brief definitions, and asked participants to rate the relative importance of those values to them, from very important to not at all important (Table 5). In general, most caregivers rated most of the values important or very important. The values with the highest average rankings were reading, consistency, and cooperation, while the values with the lowest averages were structure, exploring controversial issues, and organization. The mean for items was between “important” and “very important.”

Table 5. Importance of parenting values

Value (description)	*M* (*SD*)	Distribution	*n*
Reading (Regularly reading to your child and encouraging your child to practice reading)	4.74 (0.51)		136
Consistency (consistent, predictable discipline, expectations, and rules for child)	4.69 (0.55)		136
Cooperation (Working together with your child, sharing family jobs and tasks, and encouraging family cooperation)	4.68 (0.50)		136
Exchange of information (Sharing ideas with your child and encouraging your child to share ideas with you)	4.67 (0.54)		137
Family discussions (Regularly talking with your child and having conversations as a family)	4.64 (0.62)		135
Goal setting (Setting goals for your child's growth, development, and learning)	4.64 (0.59)		136
Expression of personal opinions (Allowing your child to have their own ideas, values, and opinions)	4.63 (0.60)		135
Order (Maintaining a neat and clean home)	4.60 (0.61)		137
Exploration of new ideas (Encouraging your child to be curious and explore new topics and ideas)	4.54 (0.69)		137
Routine (Maintaining regular schedules and routines for your child)	4.36 (0.75)		136
Structure (Emphasizing structured activities and routines for your child)	4.35 (0.68)		136
Exploring controversial issues (Discussing challenging or sensitive topics with your child)	4.33 (0.90)		134
Organization *(Planning and organizing your child's schedule and activities)*	4.16 (0.81)		135

Note. Means calculated using the following values: 5 = very important, 4 = important, 3 = in the middle, 2 = not very important, 1 = not at all important. Distribution graphs show higher importance on the left. Value word descriptions are as show in the questionnaire.

To begin to explore caregivers' perspectives on science, participants were asked to describe what they thought of when they heard the word "science." Table 6 outlines the most common categories of responses. By far the most common type of response related to the active practices of science, such as discovering, inventing, experimenting, and learning. Many caregivers also mentioned nature or natural sciences, human-related topics, science knowledge, or a positive enjoyment of science.

Table 6. Common response categories for caregivers' understanding of the word "science"

Category (definition)	No. of responses (%)	Examples
Science practices Response mentioned a practice of science using a verb or action noun, such as discovering, inventing, learning, or experimenting.	61 (55.0%)	*Explorando cosas, como quimicos. [Exploring things, like chemicals.]* *Exploring things with hands on-activities, investigating, having knowledge.*
Science topics—Nature Response mentioned a specific topic of science or area of study related to nature or biology, such as nature, plants, zoolology, earth, animals, and the natural world.	23 (20.7%)	*Tecnología y cosas nuevas, como descubrimientos de naturaleza, animales, arte. [Technology and new things, like discoveries about nature, animals, art.]* *How the world works. I have a degree in Zoology so science is a huge part of my son's life.*
Science topics—Humans Response mentioned a specific topic of science or area of study related to humans, including the human body, medicine and health, or food.	15 (13.5%)	*Tecnología, progreso, esparanza para el nivel salúd. [Technology, progress, hope for the level of human health.]* *Explaining-inventions-creations-experiments-humans-animals-universe-etc.*
Science knowledge Response mentioned science facts or knowledge not associated with a verb or action noun, such as knowledge, theories, facts, or the way things work.	15 (13.5%)	*Conocimiento, experimentar y conocer. [Knowledge, experimenting, knowing.]* *The facts about why things are or work the way they do..*
Enjoyment Response mentioned positive emotions related to science, such as fun, interesting, or exciting.	13 (11.7%)	*Que es divirtido y para aprender algo nuevo y importante. [How it's fun and learning something new and important.]* *Fun, exploration.*

Note. Responses could be coded into multiple categories. Percent calculated based on total non-missing responses (n = 111).

Caregivers were also asked to rate their level of agreement to a series of science-related statements. These statements were organized around three topics: the general importance of science to them (importance of science), the value of science to them (personal value of science), and their enjoyment of learning and doing science (enjoyment of science). In general, research participants had relatively positive views of science, with average responses in all three topic areas falling between "agree" and "strongly agree." Average scores for the three topic areas were nearly identical. As indicated by the response distribution, a small group of research participants had particularly strong and positive views towards science, while the remaining responses were more evenly distributed (Table 7).

Table 7. Attitudes and beliefs about science

Scale	*M* (*SD*)	Distribution	*n*
Importance of science	3.17 (0.57)		135
Personal value of science	3.16 (0.54)		134
Enjoyment of science	3.16 (0.59)		134

Note. 4 = Strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree. Distributions show stronger agreement on the right.

Finally, caregivers indicated the frequency with which they engage in different science-related activities, such as reading a book about science or visiting a science museum like OMSI (Table 8). By far the most common science-related activity reported was watching a TV program about science, with the average rating falling between "regularly" and "sometimes." Many caregivers also reported occasionally reading a science article or book about science, visiting a website about science topics, visiting a science museum like OMSI, or listening to a science-related radio program. Very few caregivers reported attending a science club with any frequency. The mean value across all of the activity items, excluding individuals with less than four valid responses, was 2.76 (*SD* = 0.78, *n* = 136).

Table 8. Frequency of science learning activities

Activity	*M* (*SD*)	Distribution	*n*
Watch TV programs about science	3.51 (0.93)		136
Read science magazines or science articles in newspapers	2.87 (1.05)		135
Borrow or buy books on science topics	2.80 (1.03)		136
Visit websites about science topics	2.80 (1.10)		134
Visit a science museum like OMSI	2.78 (1.21)		136
Listen to radio programs about advances in science	2.70 (1.10)		136
Attend a science club	1.84 (1.03)		135

Note. 5 = Very often, 4 = regularly, 3 = sometimes, 2 = hardly ever, 1 = never. Distributions show higher frequency on the left.

Correlations

To better understand why caregivers might be more or less interested in science, and ultimately be more or less likely to support their own children's science-related interests, we explored associations between their reported science interests and responses to other survey questions. General importance of science, personal value of science, enjoyment of science, and science activities were all strongly and positively correlated (Table 9). The strongest correlations were between the importance of science and the personal value of science, as well as between enjoyment of science and personal value of science.

Table 9. Correlations among science interest measures

	Importance of science	Personal value of science	Enjoyment of science	Science activities
Importance of science	1.00			
Personal value of science	0.566**	1.00		
Enjoyment of science	0.378**	0.602**	1.00	
Science activities	0.380**	0.497**	0.427**	1.00

Note. Pearson correlations shown. Spearman correlations were nearly identical.
*$p < 0.01$, **$p < 0.001$

Most associations between the science interest scales and other questionnaire items were small or nonexistent, with a few exceptions (Table 10). Men were more likely on average to engage in science activities more frequently ($M = 3.03$) compared to women ($M = 2.65$), $t(130) = -2.45$, $p = 0.016$, $r = 0.210$. Men also had slightly more positive views of the general importance of science and personal value of science on average compared to women, although these differences were not statistically significant. Age was positively associated with importance of science (Spearman $r = 0.178$, $p = 0.041$), personal value of science (Spearman $r = 0.218$, $p = 0.012$), and engaging in science activities (Spearman $r = 0.236$, $p = 0.006$), but not enjoyment of science (Spearman $r = -0.036$, $p = 0.684$). In other words, older participants were slightly more likely on average to agree or strongly agree with the importance, personal value, and enjoyment of science statements and were slightly more likely on average to engage in science activities more frequently.

Table 10. Proportion of shared variance (effect sizes)

	Importance of science	**Personal value of science**	**Enjoyment of science**	**Science activities**
Sex[1]	0.002	0.006	0.015	0.044*
Age[2]	0.032*	0.048*	0.001	0.056**
Questionnaire language[1]	0.031*	0.019	0.021	0.077**
Ethnicity (Hispanic/Latino, not Hispanic/Latino)[1]	0.035*	0.006	0.002	0.031*
Race (white only, black only, other and multiple)[3]	0.003	0.017	0.023	0.030
Education level (less than HS diploma, HS diploma, above HS diploma)[3]	.029	.002	.000	.008
Taken college science courses[1]	0.003	0.021	0.007	0.031*
Value of consistency/structure[2]	0.026	0.008	0.019	0.033*
Value of communication[2]	0.027	0.068**	0.034*	0.046*

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$
[1]r^2 calculated after Field (2013) for either t-test of u-test , depending on distribution of responses.
[2]Squared Spearman (non-parametric) correlation
[3]Eta squared

Compared to caregivers who completed the English questionnaire, caregivers filling out the Spanish version on average were more likely to agree with the importance of science statements (English mean = 3.07, Spanish mean = 3.26, $t(133) = -2.049$, $p = 0.042$) and report engaging in science-related activities more frequently (English mean = 2.52, Spanish mean = 2.95, $t(134) = -3.333$, $p = 0.001$, $r = 0.277$). Hispanic/Latino participants on average were also more likely to agree with the importance of science statements (Not Hispanic/Latino mean = 3.02, Hispanic/Latino mean = 3.2441, $t(126) = -2.138$, $p = .034$, $r = 0.187$) and report engaging in science-related activities more frequently compared to non-Hispanic/Latino participants (Not Hispanic/Latino median = 2.43, Hispanic/Latino median = 2.71, U = 1444.00, $p = .042$, $r = 0.176$.), although these differences were small. Neither race nor education level were significantly correlated with the science interest scales. Those responding who had taken at least one college science course reported engaging in science learning activities slightly more frequently (median courses = 3.00) compared to those who had not taken any college science courses (median = 2.57), U = 749.50, $p = 0.048$, $r = 0.175$.

Caregivers' reported value for communication was positively associated with personal value of science ($r = 0.261$, $p = 0.002$), enjoyment of science ($r = 0.185$, $p = 0.033$), and science learning behaviors ($r = 0.214$, $p = 0.013$). In contrast, caregivers' reported value for consistency and structure was only significantly correlated with science learning activities ($r = 0.181$, $p = 0.035$).

Multivariate analyses

Finally, five separate multiple linear regression models were constructed to assess the unique relationships among parent characteristics, importance of science, personal value of science, and frequency of science activities. The results from these models are outlined in Table 11 and described in detail below. Unless indicated, based on a review of residual plots, distance, leverage, influence measures, and collinearity diagnostics, there was no indication of outliers or violations of the assumptions of the regression models (Tabachnick & Fidell, 2007). All statistical tests were two tailed, using a critical value of 0.05.

Table 11. Multiple linear regressions

Variable	Outcome variable Importance of science	Personal value of science	Enjoyment of science	Science activities (model 1)	Science activities (model 2)
Constant	1.594 (0.454–2.735)	1.859 (0.782–2.937)**	2.368 (1.122–3.614)***	-0.875 (-2.225–0.476)	0.620 (-0.817–2.058)
Demographics					
Age	0.009 (-0.005–0.023)**	0.012 (-0.002–0.025)	-0.006 (-0.021–0.010)	0.015 (-0.001–0.031)	0.020 (0.002–0.037)*
Sex (female)	0.015 (-0.239–(0.269)	-0.094 (-0.333–0.146)	-0.197 (-0.474–0.079)	-0.204 (-0.486–0.078)	-0.293 (-0.613–0.027)
Ethnicity (Hispanic/Latino)	0.305 (0.073–0.537)	0.159 (-0.061–0.380)	0.152 (-0.102–0.407)	0.174 (-0.089–0.437)	0.335 (0.042–0.627)*
Science courses (yes)	0.112 (-0.177–0.401)	0.180 (-0.093–0.454)	0.165 (-0.151–0.482)	0.238 (-0.083–0.559)	0.380 (0.016–0.745)*
Parenting values					
Consistency and structure	0.074 (-0.176–0.325)	-0.135 (-0.372–0.103)	0.023 (-0.251–0.298)	0.068 (-0.213–0.348)	0.070 (-0.241–0.381)
Communication	0.156 (-0.096–0.408)	0.316 (0.078–0.555)*	0.195 (-0.081–0.471)	0.077 (-0.209–0.364)	0.242 (-0.074–0.559)
Science interest	--	--	--		
Importance of science	--	--	--	0.178 (-0.067–0.423)	--
Personal value of science	--	--	--	0.327 (0.025–0.69)*	--
Enjoyment of science	--	--	--	0.279 (0.037–0.521)*	--
R^2	0.111*	0.155*	0.064	0.390***	0.178**
F	2.287	2.366	1.273	7.542	3.997
n	117	116	116	116	118

Note. Unstandardized regression coefficients shown, with 95% confidence intervals in parentheses. The reference categories for sex, ethnicity, and science courses were male, non-Hispanic/Latino, and no college science courses taken, respectively.
$*p < 0.05$. $**p < 0.01$. $***p < 0.001$.

Predicting science importance index

Multiple regression analysis was used to evaluate the relationship between expressed importance of science and participant age, sex, self-identified ethnicity, college science courses taken, expressed values for structure and consistency, and expressed values for communication. Sex, ethnicity, and college science courses taken were coded as dummy variables, with male, not Hispanic/Latino, and no college science courses taken as the reference categories, respectively. The total sample size for the analysis was 117.[3]

Overall, the predictors explained approximately 11.1% of the variance in the outcome variable (R = 0.33, F(6, 110) = 2.287, p = 0.041). Self-identifying as Hispanic/Latino was the only statistically significant regression coefficient (B = 0.305, t(110) = 2.608, p = 0.010). Controlling for all other variables, self-identifying as Hispanic/Latino was related to an average 0.305 increase in expressed science importance, or almost half a point on the averaged four-point scale. Based on the squared semi-partial correlation (0.055), this variable contributed uniquely to about 5.5% of the variance in the outcome variable. Based on the regression equation, participants who had not taken any college science courses and were one standard deviation below mean age, male, not Hispanic/Latino, and one standard deviation below for the expressed value of consistency and communication were predicted to be in the middle of the scale for science importance (between agree and disagree). Participants who had taken at least one college science courses and were one standard deviation above mean age, female, Hispanic/Latino, and one standard deviation above for the expressed value of consistency and communication were predicted to have a high value for importance of science (between agree and strongly agree on average).

Predicting science personal value index

Multiple regression analysis was used to evaluate the relationship between expressed personal value of science and participant age, sex, self-identified ethnicity, college science courses taken, expressed values for structure and consistency, and expressed values for communication. Sex, ethnicity, and college science courses taken were coded as dummy

[3] One predicted value met the criteria of a multivariate outlier, with a Mahalanobis distance of 22.85, or p < 0.001 for value evaluated as a χ^2 distribution with degrees of freedom equal to the number of independent variables (Tabachnick & Fidell, 2007).

variables, with male, not Hispanic/Latino, and no college science courses taken as the reference categories, respectively. The total sample size for the analysis was 116.[4]

Overall, the predictors explained approximately 11.5% of the variance in the outcome variable (R = 0.34, F(6, 109) = 2.366, p = 0.035). Expressed value for communication was the only statistically significant regression coefficient (B = 0.316, t(109) = 2.626, p = 0.10). Controlling for all other variables, a one point increase in the value of communication was associated with a 0.316 point increase in the outcome variable, or almost half a point on the averaged four-point scale. Based on the regression equation, participants who had not taken any science courses and were one standard deviation below mean age, male, not Hispanic/Latino, and one standard deviation below for expressed value for consistency and communication were predicted to be just above the middle of the scale for science importance (between agree and disagree). Participants who had taken at least one college science courses and were one standard deviation above mean age, female, Hispanic/Latino, and one standard deviation above for expressed value of consistency and communication were predicted to place high value on the importance of science (between agree and strongly agree on average).

Predicting enjoyment of science index

Multiple regression analysis was used to evaluate the relationship between expressed enjoyment of science and participant age, sex, self-identified ethnicity, college science courses taken, expressed values for structure and consistency, and expressed values for communication. Sex, ethnicity, and college science courses taken were coded as dummy variables, with male, not Hispanic/Latino, and no college science courses taken as the reference categories, respectively. The total sample size for the analysis was 116.[5]

Overall, the predictors explained approximately 6.4% of the variance in the outcome variable (R = 0.25, F(6, 109) = 1.237, p = 0.293). The omnibus model ANOVA was not statistically significant and none of the regression coefficients differed significantly from zero.

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[4] One predicted value met the criteria of a multivariate outlier, with a Mahalanobis distance of 22.66, or p < 0.001 for value evaluated as a χ^2 distribution with degrees of freedom equal to the number of independent variables (Tabachnick & Fidell, 2007).

[5] One predicted value met the criteria of a multivariate outlier, with a Mahalanobis distance of 22.66, or p < 0.001 for value evaluated as a χ^2 distribution with degrees of freedom equal to the number of independent variables (Tabachnick & Fidell, 2007).

Predicting science behavior index

Multiple regression analysis was used to evaluate the relationship between the frequency of self-reported science learning behaviors and participant age, sex, self-identified ethnicity, college science courses taken, expressed values for structure and consistency, expressed values for communication, expressed importance of science, expressed personal value for science, and expressed enjoyment of science (model 1). Sex, ethnicity, and college science courses taken were coded as dummy variables, with male, not Hispanic/Latino, and no college science courses taken as the reference categories, respectively. The total sample size for the analysis was 116.

Overall, the predictors explained approximately 39.0% of the variance in the outcome variable ($R = 0.63$, $F(9, 106) = 7.542$, $p < 0.001$, $n = 116$). Two of the regression coefficients, personal value for science and enjoyment of science, were statistically significant and one, age, approached statistical significance. Controlling for all other variables, a one point increase in personal value for science was associated with a 0.327 point increase in frequency of science learning behaviors, or almost half a point on the averaged five-point scale ($B = 0.327$, $t(106) = 2.149$, $p = 0.034$). Similarly, controlling for all other variables, a one point increase in enjoyment of science was associated with a 0.279 point increase in frequency of science learning behaviors, or over a quarter of a point on the averaged five-point scale ($B = 0.279$, $t(106) = 2.289$, $p = 0.024$). Controlling for all other variables, an increase in one year of age was associated with a 0.015 increase in frequency of science learning behaviors ($B = 0.015$, $t(106) = 1.853$, $p = 0.067$).

Based on the regression equation, participants who had not taken a college science courses and were one standard deviation below mean age, male, not Hispanic/Latino, one standard deviation below for the expressed value of consistency and communication, and one standard deviation below the mean for all three science interest scales were predicted to “hardly ever” engage in science learning activities on average. Participants who had taken at least one college science courses and were one standard deviation above mean age, female, Hispanic/Latino, one standard deviation above average for expressed value of consistency and communication, and one standard deviation above the mean for all three science interest scales were predicted to sometimes or regularly engage in science learning activities on average (average frequency almost exactly between sometimes and regularly).

We also ran the model without the science interest indices (model 2) in order to explore potentially important predictor variables mediated by expressed science interest. All predictor variables were as described above and the total sample size for this model was 118. Overall, without the science interest indices, the predictors explained approximately 17.8% of the variance in the outcome variable ($R = 0.42$, $F(6, 111) = 3.997$, $p = 0.001$, $n = 118$). Three of the regression coefficients were statistically significant: age, identifying as Hispanic/Latino, and science courses taken. Controlling for all other variables, an increase in one year of age was associated with a 0.020 point increase in the frequency of science learning behaviors ($B = 0.020$, $t(111) = 2.180$, $p = 0.031$). Controlling for all other variables, identifying as Hispanic/Latino, compared to not identifying as Hispanic/Latino, was associated with a 0.335 point increase in the frequency of science learning behaviors ($B = 0.335$, $t(111) = 2.264$, $p = 0.026$). Finally, controlling for all other variables, having taken at least one college science course, compared to not having taken a college science course, was associated with a 0.380 point increase in the frequency of science learning behaviors ($B = 0.380$, $t(111) = 2.067$, $p = 0.041$). The change in significance for age, identifying as Hispanic/Latino, and science courses suggests that the relationship between these factors and the frequency of science activities is primarily due to differences in science personal value and enjoyment, although none of the three variables was a statistically significant predictor of science personal value or enjoyment in the original regression models.

Discussion

The goal of the study was to advance research on parents' science-related beliefs, values, and interests in order to better understand how these parent characteristics might influence their children's engagement with science and, ultimately, science interest pathways such pursuing science-related careers and hobbies. As part of a larger, mixed-method study on interest development in early childhood, we conducted a secondary analysis of data from a cross-sectional survey with parents and caregivers of Head Start children. Our measurement of parent attitudes and beliefs related to science was motivated by the four-phase model of interest development (Hidi & Renninger, 2006; Renninger & Hidi, 2011), which conceptualizes interest as a central motivator of human behavior, including both a heightened emotional state and the predisposition to reengage with a particular object, activity, or topic. The phases of the interest development model are characterized by varying amounts of affect, knowledge, and value, with earlier phases of interest primarily consisting of focused attention and positive affect toward the subject, while later phases incorporate knowledge and value built over time. Based on this framework, we measured parents' associations with the word science, their expressed importance of science, the value of science to them, their enjoyment of science, and the frequency that they engage in science-related learning activities.

Aligned with prior research (DeWitt & Pegram, 2014; National Science Board, 2014), parents generally expressed positive views of science. Mean scores for the importance of science, personal value of science, and enjoyment of science scales all fell between agree and strongly agree, although the only science-related learning activity that parents reported engaging in more than "sometimes" on average was watching TV programs about science. Also aligned with prior research, parent responses to the open-ended question about the meaning of the word "science" suggest a relatively narrow view of science fields, with many of the responses focused around nature or biology. However, the most common category of response to this question related to science practices, such as discovering, inventing, learning, and experimenting. This indicates a more active and dynamic perspective on science and science practices, aligned with current science standards (e.g., NGSS Lead States, 2013).

Together, these findings indicate both issues to address and positive trends on which to build. For example, across the fields of science, women have achieved greater parity in the natural sciences, including biology and the medical sciences (Hill et al., 2010; National Science Board, 2014). Interestingly, these correspond directly to the most common fields of science mentioned in participants' open-ended responses. Therefore, an important strategy for addressing gender disparities in other fields of science, such as physics and the computer and mathematical sciences, may be to broaden parents' awareness of these fields. Such efforts could build on parents' positive views of science in general and their awareness of science as an active professional practice, rather than simply a body of knowledge.

In contrast to other data (National Science Board, 2014), education level and number of college science courses taken were generally not strongly associated with science interest or learning activities. This may in part be due to the restrictive nature of the sample. All participants in the study were part of the Head Start program and therefore the variation in education level and number of science courses taken was relatively low compared to that of national surveys. However, the findings indicate that despite persistent disparities in science achievement across socioeconomic levels (Gershenson, 2013), parents from all backgrounds can become engaged with science and potentially share these interests and values with their children.

Perhaps the most important finding from the study is the strong association between parents' enjoyment of science and the frequency with which they reported engaging in science-learning activities. There is consistent evidence from national and international data that students' enjoyment of science is a central motivator of science engagement and participation, serving as a mediating variable for other factors, such as valuing science and science knowledge (Ainley & Ainley, 2011a, 2011b). Both the four-phase model of interest development and other interest theories posit a central role of enjoyment in interest development and behavior motivation (Hidi & Renninger, 2006; Renninger & Hidi, 2011; Silvia, 2006). Similarly, in our multivariate analyses, enjoyment of science and personal value of science were strongly associated with the frequency that parents reported engaging in science-related learning activities, after controlling for age, sex, ethnicity, and science courses taken, parental values related to consistency and structure and communication, and expressed importance of science to them. Collectively, these variables explained almost 40% of the variation in frequency of reported science-learning activities.

These findings highlight the utility of the four-phase model of interest development for conceptualizing parents' science-related beliefs, values, and interests and suggest important leverage points for educational programs and community organizations. Although this study did not directly measure child outcomes or parent-child interactions, prior research suggests that parents influence children's' interest in and engagement with science both indirectly, by providing science-related experiences and learning resources (e.g., Alexander et al., 2012, 2013) and directly, by communicating enjoyment of and value for science during conversations and interactions with children (e.g., Alexander et al., 2013; Barron et al., 2009; Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; Frenzel et al., 2010; Leibham et al., 2005; Tenenbaum & Leaper, 2003; Valle & Callanan, 2006). Given that enjoyment of science was strongly associated with frequency of science-related learning activities, designing parent support programs that try to increase parents' enjoyment of science, such as offering hands-on experiences with science activities in low-risk settings, may be a productive strategy for supporting long-term child outcomes. Parents who enjoy science may be more likely to learn more about science throughout their lives, provide more science-related experiences and resources for themselves and their children, and share their enthusiasm for and interest in science with their children.

Conclusion

Given that research has repeatedly shown a positive association between parents' and children's beliefs, values, and interests related to science (Andre et al., 1999; Dabney et al., 2013; Frenzel et al., 2010; Hidi & Harackiewicz, 2000; Simpkins et al., 2006; Tenenbaum & Leaper, 2003), an important next step for investigators will be to explore in more depth the mechanisms and processes underlying these relationships. As part of a larger study, we collected observations and parent interview data from seven families recruited through the questionnaire and with the help of Head Start staff, in order to identify characteristics of parent-child interactions that are potentially related to science interest development in early childhood. These findings will be reported in another paper. Preliminary results suggest parent enjoyment of science does indeed directly influence parent-child interactions, with parents who report higher levels of science enjoyment more actively engaging in science-related experiences and demonstrating more positive affect and enjoyment. These behaviors appear, in turn, to be associated with parent reports of children's extended interests in science-related activities and topics. Our hope is that these findings will contribute to the long-term agenda to understand and support the role parents can play in their children's science-related interest development pathways, including education, careers, and everyday pursuits.

CHAPTER 3:
THE ROLE OF HEAD START PARENTS IN SUPPORTING EARLY CHILDHOOD SCIENCE INTEREST DEVELOPMENT

There is growing evidence that children develop science-related interests in early childhood, before they enter school, and that these early interests may have long-term implications for science participation and achievement. Although researchers have made headway in describing early childhood science-related interest development, very little is currently known about the proximal processes influencing these interests and how they relate to other more distal factors. To address this gap in the literature, we conducted a qualitative, in-depth study with seven mothers and their four-year-old daughters participating in the Head Start program. Over several months, families were videotaped engaging in four different science-rich contexts: (a) reading science books at home, (b) visiting the early childhood learning space at a science center, (c) using science-related activity boxes at home, and (d) doing a science-related activity of their choice. We also conducted two in-depth interviews with parents from each family in order to elicit parents' perspectives on the interactions and explore parent beliefs and other distal factors potentially influencing children's interest development. While all of the parents in the study reported that their children exhibited science-related interests that extended beyond the sessions, a subset of parents provided evidence that their children were moving beyond situational interest and developing emerging individual interests in science-related topics or practices. Close analysis of video and interview data suggested five factors associated with these emerging individual interests: (a) parent enjoyment of science, (b) active parent involvement, (c) successfully re-engaging children, (d) parent awareness and value for everyday learning, and (e) reflective parent orientations. These findings represent important hypotheses for future research and promising strategies for other Head Start and low-income families to support their young children's developing science-related interests.

Introduction

A central goal of science education and policy efforts over the last several decades has been to ensure a robust and diverse science and engineering workforce (Langdon et al., 2011; National Academy of Sciences et al., 2011; National Science Board, 2010, 2012, 2014). Increasing participation in science across communities of all cultural and socioeconomic backgrounds is an issue of both practical and ethical concern, since it is broadly recognized that in order to maintain a strong and innovative scientific enterprise in the US, all communities must have access to opportunities to learn about and engage with science and, ultimately, be equitably represented in the science workforce (Hill et al., 2010; National Academy of Sciences et al., 2011; National Science Board, 2010). Many researchers and policymakers have argued that attracting underrepresented groups to the sciences can help fill workforce gaps, diversify the field, and maximize innovation (Hill et al., 2010; National Science Board, 2010; National Science Foundation., 2011). According to the National Academy of Sciences, “increasing the participation and success of underrepresented minorities in S&E [science and engineering] contributes to the health of the nation by expanding the S&E talent pool, enhancing innovation, and improving the nation’s global economic leadership” (National Academy of Sciences et al., 2011, p. 3). In addition, policymakers argue that declining interest and participation in science leads to a less scientifically literate citizenry and fewer adults able to function successfully in an increasingly scientific and technological world (National Academy of Sciences et al., 2011; Osborne et al., 2003).

Yet despite national consensus on the importance of these issues, major disparities persist in science-related academic achievement, access to science learning opportunities inside and outside of school, and workforce participation between men and woman and across racial, ethnic, and socioeconomic groups. According to the National Science Board (2014), the substantial gaps across racial and ethnic communities in science and math school achievement, the proportion of students earning advanced mathematics and science credits, and high school graduation rates remain persistent challenges in K-12 education. Similarly, women and minority racial and ethnic groups, and especially Blacks and Hispanics, continue to be underrepresented in the science and engineering workforce (Hill et al., 2010; National Science Board, 2014). For example, “despite accounting for half of the college-educated workforce, in 2010 women constituted 37% of employed individuals with a highest degree in an S&E field and 28% of employed individuals in S&E occupations," with these differences particularly apparent in the fields of engineering and computer and mathematical sciences (National Science Board, 2014). Income level and socioeconomic status are generally strongly associated with academic performance and access to learning resources and often interact with issues of gender and racial/ethnic equality in STEM achievement and participation (Ainley & Ainley, 2011a; Corbett, Hill, & St. Rose, 2008; Gershenson, 2013; Institute for Museum and Library Services, 2013; McGraw, Lubienski, & Strutchens, 2006).

In addition to addressing issues of preparation, access, affordability, and academic and social support, researchers and policymakers have identified interest and motivation as key leverage points for addressing these disparities (National Academy of Sciences et al., 2011; National Research Council, 2005, 2009). Interest, often defined as a heightened emotional state of engagement, as well as a predisposition to reengage with a particular object, event, or topic (Hidi & Renninger, 2006), is a critical factor driving long-term engagement with science (Falk & Dierking, 2010; Falk, Osborne, & Dorph, 2013; Maltese & Tai, 2010; National Research Council, 2009; Tai, Liu, Maltese, & Fan, 2006) and a central component to successful learning (Alexander et al., 2013; Fisher et al., 2012; National Research Council, 2009; Renninger, 2007; Silvia, 2006) (see reviews by Hidi & Renninger, 2006; Renninger & Hidi, 2011; Renninger & Su, 2012). The strong emotional arousal associated with interest has been repeatedly linked to increased comprehension, knowledge gains and information integration, focused attention and engagement, perseverance during complex and challenging tasks, increased self-regulation behaviors, and buffering against unfavorable learning conditions (Hidi & Renninger, 2006; Kang et al., 2010; Lewalter & Scholta, 2009; National Research Council, 2000b; Renninger & Su, 2012; Silvia, 2006). Interest triggered in a particular moment also sets the stage for the development of more enduring individual interests (Hidi & Renninger, 2006), which extend beyond a specific context and can lead to identity development (Alexander et al., 2012; Renninger, 2007) and career and hobby pathways (Archer et al., 2010; Brickhouse et al., 2000; Hughes, 2001; McCreedy & Dierking, 2013; Packard & Nguyen, 2003; Silvia, 2006; Watt & Eccles, 2008). Scholars have argued that individual interest is critical for science learning and achievement in particular, motivating individuals to focus attention on science topics and activities, identify and seek answers to meaningful science questions, engage and persevere in science learning experiences, and develop positive attitudes toward science (Renninger, 2007; Renninger & Su, 2012).

Although the focus of interest and interest development research is often on older children (see Alexander et al., 2013), there is growing evidence that before they enter school, children do indeed develop enduring interests, including science-related interests, that persist over time and have implications for long-term learning trajectories (Alexander et al., 2012, 2013, 2008; Brotman & Moore, 2008; Fisher et al., 2012; Patrick et al., 2008). In their pioneering studies, Renninger and colleagues provided evidence that preschool children exhibit strong, individualized, gender-differentiated interests focused around specific objects or themes and that these interests are associated with differences in attention, cognition, temperament, persistence, and social play behaviors (Renninger, 1989; Renninger & Leckrone, 1991; Renninger & Wozniak, 1985). Subsequent research indicates that these interests often persist and have implications for children's attitudes, behaviors, and achievement in kindergarten and beyond (Alexander et al., 2013; Leibham et al., 2013; Neitzel et al., 2008).

As these findings emerge, researchers are just beginning to investigate the factors and processes that influence early childhood interest development. From a developmental, ecological perspective (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007), young children's science-related interests are expected to be directly shaped by ongoing, proximal processes in those children's lives, and especially interactions between children and their caregivers, and indirectly influenced by more distal processes, such as science-related cultural values and norms, caregiver beliefs, and the availability of science engagement opportunities and learning resources. Researchers have documented the many ways that preschool children and their families engage in scientific activities and learning practices in a variety of settings (Callanan & Jipson, 2001; Callanan & Oakes, 1992; Callanan et al., 2007; Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; National Research Council, 2009; Rigney & Callanan, 2011; Valle & Callanan, 2006). To date, however, there has been almost no research to understand the proximal processes influencing children's developing science-related interests.

Recognizing the current state of the field, the purpose of this study was to systematically document the ongoing proximal processes potentially driving young children's developing science-related interests, as well as the contextual factors shaping these processes, with the ultimate goal of developing a theoretical model of early childhood science interest development to be further refined and tested in future research. The qualitative study reported in this article was part of a larger, mixed-method investigation in collaboration with the Mt. Hood Committee College (MHCC) Head Start program and the Oregon Museum of Science and Industry (OMSI). The initial phase of the study was a quantitative, cross-sectional survey with Head Start parents and caregivers to explore relationships between parent characteristics, child-rearing beliefs, science interests, and science learning practices. Using findings from the questionnaire, we recruited a group of seven mother-daughter dyads for a more in-depth, qualitative investigation of the proximal processes and contextual factors potentially shaping early childhood science-related interest development.

Theoretical framework

This research was guided by two theoretical frameworks: (1) the four-phase model of interest development (Hidi & Renninger, 2006; Renninger & Hidi, 2011) and (2) the bioecological model of human development (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007). The four-phase model of interest development provides a detailed definition of interest and a framework for understanding how interest is initially sparked and then evolves over time, from situational to individual interest. Complementing this framework is the broader perspective provided by the bioecological model. In articulating this model, Bronfenbrenner and colleagues highlighted the importance of understanding both the proximal and distal processes shaping human development and specified a framework for capturing the complexity and multiple ecologies of individuals' lives. Together, these perspectives shaped the design of the study and were used to identify sensitizing concepts (Blumer, 1986; Charmaz, 2006) for data collection and analysis.

Four-phase model of interest development

Within the field of science education and learning, Renninger and Hidi (Hidi & Renninger, 2006; Renninger & Hidi, 2011) have developed one of the most broadly used and empirically supported theory of science interest and interest development (National Research Council, 2009). In their model, they defined interest broadly as "the psychological state of engaging or the predisposition to reengage with particular classes of objects, events, or ideas over time" (Hidi & Renninger, 2006, p. 112) and individual interest, specifically, as a "a person's relatively enduring predisposition to reengage particular content over time as well as to the immediate psychological state when this predisposition has been activated" (p. 113). They also argued that interest involves “a particular relation between a person and the environment and is sustained through interaction” (Renninger & Hidi, 2011, p. 169).

This theoretical perspective places individual interest at one end of a continuum of four phases of interest development (Hidi & Renninger, 2006). Based on prior research, Hidi and Renninger posited a model of interest development that specifies four distinct and sequential phases, including two phases of situational interest (triggered and maintained) and two phases of individual interest (emerging and well-developed). The researchers argued that each phase is a prerequisite for subsequent phases and that the characteristics of each are mediators of subsequent interest development. The phases are characterized by varying amounts of affect, knowledge, and perceived value related to a specific subject, with earlier phases of interest primarily consisting of focused attention and positive affect, while later phases incorporate knowledge and value constructed over time. For example, an individual may have a strong, positive response toward science while watching a demonstration at a science center. However, for that interest to be maintained and to continue to develop, the individual must, according to Hidi and Renninger, develop deeper knowledge of and increased value for science. Therefore, as the researchers argued, support and opportunities to continue to engage with the topic are necessary for individual interest to develop. Recently, Renninger and colleagues have further refined the model to highlight how different configurations of the phase of interest development, the achievement demands of the learning environment, and metacognitive awareness require different supports for interest development (Renninger & Su, 2012).

Only relatively recently has this model, and a focus on interest and interest development more generally, been applied to early childhood. Historically, many scholars have argued that there is little evidence of preschool children showing enduring, stable interests (see Alexander et al., 2012). However, in the last two decades, research has indicated that many young children do indeed develop domain-specific interests that persist for months and even years (Alexander et al., 2013, 2008; Leibham et al., 2013; Neitzel et al., 2008; Renninger & Su, 2012). For example, in a four-month study with 211 four-year-olds, primarily using data from caregiver questionnaires, Johnson and colleagues (2004) found that at the majority of time points at which caregivers were contacted (66% of the time for girls, 72% the time for boys), children showed evidence of focused conceptual interests, defined based on whether caregivers felt children tended to “keep the same play interest for more than one week at a time” (p. 330), and that 42 of the children, primarily boys, maintained the same conceptual interests throughout the study. Many investigations have documented how these emerging interests in early childhood include science-related concepts and skills, such as birds, dinosaurs, and mathematics (Alexander et al., 2012; DeLoache et al., 2007; Fisher et al., 2012).

There is also growing evidence that these interests persist into the school years and have implications for children’s behavior and learning before and after they enter school. Studying early childhood interest in general, researchers have found that children as young as three have strong and individualized interests focused around activities, objects, themes, or topic domains; that gender differences in these interests are already apparent at this early age and; that these interests are associated with attention, level of recognition of previously encountered images and pictures, recall of previously presented objects, length of and variation in play activities with interest objects, the nature of play with other preschoolers, and temperament and persistence during play with objects of interest (Fink, 1994; Renninger, 1989; Renninger & Leckrone, 1991; Renninger & Wozniak, 1985; Rowe & Neitzel, 2010). These interests have also been associated with how children later participate in the classroom as they enter kindergarten (Neitzel et al., 2008). Specific to science, several studies have found meaningful differences in children’s science interests as they are just entering school (Mantzicopoulos et al., 2008; Patrick et al., 2008). For example, using an age-appropriate puppet-based assessment, Patrick and colleagues (2008) identified three different motivational profiles among 110 kindergarten students. The majority of students (72%) held positive motivational beliefs across all three scales. However, some children (15%) “said they liked science but it was difficult and they were not good at it” (p. 139) and a small group of children (14%) “reported not liking science even though they were somewhat good at it and it was easy” (p. 139).

Providing the most compelling evidence to date of the long-term importance of early childhood science interest development, Alexander and colleagues (Alexander et al., 2013; Leibham et al., 2013) conducted a prospective, longitudinal study of early science interest development in preschool and elementary school. Beginning when children were four years old, the researchers tracked the interests, as well as environmental and distal factors potentially influencing interest development, of 116 children over the course of four years, primarily through ongoing phone calls and emails with parents. When the children were eight, researchers used standardized measures to assess science knowledge, science self-concept, and general reading ability. Controlling for other factors, intense science-related interests when children were in preschool predicted science self-concept and knowledge four years later, when children were eight. However this relationship was only significant for girls. For these children, early science interest appeared to be a stronger predictor of self-concept and knowledge than current science interest (Leibham et al., 2013).

Factors influencing early childhood interest development

Building on these studies and the four-phase model of interest development, researchers over the last several decades have begun to identify a variety of factors and processes shaping science interest and interest development in early childhood. Despite growing evidence that preschool children exhibit individual differences in enduring, science-related interests before they enter school, little research has been done to understand how interests develop, especially with young children (Alexander et al., 2012; Fisher et al., 2012; Renninger, 2007). To date, there is some evidence that before children enter school, gender, caregiver-child interactions, children's interests and questions, and caregivers' attitudes and beliefs are important proximal processes and contextual factors shaping the development of young children's science-related interests.

Gender

Gender is one of the few personal and demographic factors related to early childhood interest development that has been studied in any detail. Researchers have consistently found gender differences among preschool children in the types and duration of interests (Alexander et al., 2012, 2013; DeLoache et al., 2007; Johnson et al., 2004; Neitzel et al., 2008). Furthermore, research on caregivers' socialization of boys and girls has found significant differences "in terms of the degree to which caregivers encouraged sex stereotypes in play activities and household chores" (Alexander et al., 2012, p. 781). However, although there is substantial evidence that gender differences exist in science-related interests for children in middle school, high school, and beyond (Alexander et al., 2013), findings are more mixed in research on young children.

Several studies have found gender differences in science-and math-related interests and interest pathways in early childhood (Alexander et al., 2012; Leibham et al., 2013), while others have found no significant differences (Fisher et al., 2012; Mantzicopoulos et al., 2008; Patrick et al., 2008). The discrepant findings across studies may be due to caregivers' tendency to self-report interest based on cultural stereotypes. Recent studies using caregiver self-report methods (Alexander et al., 2012) have shown significant gender differences, while studies using observation or child interview methods (Fisher et al., 2012; Mantzicopoulos et al., 2008; Patrick et al., 2008) have not. Research in both informal learning contexts and classrooms indicates that adults often provide more scientific explanations to boys than girls (Crowley, Callanan, Tenenbaum, et al., 2001), although these findings have not been linked directly with interest or motivation.

Caregiver-child interactions

Caregiver-child interactions is another factor that has long been speculated to be central to early childhood interest development. From a developmental perspective, the daily experiences and social interactions of young children, particularly interactions with their primary caregivers, are seen as central drivers of learning and development (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007; National Research Council, 2000a). There is substantial evidence that parents and preschool children frequently engage in scientific activities and learning practices that may offer an important context for science-related interest development (Callanan & Jipson, 2001; Callanan & Oakes, 1992; Callanan et al., 2007; Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; National Research Council, 2009; Rigney & Callanan, 2011; Valle & Callanan, 2006). Scholars have speculated that during these interactions, caregivers influence interest by (a) communicating important messages about attitudes, beliefs, and values through modeling interest and enthusiasm and providing opportunities for involvement; (b) regulating family time and activities; (c) answering curiosity questions, co-constructing knowledge, and engaging in conversations; and (d) providing encouragement and motivation (Alexander et al., 2013; Barron et al., 2009; Frenzel et al., 2010; Leibham et al., 2005; Tenenbaum & Leaper, 2003). However, only a limited number studies have tried to directly measure the influence of caregivers on the development of young children's interest before they enter school and these studies have primarily focused on distal, rather than proximal, factors and processes. Specifically, in two longitudinal studies focused on conceptual interest development with four-year-olds, researchers identified parent beliefs associated with the development of sustained interests in young children, including beliefs about academic stimulation, satisfying their children's curiosity, providing interest-related materials and learning opportunities, consistency and structure, and the value of communication (Johnson et al., 2004; Leibham et al., 2005). There is a recognized need, however, to better understand how these distal factors directly influence parent-child interactions.

Children's interests and questions

Related to parent-child interactions, many researchers have suggested the important role of children's interests and questions for driving early childhood interest development. Children are not simply passive participants during interactions with caregivers. In general, developmental research strongly emphasizes that young children are active agents in their learning processes, influencing their own developmental and learning outcomes (Institute of Medicine & National Research Council, 2012; National Research Council, 2000a, 2009). In particular, children's questions, focused around their own interests, may be an important mechanism through which young children elicit caregiver discourse and shape their own development (Alexander et al., 2013; Callanan & Oakes, 1992; Callanan et al., 2012; Chouinard & Imberi-Olivares, 2011; Hidi & Renninger, 2006).

Although relatively few studies have been conducted in this area, the existing research indicates that these questions are a frequent part of caregiver-child conversations and that the majority appear to be intended to elicit factual or causal information, rather than, for example, attention or permission (Callanan & Oakes, 1992; Chouinard et al., 2007; Frazier et al., 2009; Kelemen et al., 2005; Mills et al., 2011). Several studies have been focused on cause-related questions, indicating that children frequently ask such questions related to physical, biological, and social phenomena (Callanan & Oakes, 1992; Kelemen et al., 2005). Some studies have begun to directly connect children's questions with interest development. In one study of the "extremely intense interests" of young children between the ages of 11 months and six years (DeLoache et al., 2007), caregivers reported that these interests pervaded their children's lives and that as children got older, they "constantly talked about the object of interest" and also "asked endless questions" (p. 1583). Researchers have speculated that developing interests may motivate children to ask curiosity questions (Hidi & Renninger, 2006), which in turn elicit interactions with caregivers and other adults and supports further interest development (e.g., Alexander et al., 2008; Hidi & Renninger, 2006; Renninger, 2007).

Caregiver attitudes and beliefs

Finally, another factor potentially shaping the development of early childhood science interest is caregivers' own attitudes related to science. In general, caregivers internalize an array of beliefs, values, and attitudes related to child-rearing and early childhood development that, in turn, influence interactions with their own children (Holden & Miller, 1999; Huang et al., 2005; Keels, 2009; National Research Council, 2000a; Rogoff et al., 2003; Tazouti et al., 2010). Researchers have yet to specifically examine caregivers' beliefs related to science interest development in early childhood and the relationship between these beliefs and child-rearing behaviors and discourse. However, scholars have generally argued for the importance of child-rearing beliefs as a factor influencing caregiver-child interactions and, consequently, child development (Holden & Miller, 1999; Huang et al., 2005; Tazouti et al., 2010) and several studies have identified direct and indirect relationships connecting caregiver beliefs, child-rearing practices, and early childhood development (Barnett et al., 2010; Barnyak, 2011; Plowman et al., 2008; Tazouti et al., 2010). Studies have also documented variation in child-rearing beliefs related to science and technology (Braswell et al., 2012; Plowman et al., 2008) and have shown positive correlations between caregivers' and parents' science-related interests, beliefs, and values and those of their children (Andre et al., 1999; Frenzel et al., 2010; Tenenbaum & Leaper, 2003). As noted above, researchers have speculated that caregivers communicate important messages about attitudes, beliefs, values, and interest through modeling and providing opportunities for involvement; showing interest and enthusiasm related to particular topics, objects, or domains; and providing encouragement and motivation (Barron et al., 2009; Frenzel et al., 2010; Leibham et al., 2005; Tenenbaum & Leaper, 2003). These aspects of caregiver-child discourse may mediate the link between the distal factor of caregiver interest and beliefs and children's own interest development.

Bioecological model of human development

Long-term, developmental perspectives are often missing from research on family and early childhood science engagement and learning. For example, many of the studies of how preschool children and their families engage in scientific activities and learning practices are cross-sectional in nature, focusing on a few, short interactions between caregivers and children across families (Alexander et al., 2013; Callanan et al., 2012). However, in order to address critical social issues and needs, it is important to understand how these short-term interactions and processes relate to long-term developmental and learning outcomes. Bronfenbrenner's bioecological model of human development (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007) provides a detailed, research-based framework for studying these long-term processes, including the development of children's science-related interests.

The bioecological model, defined as a "theoretical system for the scientific study of human development over time" (Bronfenbrenner & Morris, 2007, p. 753), makes two central claims: (1) proximal processes, or the ongoing, direct experiences of an individual with his or her environment, including other individuals, are t he primary engines of development; and (2) the impact of these proximal processes are indirectly influenced by personal, environmental, and temporal factors that are more or less distal to the direct experiences of the individual. From an analytic perspective, these claims assert that proximal processes, such as caregiver-child interactions, should have a direct association with developmental outcomes, while other contextual factors, such as availability of learning resources or child-rearing beliefs, should be indirectly associated with those outcomes, either mediated through proximal processes or moderating the relationship between those processes and children's learning and development. Bronfenbrenner and Morris also posited that in order to have a significant influence on an individual's development, proximal processes must be fairly regular and ongoing.

Since the original ecological model of development was formulated (Bronfenbrenner, 1979), Bronfenbrenner has developed more specific recommendations for research designs and approaches intended to study development from a bioecological perspective. Bronfenbrenner and Morris (2007) defined research designs that permit the holistic study of development as "process-person-context-time (PPCT)" models (p. 798). These designs attempt to operationalize and measure proximal processes appropriate to the developmental outcomes of interest;

personal characteristics of study participants and contextual factors that likely influence those processes; and the cross-context, longitudinal influence of those processes on development.

This theoretical framework and research model has several implications for the study of young children's developing science-related interests. First, proximal processes, and particularly caregiver-child interactions (Bronfenbrenner & Morris, 2007; National Research Council, 2000a), are expected to be the primary influence on children's situational interests and developing individual, enduring interests. To date, the few studies of young children's science-related interests have primarily focused on more distal factors, such as opportunities to engage with science (e.g., Alexander et al., 2012). While these factors are no doubt important, the bioecological model suggests that they should influence development only to the degree to which they afford or constrain more direct, proximal processes. Notably, almost no research has been conducted to identify and understand the proximal processes that support or hinder young children's science-related interest development.

Second, in order to have a strong impact on interest development, these proximal processes must be regular and ongoing. Many of the existing studies on interactions between preschool children and their caregivers have been cross-sectional and focused on particular, unique situations, such as a visit to a children's museum or science center. These studies provide little insight into the ongoing, regular aspects of caregiver discourse and caregiver-child interactions that incrementally over time guide children's developing interests. Therefore, research to identify such processes must be both longitudinal, capturing interactions and discourse over time and across settings, and also detailed and naturalistic, focusing not on indirect indicators of interest development but on the day-to-day talk, behaviors, and experiences of young children.

Finally, in order to develop a holistic, ecological model of interest development, research studies must be sensitive to the personal and contextual factors that shape the more direct, proximal mechanisms of interest development. As Bronfenbrenner and Morris (2007) noted, researchers must not leave these discoveries to chance but must strategically design studies to reveal interactions and indirect effects. Based on the limited research described above, an important personal factor shaping the proximal processes of interest development may be young children's questions and especially those that elicit caregiver discourse and deeper caregiver-child interactions. Similarly, although findings are mixed, children's gender may influence the nature of caregiver discourse, based on social and cultural stereotypes. Studies also suggest that child-rearing beliefs and values may be an important influence on caregiving behaviors and thus, an indirect influence on interest development.

Research questions

Guided by the bioecological model and the interest development literature, we conducted a qualitative investigation to document the proximal processes of caregiver-child interactions that potentially contribute to early childhood science interest development. The study was designed to address two broad research questions:

1) What are common, ongoing patterns of caregiver and child discourse and caregiver-child interactions that potentially influence the development of preschool children's early science-related interests?
2) What contextual factors potentially influence these proximal processes and contribute to or hinder the development of preschool children's early science-related interests?

As described in the findings section below, the experiences of families in this study were unique and diverse, providing strong indications of situational and emerging individual science-related interests. In this article, we focus particularly on describing two different types of interest pathways that emerged from the data and exploring the distal and proximal factors that appeared to distinguish and potentially explain these different pathways. This focus was motivated by attention to the importance transition from maintained situational interest to emerging individual interest, as highlighted by Alexander and colleagues (2013). Given the small sample size of the study, our goal was to generate hypotheses related to the two research questions above that could motivate the refinement and testing of theory in future work.

Methods

In describing the data collection and analysis methods below, we begin with an overview of the research design, followed by detailed descriptions of the activities and contexts for data collection, participant recruitment procedures, and observation and interview protocols.

Research design

The study design followed a "sequential contributions" approach to combining qualitative and quantitative methods (Morgan, 2014), beginning with an initial quantitative survey of 138 English- and Spanish-speaking parents and caregivers of Head Start children designed to assess their child-rearing beliefs and science-related attitudes, interests, and learning behaviors (described in Chapter 2). This was followed by a more intensive, in-depth qualitative study of a subset of parents and children in order to focus on the proximal processes that shape early childhood science interest development. Advantages of mixed-method research include strengthening the validity of findings through data triangulation, capturing the complexities of social learning environments, building on the strengths of different data collection techniques, and using findings from one method to inform other aspects of the study (Frechtling, 2010; Morgan, 2014). In particular, gathering initial quantitative data that informs a core qualitative study is ideal for using the strengths of quantitative research to identify major differences between subgroups of potential participants and guide purposive sampling (Morgan, 2014). An additional advantage to this design is the ability to compare characteristics of qualitative study participants with a larger, more representative sample.

As described in this article, seven mothers with four-year-old daughters and varying levels of science interest were recruited for the phase 2 qualitative study, involving interviews and videotaped observations of the families interacting in a variety of science-related contexts. Qualitative research is a broad approach to scientific inquiry that, in contrast to quantitative methods, emphasizes discovery and emergent findings, the subjective experiences of participants and researchers, and the exploration of the complexities of specific contexts and settings (Morgan, 1998, 2014). The approach is particularly appropriate when existing theories and empirical findings are lacking and there is a need to capture the complexities of social systems and identify patterns that can be further explored in subsequent, quantitative studies (Creswell, 2013; Marshall & Rossman, 2011; Morgan, 1998, 2014).

Only mothers were selected in order to eliminate parent gender as a source of variation in the study and because the vast majority of phase 1 participants were female. Similarly, we focused on families with four-year-olds in order to eliminate differences due to child age. Research also highlights this age as a critical time period in which children are beginning to develop understandings of themselves relative to social and cultural norms (e.g., Goodvin, Meyer, Thompson, & Hayes, 2008; Ontai & Thompson, 2008; Thompson, 2006) and show signs of emerging interests in science-related topics and activities that have been associated with behaviors and attitudes into elementary school (e.g., Alexander et al., 2012, 2013). We also had to limit the phase 2 study sample to only English-speaking families because resources were not available to collect and analyze video and interview data in Spanish. In the future, we plan to collaborate with bilingual and bicultural researchers and study interest development processes for both English- and Spanish-speaking families.

Girls were specifically chosen because child gender has been identified as a potentially critical factor influencing early science interest development. As described above, Alexander and colleagues (2012) found that the connection between children's indications of early science interest and opportunities afforded by caregivers to engage with science was strongest for girls. More broadly, researchers have documented persistent gender disparities in extracurricular opportunities to engage with science (Brotman & Moore, 2008). Although this approach to recruitment necessarily limits the generalizability of study findings, understanding interest development in girls is arguably more critical to broadening access to science careers (Brotman & Moore, 2008; Hill et al., 2010; National Academy of Sciences et al., 2011). Focusing data collection on caregiver-girl interactions also helped address the challenge of identifying contexts and activities that were engaging for all participants.

Activity descriptions

Four different data collection sessions were designed to represent social contexts in which child-rearing practices are salient and science-related discourse likely to be elicited: (1) reading a science-related book together; (2) visiting Science Playground, the early childhood space for six year olds and younger at OMSI; (3) engaging in an open-ended science activity; and

(4) participating in an activity with their daughters of their own choosing that they felt related to science. Each of these contexts has been the frequent focus of science learning and engagement research and represent common ways that preschool children and their families engage with and learn about science. For example, there is a large body of literature on caregiver-child interactions in science centers (National Research Council, 2009) and during shared book reading (e.g., Barnyak, 2011; Leung, 2008). Providing a hands-on, science-related activity is also a common way researchers have studied family science engagement and discourse (e.g., Siegel, Esterly, Callanan, Wright, & Navarro, 2007; Tenenbaum & Callanan, 2008; Wertsch, Minick, & Arns, 1999). Although previous studies have focused on each of these contexts, no research to date has looked at the proximal processes of science interest development shared across contexts within the same families. During all the sessions, observations followed best practices in video-based research (Barron, 2007; Derry et al., 2010; National Research Council, 2009, pp. 323–324). All activities and materials used during the sessions were previously prototyped with two mother-child dyads not involved in the study.

In the first session, we brought three science-related books to the families' homes and asked them to read together as they typically would. Families were told that they could read some or all of the books, spending as much or as little time as they wanted. The three books were: *Me… Jane* (McDonnell, 2011), *The Fantastic Undersea Life of Jack Cousteau* (Yaccarino, 2012), and *Around One Log* (Fredericks, 2011). These books were chosen, in consultation with early childhood science education experts at OMSI, to be engaging and accessible for families with four-year-old daughters and to highlight both science topics (e.g., forest ecology, underwater animals) and processes and practices (e.g., the life of a scientist, scientific investigations).

In the second session, we invited mother-child dyads to visit the early childhood space at OMSI, Science Playground, designed for six-year-olds and younger. The space is a large, brightly colored, open exhibition hall on the second floor of the science center filled with interactive exhibits and play spaces. Major areas within the hall include a market area, with props and materials for imaginative play related to shopping and cooking; a sand area; a water area; a ball and air exploration area; a natural sciences area, with imaginative play spaces and information about forest animals and plants; a blocks area; and an infant space. At one side of the hall is a separated learning lab with rotating science and art activities, such as flubber and collage art. The hall and learning lab are usually staffed with educators and volunteers, although none of the families interacted with staff members during the study.

In the third session, similar to the joint book reading, we brought two open-ended science activity boxes to the families' homes and asked them to explore the activities in any way they wanted for as long as they wanted. The first activity box, "exploring natural materials," included a large magnifying glass, a ruler, and a variety of flowers, leaves, rocks and agates, and other natural materials. A small card in the box prompted families to "investigate and compare natural materials with your child" and suggested several possible activities, such as sorting the objects in different ways. The second activity box, "exploring bubbles," included a small bowl, dish soap, corn syrup, string, straws, and pipe cleaners. The card in the box prompted families to "investigate bubbles and build bubble tools with your child" and, in addition to providing instructions for making the bubble solution, suggested several possible activities, such as building creative bubble tools. Both activities were based on NSF-funded projects at the Boston Children's Museum (Boston Children's Museum, 2012, n.d.).

For the final session, parents were asked after the second sesssion to pick an activity they did with their daughters that they felt was related to science. Without prompting, all six of the families that were able to participate in the family choice session chose outdoor experiences. Five of the families chose walks in a park or natural area and one of the families chose a walk to collect leaves followed by a leaf rubbing activity.

Participant recruitment

Participant selection and recruitment for phase 2 qualitative data collection was conducted in close collaboration with the MHCC Head Start program. In phase 1, study participants recruited during monthly Head Start parent meetings were asked to provide their names and contact information if they were interested in participating in additional research activities to understand how parents and caregivers support their children's learning and development. Of those who provided information, the first author then contacted potential participants who were female, had at least one four-year-old daughter, and spoke only English in the home. Because of these recruitment criteria, and in particular because over half of participants reported speaking a language other than English in the home, only three families were recruited using this approach. Five additional families were then identified and recruited by Head Start program staff and asked to complete the phase 1 questionnaire.

In total, eight mother-daughter dyads were recruited. One family, originally contacted by Head Start program staff, dropped out after the first session without completing the phase 1 questionnaire and therefore was only included in initial coding and analysis. As incentives for participating, each family was offered a one-year membership to OMSI and the variety of science activities and learning resources used during the study. To minimize the influence on caregiver and child behaviors, families were told that the broad goal of the study was to understand child-rearing and early childhood development but were not informed of the specific focus on science-related interests until the end of the second interview.

Observations

Data collection included videotaped observations of parent-child interactions in the four different purposively designed social contexts. As described above, the context for each of the videotaped sessions was designed to balance the need to maintain naturalistic parent-child interactions, provide a degree of contextual consistency across families, and capture discourse and interactions potentially related to science interests. Between January and August 2014, the first author observed and videotaped each family in the four different social contexts in which child-rearing practices were salient and science-related discourse was likely to be elicited. Field notes collected during these initial observations were also included as part of data analysis.

The protocol for observations varied depending upon the session. For the reading and activity box sessions, the first author brought the materials to the families' homes at a prearranged time, set up the video camera in a location chosen by the parents, briefly introduced the materials, and left the mothers and children to interact on their own. Parents notified the researcher with a text message when they were done with the session, at which time the first author returned and debriefed for a few minutes with the families. During the reading session, families were told they could read all the books or choose to focus on only one or two. Similarly, during the activity box session, families could try both boxes or focus on only one.

During the OMSI visit, the first author met families at the front entrance to the science center and escorted them to Science Playground. At this point, families were invited to explore the exhibits for as much or little time as they wanted while the researcher followed at a respectful distance with the video camera. Videotaping ended when either the digital camera was full (approximately one and a half hours) or families decided to leave the early childhood space. The protocol for the family choice session was similar. The first author met families in a predetermined location, usually their homes, and then videotaped the parents and children engaging in the chosen activity or visiting the chosen location, following at a respectful distance with the video camera. Again, videotaping ended when either the digital camera was full or the families decided they were finished.

Interviews

Qualitative interviews were conducted with each of the parents after the OMSI visit (session 2) and after the family choice session (session 4) in order to explore caregiver perspectives on the interactions and help identify distal factors, such as caregiver values and beliefs, that may influence proximal processes related to early childhood interest development. Data from these interviews also provided a check of our interpretations of the videotaped interactions and helped capture important contexts of early childhood interest development, such as preschool, not directly observed in the study.

The conversations were semi-structured (Patton, 1987, 2002), meaning that the general focus and content were predetermined but that the interviewer had the flexibility to vary wording and question order to create a more natural conversation and to take advantage of opportunities to follow up on caregivers' ideas as they emerged during the interview. Generic interview guides were developed for each round and then tailored to the specific families (see Appendices C and D for copies of the generic guides). Each conversation began with questions focused on parents’ perspectives and reflections related to the previous two sessions. During these portions, we used pre-prepared segments from the videotaped parent-child interactions to prompt reflections and explore situation-specific beliefs and perspectives. For example, parents were asked to describe in as much detail as possible what they remembered about the particular experience with their children and what they were thinking about during the session. Each interview ended with more general questions about parenting beliefs related to supporting young children’s interests, learning, and development.

At the end of the final interview, we posed specific questions about what participants felt parents can do to support children’s developing science-related interests and what other factors besides parents influence these interests. Parents were also asked to discuss why they chose the particular activity for the family choice session and how that activity relates to science. All interviews were videotaped and analyzed with the interaction data, as described below. All seven of the families included in the full data analysis were able to complete both rounds of interviews.

Data analysis

In qualitative research, data analysis begins as soon as the researcher enters the study setting and continues throughout the process of collecting, organizing, and interpreting data and communicating findings (Charmaz, 2006). In contrast to quantitative studies, analysis is iterative, emergent, exploratory, and closely linked with data collection and interpretation. For this study, we adopted a constructivist grounded theory approach, particularly informed by the recommendations of Charmaz (2006). Although the process, as recommended by Charmaz, is not linear, in general we followed three broad phases of analysis: (1) initial coding, (2) focused coding, and (3) interpretation. Using NVivo software, video data from the sessions and interviews were coded directly. Throughout the data analysis, we wrote descriptive and interpretive memos to document our analytic process and ensure that our interpretations remained grounded in the data and participants' perspectives (Charmaz, 2006). We also used the "constant comparative method" (Charmaz, 2006; Glaser & Strauss, 1967), including comparing data within and across participants and settings, during each phase to guide and motivate the analysis.

During initial coding, the first author reviewed all of the videotaped sessions and interviews incident by incident and utterance by utterance, assigning short, low-inference codes that captured the essence of the participants’ actions and talk. This process resulted in numerous tags and annotations that were then carefully reviewed in order to draft a focused coding framework for the next stage of analysis. To guide the selection of these focused codes, the researcher used sensitizing concepts from prior literature and theory, the salience of codes to the study’s research questions, the frequency of common actions and comments in initial coding, evidence of the importance of a situation for shaping interest and interest development, and ideas that emerged in field notes and early analytic memos. During this stage, the second author also reviewed a subset of the sessions and interviews and both authors met to discuss critical interactions and emergent themes and patterns. These discussions informed the draft focused coding framework and provided a check on the first author's interpretations and assumptions.

In the next stage, the focused coding framework was revised and applied systematically to all of the videotaped sessions and interviews from the seven families that completed the study. Initially, the first author applied the framework to a subset of codes and used this process to clarify and refine code definitions and distinctions. This revised framework was then sent to the second author and one other researcher with extensive video coding experience who had not been involved in the study before this point. These two individuals used the updated coding framework to analyze a subset of the interview and session videos. The three researchers then met to discuss and revise the coding framework, including clarifying and refining code definitions, removing and revising codes that made unjustified assumptions or value statements about family actions and comments, adding codes to capture critical aspects of the interactions and interviews that had been missed previously, and reorganizing the framework to reflect emerging ideas about the nature of the interactions and the factors and processes influencing interest and interest development. Finally, the first author applied this revised coding framework to all of the video data, continuing to clarify code definitions as needed. This process resulted in approximately 5000 coding references for the 14 interviews and the 26 family sessions.

Four distinct sets of codes emerged during this analysis process: (a) indicators of interest and interest development, (b) holistic parent-child interaction characteristics, (c) micro parent and child behaviors, and (d) parenting beliefs and perspectives. In the first category, we developed a set of codes to capture child situational interest and interest loss during the sessions, including indicators of interest loss, factors that appeared to precipitate the interest loss, strategies parents used to respond, and short-term outcomes of the interactions. Similarly, we developed a set of codes to capture evidence from the interviews about child interests sparked during the sessions that were sustained beyond the particular experiences, as well as the types of interests that were sustained. These codes were emergent from the data but ended up being critical for identifying parenting strategies and other factors connected with child interest development.

The second category of codes included holistic characteristics of the sessions and interviews. These were intended to capture general patterns of parenting, parent-child interactions, and parenting beliefs and were applied to each video as a whole. The categories of codes that fell into this group included: parent goal orientation, leadership style, parent involvement, parenting routines, power and affect dynamics, and reflective parenting. At the same time, we also developed “micro” codes that were applied to specific actions, comments, and instances within the videotaped sessions. These codes were intended to both identify more nuanced patterns of interaction potentially related to children’s interests and interest development and to provide a check for the holistic codes. For example, instances of changing focus from one activity box to the next or from one book to the next were tagged and coded as either child initiated or parent initiated. These codes then provided both a detailed picture of the flow of the interactions and a check on the “leadership style” holistic coding. In total, we developed eight categories of micro-interaction codes: activity change, child challenges, choice and control, extended exchange, new possibility, parent affect, personal connection, and science foundations (see Appendix E for further discussion of coding video data at multiple levels).

Finally, a separate set of codes was developed to capture parenting beliefs and perspectives that emerged during the interviews. Categories of these codes included: awareness of child interests, awareness of science, beliefs about learning resources, goals for children, openness to parent learning, parenting reflections and aspirations, and strategies for supporting interest, learning, and development.

The final stage of the analysis process was interpretation. Qualitative research, especially within the constructivist grounded theory tradition, is a constant process of interpretation, beginning from the very moment the researcher conceptualizes the study, guided by his or her own perspectives and values. At this stage of the data analysis process, however, interpretation became particularly important as we moved from coded data segments to broader, more theoretical statements about patterns and processes highlighted by the codes. This stage included extensive memo writing to explicate codes and code categories and begin to describe and organize patterns within the data, strategic comparisons within the dataset, and ongoing discussions between the first and second author. Potential themes were identified, along with supporting evidence, leading to further analysis and comparisons. During this process, we also used a negative case analysis approach, involving the search for data that disconfirms or contradicts the researcher's hypotheses or themes and leads to subsequent revisions better fit the data (Creswell, 2013).

An important goal during the analysis was to avoid making assumptions about "good" or "bad" parenting practices or implicitly judging families based on normative ideas about parenting and child-rearing. Several deliberate strategies were used to minimize this problem. First, implicit researcher values and assumptions were a key topic of coding review discussions, often resulting in revisions to the coding scheme or coding terminology to avoid value-laden language and focus primarily on observable behaviors and actions. Second, when holistic codes were used to rate or classify interactions, these ratings or classifications were applied relative to other families within the dataset, rather than predetermined expectation. Third, we used the interest indicator codes as a primary filter for understanding promising parenting strategies and factors that may support or hinder child interest development. Again, this avoided the issue of associating parenting approaches with interest development based on normative assumptions, rather than evidence of outcomes. Finally, the in-depth interviews and extensive contact with the families and parents provided deep insight into participants' own perspectives, the cultural values and assumptions underlying parent actions, and contextual factors influencing the interactions and interest development. The interview data in particular motivated us to question our own assumptions about parenting and better understand and appreciate the lived experiences of these families. Overall, we sought to identify the funds of knowledge and repertoires of practice (González, Moll, & Amanti, 2005; Gutierrez & Rogoff, 2003) already present within low-income families that showed promise for supporting girls' developing science-related interest in early childhood.

Findings

The analysis process resulted in a rich description and understanding of parent-child interactions in the different contexts, parents' beliefs and values guiding their approaches to child-rearing, the nature of emerging science-related interests in early childhood, and the many complex factors and processes that shape these interests and afford and constrain the lives of these families more broadly. In this article, guided by our research questions, we focus particularly on evidence of sparked and sustained science-related interests during the study and the parenting strategies and beliefs that appeared to be associated with interest development. We begin by describing the characteristics of study participants and their experiences with the sessions in general. We then focus the remainder of the findings section on evidence of different interest pathways sparked by the study and distal and proximal factors that appeared to be related to these interests. Following Morgan (1993), throughout the findings section we use code frequencies and counts to make explicit how different patterns of engagement informed our analysis and guided our theoretical interpretations.

Study participants

Table 12 provides a summary of parent characteristics for the seven families that completed the study.[6] Overall, the participants represented a range of backgrounds, family structures, education levels, and beliefs and interests related to science. Three of the families were involved in full-day Head Start, specifically designed for working parents, while the remainder had children in part-day programs. The age of the mothers ranged from 22 to 37. Most of families had two adults in the household, although two parents were single mothers, and the number of children in the house ranged from 1 to 3. Several of the parents with older children reported having had families with a previous partner. Two mothers identified as Black, one as Black and American Indian/Native Alaskan, one as Mexican, and three as White, not Hispanic/Latino. Most parents had none or only some college experience, although one reported completing a bachelor's degree. In general, most parents expressed neutral to positive

[6] All the names used in this report are pseudonyms, chosen by the participants.

values towards and interest in science but most reported hardly ever engaging in science-related learning activities, such as watching a science TV program or reading a science book.

As a comparison, Table 13 shows demographics for all phase 1 participants. Phase 2 parents were generally representative of the larger population, although, as noted previously, over half of study 1 participants were Hispanic/Latino. All participants for both phases, by being eligible for the Head Start program, were from low socioeconomic backgrounds.

Table 12. Phase 2 participant characteristics

Name	Demographics: HS program	Age	Adults in house	Children in house	Work	Ethnicity	Race	Highest degree	Science interest measures: Importance of science	Science personal value	Science enjoyment	Science learning activities	Perspective on science
Raymona	Part-day HS, EHS	30	1	3 (0 –3, 4, 6–9)	Caring for children, house keeper.	Not Hispanic/ Latino	Black	Some college credit (no degree)	Medium (2.5)	Very high (4.0)	Very high (3.5)	Sometimes (2.7)	*"Detailed, realistic explanations of things."*
Tanisha	Full-day HS	22	1	1 (4)	Drive thru cashier, cleaning.	Not Hispanic/ Latino	Black	Some college credit (no degree)	Medium (2.75)	High (3.25)	High (3.25)	Hardly ever (1.9)	*"Questions, ideas, answers, earth, chemicals, creations."*
Darlene	Part day, EHS, PAT	26	2	2 (0–3, 4)	Teaching my children life skills.	Not Hispanic/ Latino	White	Grade 1 through 11	Medium (2.5)	High (3.25)	Very high (4.0)	Sometimes (2.9)	*"Periodic table."*
Emily	Part-day HS	36	2	2 (4, 13–15)	Cleaning and caring for my kids.	Not Hispanic/ Latino	White	Regular high school diploma	Medium (2.0)	Medium (2.25)	Medium (2.5)	Hardly ever (2.1)	*"The word science means to me the discovery of new things."*
Sabrina	Full-day HS	23	2	2 (0–3, 4)	Caring for disabled adults	Not Hispanic/ Latino	Black, AI/NA	Some college (no degree)	Medium (2.5)	Medium (2.5)	Very high (3.5)	Hardly ever (2.3)	*"Science means fun to me, always my favorite subject."*
Michelle	Full-day HS	35	2	3 (4, 5, 13–15)	Customer service	Mexican	White	Some college (no degree)	Low (1.5)	Medium (2.25)	High (3.25)	Hardly ever–Sometimes (2.6)	*"Studying cool things."*
Maddy	Part-day HS	37	2	3 (4, 6–9, 13–15)	Volunteer work with daughter's school	Not Hispanic/ Latino	White	Bachelor's degree	High (3.25)	Very high (3.5)	Very high (4.0)	Sometimes (3.0)	*"Testing a hypothesis to see how things work."*

Notes. Adults in household includes participant. EHS = Early Head Start. PAT = Parents as Teachers. Perspective on science taken from survey question, "When you hear the word science, what does it mean to you?" Very high: greater than 3.25 (strongly agreed with at least two items and agreed with other items), High: 2.75–3.25 (disagreed with no more than one item, strongly agreed with no more than one item, agreed with other items), Medium: 2–2.75 (agreed with at least one item), Low: less than 2.

Table 13. Head Start phase 1 participant characteristics

	Proportion (%)
Sex (*n* = 133)	
Male	23.3%
Female	76.7%
Age (*n* = 134)	
18–25	22.4%
26–35	56.7%
36–45	15.7%
> 45	5.2%
Questionnaire language (*n* = 138)	
Spanish	54.3%
English	45.7%
Ethnicity (*n* = 130)	
Hispanic/Latino	66.2%
Not Hispanic/Latino	33.8%
Race (*n* = 101)	
White	57.4%
Black	13.9%
American Indian/Native Alaskan	6.9%
Other	28.7%
Education level (*n* = 127)	
Less than HS diploma	28.3%
HS diploma or equivalent	40.9%
Some college	18.9%
Associate's degree or above	11.8%
Age of children (*n* = 134)	
0–3	73.9%
4	51.5%
5	24.6%
6–9	42.5%
10–12	13.4%
13–15	9.0%
16–18	5.2%

Note. HS = high school. The mean participant age was 31.2 years (*SD* = 7.27, 95% *CI*: 30.0–32.5, Median = 29.5, Range: 20–57). Participants could indicate multiple races. Age of child indicates proportion of families with at least one child in the corresponding age group. The mean number of children was 2.50 (*SD* = 0.974, 95% *CI*: 2.34–2.67, Median = 2.00, Range: 1–5.

Overview of family experiences

In general, families indicated that they enjoyed participating in the study and the variety of sessions appeared to provide the participants rich contexts for engaging with scientific topics and practices, sparking and reinforcing science-related interests, and reflecting on what it means to support children's learning and development in preschool. More broadly, many of the parents expressed an appreciation for the resources and materials provided to them during the study and for the opportunity to spend special, focused time with one of their children.

In total, the data set included 26 family sessions and 14 videotaped interviews, representing approximately 27 hours of video, in addition to field notes and analytic memos. The length of time between the first consent meeting, which preceded the reading session, and the final interview ranged between 40 and 79 days, with an average of 64 days. The length of time between the reading session and the final interview was similar, ranging between 32 and 67 days, with an average of 51 days. Families' schedules were often complicated and parents frequently had to reschedule appointments during the study. Two of the families were not able to participate in the OMSI visit because of reoccurring scheduling and transportation challenges and one family was not able to participate in the family choice session for similar reasons.

The length of the observations varied by session type. Time spent during the reading sessions ranged from 24 to 52 minutes, with an average of 36 minutes. All the families ended up spending at least a small amount of time on each of the three books. For the OMSI visit, videotaping time ranged from 35 minutes to 90 minutes, with an average of 54 minutes, and many of the families indicated that they had spent additional time in other areas of the science center after the videotaping was complete. All but one of the families tried both of the activities for the activity box session, spending from 28 to 63 minutes during the session, with an average of 44 minutes. The length of the outdoor family choice experiences ranged from 11 to 63 minutes, with an average of 33 minutes.

Evidence for sustained interest

The activities and experiences provided during this study were primarily intended to create rich contexts for studying parent-child interactions and factors potentially associated with the foundations of young children's science-related interests. However, during interviews with parents, it quickly became clear that the sessions had sparked interests that, in many cases, extended beyond the specific sessions. Both prompted and unprompted, parents described how, through participation in the study, their children had become interested in rotting logs, bugs, leaves, collecting natural objects, chipmunks and squirrels, Jane Goodall, monkeys and chimpanzees, using magnifying glasses, experimenting and testing, rocks and gems, animals and sea life, and more. For some of these families, the period between when the initial interest was sparked and when the parent reported the sustained interest was quite long. As noted above, the time from the initial reading session to the final interview ranged between 32 and 67 days. Therefore, some of the interests sparked during the first reading session were still evident to parents two months later.

Although all of the parents reported sustained interests beyond specific sessions at some point during the study, it was clear that there was a difference in the breadth of the sustained interests and the degree to which they transferred beyond the specific activities and materials presented during the study. Many of the parents reported that their children continued to talk about and reengage with the specific books, materials, or activities from the sessions. However, there was no evidence that these interests extended to broader topics or skills or had transferred to other related activities or contexts. Many of these interests focused around highly engaging materials (e.g., bubbles, polished rocks, chipmunk costume) or memorable experiences (e.g., visiting OMSI, getting a special book). For example, when asked if anything had stuck with their children after the sessions, several of the parents mentioned that their daughters continued to be fascinated by the polished rocks that were part of the activity boxes:

> *The rocks and stuff. She played with them more, not that same day, but she's been playing with them throughout. And she'll be like, look at my pretty gems. I mean that was cute too. And she kept the little bag and she put all of her water balloons in there. [Michelle, interview #2]*

> *She kind of liked the rocks. Well, she loved the rocks… She likes carrying the rocks everywhere. [Emily, interview #2]*

Many children also continued to reengage with the exploring bubbles activity box:

> *Yeah, they do it themselves. She pours the Dawn herself, she pours the cornstarch, she adds the water. She can go grab the container and set herself up, from blowing the bubbles, to popping the bubbles, to cleaning it up and putting it away. [Sabrina, interview #2]*

Parents also mentioned how their children had become focused on particular books from the reading session:

> *Definitely the books. "These are the books that Scott got me, Scott bought me these books" [imitating daughter]… The [Jane Goodall] book is read all the time. She took it this weekend to her cousin's house where she stayed the night. She had to take her book and she had to tell why she got the book. [Sabrina, interview #2]*

> *Yeah, she had fun with it [the log book]. So now she hasn't read it again but she still talks about it. [Raymona, interview #1]*

One parent also brought up her child's sustained interest in the exhibits at the science center:

> *The whole OMSI thing in general? She's talked about, she was really interested in, because we looked at the sub when [her father] was on it and she saw him come out so she keeps talking about the big boat in the water… And she's just talked about dressing up like a chipmunk. She got a kick out of that, being able to have a little costume on. [Maddy, interview #1]*

In contrast, some parents discussed ways that their children's sustained interests had extended to broader topics or skills or transferred to new situations. Comments during the interviews provided evidence that in addition to re-engaging with particular materials or activities presented during the sessions, children were becoming fascinated with particular topics (e.g., the ocean, chipmunks, plants and trees, monkeys) or showing a preference for a behavior or skill (e.g., collecting leaves, comparing and measuring). For example, several families provided evidence of these broad sustained interests sparked by the natural materials activity box:

> *Yeah actually I think looking at the different leaves and stuff. We do a gardening thing on Wednesday nights and she was, and it was actually her that did it, she was looking at the different types of leaves and which ones look the same and which ones didn't. Because the teacher or educator was telling us what the different plants were and which were ready to be harvested and so I think she took more of an interest then she would have done before. [Maddy, interview #2]*

> *Oh, yeah, she wanted to go outside in my mom's yard because they have different bushes and leaves and stuff and she was saying oh, you have acorns now because they*

had fallen. And my mom was like, she couldn't believe that she was so interested. [Darlene, interview #2]

Several of the books also appeared to spark broad sustained interests in children, including interests related to bugs and insects introduced in the *Under One Log* book, Jane Goodall and the chimpanzees from in the *Me… Jane* book, and sea life and ocean exploration introduced in the Cousteau book:

> *We saw squirrels and I'm like, well, they're kind of like chipmunks. Yeah, she's like, we need to get acorns. She's really into that. She just keeps talking about how the chipmunks have acorns. And she watches a lot of Mickey Mouse so, there's like, Chip and Dale, and she was like, that's chipmunks! It was perfect for her because she was really, I think it was the next day we watched Chip and Dale and they were like trying to get the acorns for Donald Duck and she wanted to watch it over and over and over again. And so, she really connected with a lot of things. [Darlene, interview #]*

> *Yeah actually, the log book, because our other daughter found some weird bugs, red bugs, we thought they were ants at first but they weren't, on the mailbox so Erin wanted to go out and look and she asked if they came from a log [laughing]. But they're really into bugs and things outside like that. So I think she'll probably bring that up more than once. [Maddy, interview #1]*

> *Yeah, the monkey. That's all she wanted to see at the zoo, too… She usually likes the giraffes but it's all about monkeys lately… She always just talks about the monkey and Jane. She's like, "I like monkeys, I could be like Jane." [Sabrina, interview #1]*

One parent that led a walk with her daughter to collect leaves that were then used to make leaf rubbings during the family choice activity talked about her daughter's ongoing interest in the activity:

> *I thought it was a good experience for her. Now every time we go somewhere, like we walked up there for her kindergarten roundup, and now she's just like picking up everything. We walked down there for the kindergarten roundup and then we walked to the Head Start for her end-of-the-year barbecue and she had this, I don't even know where it came from. I mean I was with her, I was walking with her, but she had this half of a huge branch with all these leaves on it and I was like [questioning look]. "I've got our leaves, these are big leaves" [imitating daughter]. And I was like, they really are, they were like huge leaves, like this big. And I was like, yeah, those are nice, but we're going to school, so that's not gonna work. But yeah, she started to do it every time we leave. [Darlene, interview #2]*

The same parent also talked about several ways that the OMSI visit inspired ongoing interest in her daughter, and the ways these interests connected with the exploring bubbles activity box:

> *Definitely the trip to OMSI, with her interacting with the different elements. I think she's really starting to connect a lot of things with that. I really liked that she did do that because, I mean, I plan to have her continue on with it because she really like wants to experiment… What was she doing the other day? Oh yeah, I had straws, and she was blowing… she had her milk and she was blowing the bubbles through the straw, making bubbles with it. And she was telling me that because of her blowing the air, it was making bubbles. Like the air was causing it to make bubbles. I was like, I would've never thought that… I mean, I think she really thought it through, like, there's like little bubbles of air going through this liquid and now there's bubbles on top. [Darlene, interview #2]*

In describing these broad, sustained interests, parents often constructed narratives about connections with prior interests and experiences and future opportunities for supporting and developing these interests. In both interviews, Raymona highlighted her daughter's ongoing fascination with oceans and the Cousteau book, which she attributed to her lifelong love of water, swimming, and swim gear. In response, Raymona indicated several times how they had packed the family swim bag and set it by the door, even though it was only March, and that she was seriously considering renewing her membership to the community center and pool.

Similarly, Maddy discussed how her four-year-old daughter, as well as her six-year-old sister, had always been into bugs and things outside and that both the *Under One Log* book and the natural materials box had sparked renewed interest in insects and plants. She described several instances of her daughter becoming fascinated with something outside and how their weekly gardening class and the time that her and her daughter spend in their own backyard often created opportunities to reinforce these interests. These narratives highlighted differences across families not only in the types of sustained interests shown by children but also the parents' awareness and support for those interests.

Parenting strategies and beliefs connected with sustained interests

Of the families that participated in the study, four reported evidence of *broad* sustained interests on the part of their children, as defined above, while the three remaining parents only described sustained interests *specific* to the activities and materials presented during the sessions, without indicating that these interests had generalized to broader topics or transferred to new situations.[7] As described in more detail in the discussion section below, these different interest pathways reported by parents are aligned with the four-phase model of interest development, potentially indicating children's movement from maintained situational interest (the specific interest group) to emerging individual interest (the broad interest group). Therefore, we conducted additional analyses to explore whether there were differences between the two groups of families, including differences in parent-child interactions and parenting beliefs and values, in order to develop hypotheses about the factors and processes potentially related to early childhood science interest development.

The analyses revealed five factors associated with parent reports of *broad* and sustained science-related interest development: (a) parent enjoyment of science, (b) active parent involvement, (c) successfully re-engaging children, (d) parent awareness and value for everyday learning, and (e) reflective parent orientations. We explore each of these themes in depth below. It is important to note that we grouped the families because of emergent differences in children's sustained interests, described by mothers, and then explored the differences between the two groups based on a variety of factors. Although we found important differences between the groups for each of the themes outlined above, there were also exceptions to these patterns and a high degree of variation both between and within groups.

Parent enjoyment of science

Because all of the parents had completed the phase 1 questionnaire, it was possible to make comparisons between the broad and specific sustained interest groups based on a variety of science value and interest measures, including whether they perceived science to be important, the value they placed on science, their enjoyment of science, and the frequency at which they engaged in science learning behaviors (see Chapter 2). Of these four measures, there was a clear difference between the two groups in reported enjoyment of doing and learning about science (Table 14).

[7] The four parents who reported broad interest on the part of their children were recruited both by the researcher (Sabrina, Darlene, Raymona) and by Head Start staff members (Maddy). The three parents who reported specific interest on the part of their children (Michelle, Emily, Tanisha) were recruited by Head Start staff.

Table 14. Science interest and values, by family

Parent	*M*			
	Importance of science	**Personal value of science**	**Science enjoyment**	**Combined**
Broad interests				
Maddy	3.25	3.50	4.00	3.58
Raymona	2.50	4.00	3.50	3.33
Darlene	2.50	3.25	4.00	3.25
Sabrina	2.50	2.50	3.50	2.83
Specific interests				
Michelle	1.50	2.25	3.25	2.33
Emily	2.00	2.25	2.50	2.25
Tanisha	2.75	3.25	3.25	3.08
Head Start sample	3.17	3.16	3.16	3.16

Note. Head Start sample based on responses from 138 parents and caregivers as part of phase 1 of study (see Chapter 2). Combined shows mean for all three interest scales.

The science enjoyment scale, taken from the PISA 2006 parent questionnaire (Organization for Economic Cooperation and Development, 2009), asks research participants to rate their level of agreement, from strongly disagree to strongly agree, with four statements: (a) I generally have fun when I am learning science topics, (b) I like reading about science, (c) I enjoy acquiring new knowledge in science, and (d) I am interested in learning about science. For our analysis, a single average score was calculated for each parent, with one representing strongly disagree and four representing strongly agree. Although all of the parents in phase 2 had mean science enjoyment scores above the average for the entire phase 1 Head Start sample (3.16), the four parents reporting broad sustained interests in their children had higher scores (3.5 or above) than the three parents reporting more specific sustained interests. In other words, parents in the broad interest group agreed with all of the items and strongly agreed with at least two of these items. In contrast, parents in the specific interest group strongly agreed with no more than one of the items and agreed or disagreed with the rest of the items.

Perhaps more revealing, these differences in enjoyment of doing and learning about science appeared to translate directly into more positive affect and enjoyment from the parents during the sessions and more direct attempts to engage children with science knowledge and skills. As part of the micro-interaction coding framework, we coded instances during the sessions in which parents made a verbal sign of positive affect or interest, including statements of “like” or “love” related to the activity, exclamations of interest or enjoyment, and praise for children. This code did not include facial expressions or laughter because of the challenge of interpreting these behaviors. Similarly, we coded verbalized instances of parent negative affect or disinterest, such as statements indicating frustration, boredom, impatience, or anger. This code did include disciplining with a harsh or severe tone but did not include non-verbal indicators, such as yawning or eye rolling.

Table 15. Adjusted coded instances of parent negative and positive affect, by family

Families	Total sessions	Negative affect	Positive affect
Broad interests			
Maddy	4	0.0	55.0
Raymona	4	1.0	64.0
Darlene	4	3.0	31.0
Sabrina	3	1.3	28.0
Total	15	5.3	178.0
Specific interests			
Michelle	3	8.0	50.7
Tanisha	3	10.7	20.0
Emily	4	4.0	28.0
Total	10	22.7	98.7
Adj. total	--	30.2	131.6

Note. Adjusted counts assume family participated in all four sessions (e.g., counts for a family that participated in only 3 session were multiplied by a factor of 4/3). Adjusted subtotal for specific interest group assumes an additional family in this group (i.e., total counts were multiplied by a factor of 4/3).

Table 15 shows the number of coded instances of positive and negative affect for the broad and specific interest groups, adjusted for differences in the number of sessions completed by each family and by each group. In total, parents that reported broad sustained interests in their children exhibited almost 1.4 times as many instances of positive affect and less than a quarter the number of instances of negative affect, even after adjusting for differences in the number of sessions per family and the number of families per group. In fact, the four parents in the broad interest group exhibited almost no negative affect. Thus, in general, parents that reported broad sustained interests in their children also appeared to show more signs of excitement and interest during the sessions, potentially helping to engage their children and communicate family values and priorities. These trends were generally consistent within each group. Michelle was classified in the specific interest group and had a large number of instances of positive affect. However, she also exhibited the second-highest number of negative affect instances. Similarly, Sabrina and Emily both had the same number of positive affect instances, but Emily, who fell into the specific interest group, had four negative affect instances, while Sabrina in the broad interest group had only one.

Not only did parents in the broad interest group appear to translate their enjoyment of science into excitement and interest during the sessions, but they also seemed more able and willing to encourage science-related knowledge and skills. As part of the “science foundations” code category, we coded instances in which parents supported science-related knowledge development, including describing a science concept or phenomenon, introducing and defining a science-related term, or answering a child’s science-related question. For example, during the sessions parents identified animals or natural objects, explained natural phenomena, named colors and shapes, identified ingredients, named and described science tools such as the magnifying glass, discussed the behaviors and habits of animals, and talked about basic concepts of life and death. We also coded instances in which parents supported science-related skills or practices, such as observing, describing (e.g., color, texture, size), comparing and sorting, measuring and weighing, using scientific tools (e.g., magnifying glass, ruler), testing and experimenting, and problem-solving. Finally, we coded clear instances in which the child used or appropriated a science-related word, concept, or practice introduced by the parent in a current or previous session. These instances often represented children repeating a vocabulary word introduced and defined by the parent.

These science foundation codes were more exploratory than other codes, with an emphasis on identifying rich instances of science-related funds of knowledge and practices. Nonetheless, clear differences emerged between the broad and specific interest groups (Table 16). Families in the broad interest group were coded for over 1.5 times the number of building science knowledge instances, almost 3 times the number of building science skills instances, and over twice the number of appropriation instances, even after adjusting for differences in the number of sessions per family and the number of families per group. These families appeared to have more science-related funds of knowledge to bring to the experiences and be more focused on sharing these ideas and practices with their children. In turn, we saw more examples within this group of children appropriating and using vocabulary, ideas, and skills introduced by their parents. Again, there were a few exceptions to these trends. In particular, Sabrina was coded for fewer building science knowledge instances compared to both Tanisha and Michelle, who were classified in the specific sustained interest group.

Table 16. Adjusted coded instances of science foundations, by family

Families	Total sessions	Appropriation	Building science knowledge	Building science skills
Broad interests				
Maddy	4	26.0	33.0	17.0
Raymona	4	8.0	28.0	5.0
Darlene	4	19.0	57.0	23.0
Sabrina	3	5.3	18.7	4.0
Total	15	58.3	136.7	49.0
Specific interests				
Michelle	3	6.7	25.3	9.3
Tanisha	3	5.3	25.3	0.0
Emily	4	5.0	15.0	4.0
Total	10	17.0	65.7	13.3
Adj. total	--	22.7	87.6	17.8

Note. Adjusted counts assume family participated in all four sessions (e.g., counts for a family that participated in only 3 session were multiplied by a factor of 4/3). Adjusted subtotal for specific interest group assumes an additional family in this group (i.e., total counts were multiplied by a factor of 4/3).

Active parent involvement

Another difference that emerged between the groups was the degree to which parents actively led the sessions and how involved and engaged parents were during activities. As part of the holistic session coding framework, we classified session leadership dynamics in terms of whether the session was overall child led, parent led, or a mixed leadership style. Sessions coded as child led were characterized by children primarily choosing and directing the focus of the activities and sessions and setting the pacing and direction for shifts in focus. In contrast, parent-led sessions were characterized by parents directing the activities and setting the pacing and focus. Finally, some sessions were characterized as mixed leadership style and included both extended parent-led and child-led sections. The holistic session coding framework also included a classification of parent involvement and engagement, or the extent to which parents actively participated and were clearly focused and engaged throughout the sessions relative to other families. Sessions coded as "less involved" were characterized by parents that appeared disengaged, disinterested, or uninvolved for a large portion of the session relative to other families. Sessions coded as "more involved" were characterized by parents that actively participated and appeared focused, engaged, and involved for the majority of the session relative to other families. Finally, sessions could be coded as "mixed involvement," with extended sections in which parents were more involved and extended sections in which they were less engaged relative to other families in the study.

Table 17. Session leadership and parent involvement coding, by family

		Session leadership			Parent involvement and engagement		
	Total sessions	Child led	Mixed	Parent led	Less involved	Mixed	More involved
Broad interests							
Maddy	4	0.0%	75.0%	25.0%	0.0%	25.0%	75.0%
Raymona	4	25.0%	50.0%	25.0%	0.0%	0.0%	100.0%
Darlene	4	0.0%	0.0%	100.0%	0.0%	0.0%	100.0%
Sabrina	3	0.0%	0.0%	100.0%	0.0%	0.0%	100.0%
M	--	6.3%	31.3%	62.5%	0.0%	6.3%	93.8%
Specific interests							
Michelle	3	33.3%	33.3%	33.3%	33.3%	0.0%	66.7%
Tanisha	3	66.7%	0.0%	33.3%	0.0%	33.3%	66.7%
Emily	4	50.0%	0.0%	50.0%	0.0%	50.0%	50.0%
M	--	50.0%	11.1%	38.9%	11.1%	27.8%	61.1%

Note. Percent coded sessions represent the number of coded sessions for each family out of the total number of sessions for that family.

Table 17 summarizes the proportion of sessions for each family that were classified into each of the leadership and parent involvement codes. Overall, families in the broad interest group were much more likely to be coded as parent led or mixed leadership style compared to the families in the specific interest group. In other words, these families often took a very active, and sometimes a relatively heavy-handed approach, introducing activities and tasks; laying out instructions and guidelines; determining when to change focus and when to move on to a new portion of the session, such as a new book, activity box, or OMSI exhibit; and determining the topic and direction of conversation. In some of these families, children seemed to expect this dynamic, holding back or hesitating to begin before they received instructions or prompting from their parents.

Similarly, parents in the broad interest group were more likely to be coded as more involved. In general, parents across both groups were actively involved and engaged during the sessions. However, in several sessions, parents in the specific interest group showed signs of being distracted, such as by a cell phone; being disinterested in the activity, such as making frustrated comments about the length of the books; or being less involved, such as hanging back and watching their children play during the OMSI visit. Parents in the broad interest group, however, were almost always actively involved in the activities with their children. This contrast was particularly apparent during the OMSI visits. For example, during her visit to Science Playground, Darlene spent much of the time leading her daughter from one exhibit to the next, often providing introduction before prompting her child to try the activity. In contrast, Emily spent much of the OMSI visit following and watching her child, only occasionally approaching and becoming more involved.

These differences in leadership and involvement were also apparent in the micro-interaction coding. In particular, the two groups differed in the degree to which parents diminished or supported their children's choice and control and the number and type of extended exchanges that occurred between parents and children. Two aspects of the interactions were coded related to choice and control. First, instances of parents supporting choice and control were tagged including asking the child to make a choice, making a comment that implied the child had a choice or was in control, or actively following a choice that the child had made. For example, parents frequently asked children which book they wanted to start with during the reading session and which they wanted to read next after completing a book. Similarly, during nature walks as part of the family choice session, parents often let children choose which path to take or which part of the nature area to explore. Second, we coded instances of parents diminishing choice and control. These did not necessarily represent negative interactions between the child and parent, but often were associated with parents setting boundaries or making a choice for the child when it was apparent that the she might have difficulty with a different option. Examples included parents setting guidelines about where children could play with the bubbles, insisting on finishing a book after the child indicated they were getting bored or wanted to move on to the next book, or redirecting a child during a walk when she was headed towards a nonpublic space. In general, most of the interactions included examples of parents both supporting and diminishing choice and control as they balanced providing freedom for their children to explore and worked to create a safe and successful experience.

The extended exchanges code was designed to capture moments in which the parent or child made a comment or asked a question that led to an extended conversation related to the activity or session. These instances were defined as an extended verbal exchange related to the focus of the activities or session that: (a) was at least three conversational turns in length, (b) included conversational turns with more than one or two words for both the parent and the child, and (c) did not relate to logistics, coordination, directions, or non-session related topics. Parents reading directly from a book, label, or exhibit were also not included in this code. These exchanges were further categorized as either parent initiated or child initiated, depending on which member of the dyad took the first conversational turn in the exchange. For example, Maddy's daughter initiated an extended exchange during the activity box session while they were exploring the natural materials:

> *Child: What is this? [Picking up a grass flower]*
> *Mother: That is from a tree or bush, too. It looks like maybe a leaf, or different kind of leaf, or a pine needle. Can you feel it? Feel how…*
> *Child: It's soft and like a hair. [Feeling the grass flower]*
> *Mother: Like a hair. It does feel like a hair, doesn't it? What color is it?*
> *Child: Green! [Smiling]*
> *[Maddy, activity session]*

As an example of a parent-initiated exchange, Darlene began a conversation with her daughter as they were beginning to read the Cousteau book during the reading session:

> *Mother: Have you seen this fish before?*
> *Child: No.*
> *Mother: You haven't?*
> *Child: No. [Shaking head]*
> *Mother: Do you remember on* Finding Nemo*?*
> *Child: Yeah.*
> *Mother: Remember, it had a little light on at the beginning and it had big fish fangs.*
> *Child: Yeah, it was chasing…*

Mother: It was chasing the fish, huh?
Child: Yeah, that was chasing Nemo.
Mother: Nemo's dad.
Child: Yeah, Nemo's dad.
[Darlene, reading session]

As summarized in Table 18, all of the families in phase 2 were coded for instances of extended exchanges and supporting and diminishing choice and control. Instances of supporting choice and control were particularly common, and for most families far outweighed instances of diminishing choice and control. Comparing the broad and specific interest groups, the total number of instances of diminishing choice and control was much higher for the broad interest group compared to the specific interest group. Instances of supporting choice and control were also higher for this group, although to a lesser degree.

Table 18. Adjusted coded instances of choice and control and extended exchanges, by family

		Choice and control			**Extended exchanges**		
	Total sessions	**Diminish**	**Support**	**Total**	**Child initiated**	**Parent initiated**	**Total**
Broad interests							
Maddy	4	19.0	59.0	78.0	14.0	11.0	25.0
Raymona	4	39.0	55.0	94.0	11.0	10.0	21.0
Darlene	4	60.0	59.0	119.0	11.0	3.0	14.0
Sabrina	3	25.3	70.7	96.0	10.7	6.7	17.4
Total	15	143.3	243.7	387.0	46.7	30.7	77.4
Specific interests							
Michelle	3	21.3	45.3	66.6	13.3	8.0	21.3
Tanisha	3	29.3	50.7	80.0	8.0	10.7	18.7
Emily	4	16.0	42.0	58.0	0.0	0.0	0.0
Total	10	66.7	138.0	204.7	21.3	18.7	40.0
Adj. total	--	88.9	184.0	272.9	28.4	24.9	53.3

Note. Adjusted counts assume family participated in all four sessions (e.g., counts for a family that participated in only 3 session were multiplied by a factor of 4/3). Adjusted subtotal for specific interest group assumes an additional family in this group (i.e., total counts were multiplied by a factor of 4/3).

This is aligned with the findings above that parents in the broader interest group were more directive and more actively involved during interactions with their children. During the sessions, they provided options for their children and often supported choice, control, and agency. At the same time, they provided guidelines and boundaries, directed children towards certain options or tasks, and even contradicted children at times. Maddy was one exception to this trend, with far fewer instances of diminishing choice and control, although she exhibited a high number of supporting actions and comments. The number of diminishing choice and control instances was also higher for Tanisha compared to other families in the specific interest group, but the number of supporting actions and comments she exhibited was still lower compared to broad interest families.

The number of extended exchanges overall was much lower for all the families but there was still an apparent difference between the broad and specific interest groups. The total number of extended exchanges was higher for the broad interest group, particularly for the child-initiated exchanges. In other words, during sessions with broad interest families, there were more instances of the child making a comment or asking a question, which led to an extended conversation between the parent and child. This again suggests a tendency for parents in the broad interest group to be more actively engaged and more likely to respond substantively when a child initiated a conversation. Michelle was an exception to this pattern, having a particularly high number of child-initiated and parent-initiated extended exchanges, almost all of which occurred during the reading session.

Re-engaging children in the moment

In almost every session, children began the activities clearly excited and interested. These were novel, special experiences and many parents reported that children were not only excited by the new activities and materials but also the chance to have special time with their parents. Inevitably, however, there were times when children lost interest or became distracted. In coding moments of situational interest loss, we included instances of children becoming distracted, such as by a sibling or a passing ice cream truck; making a bid to shift the focus of an activity, such as wanting to move on to the next book or activity box; showing signs of disinterest, such as complaining that the book was too long or asking if they were done with the walk yet; and engaging in power struggles with their parents during which they became less focused on the activity and more on negotiating control with their parents. As might be expected with four-year-olds, these instances were not uncommon during the sessions and often parents were quickly able to reengage their children in the activities. The number of moments of situational interest loss ranged from 0 to 17, with the largest number of instances occurring during the reading session. The average across all the videotaped sessions was 6.0.

Once we had identified moments of situational interest loss, we also explored the factors that were related to those instances, how parents responded during these moments, and whether or not parents were successfully able to reengage their daughters. For each interest loss moment, we developed a coding framework to identify related factors, parent responses, and outcomes. Related factors included: an apparent end to the activity (e.g., last page of the book), distraction related to the research (e.g., a comment about the camera or the researcher), loss of choice or control (e.g., the parent interrupts the child or contradicts her decision to move on to the next activity box), loss of involvement (e.g., the parent takes over manipulating the materials in the bubbles activity box), no new possibilities (e.g., the child and parent have seemingly exhausted ways of interacting with the materials in the natural materials box), ongoing situational interest loss (e.g., the child had shown signs of losing interest previously and never fully reengaged), parent distracted (e.g., the parent leaves the room to deal with something in the kitchen), and parent loss of interest (e.g., the parent makes a comment indicating she is bored with reading the book).

Parent responses to children's waning interest included: checking in (e.g., asking if the child is done with the activity), commanding without negative affect (e.g., gently asking the child to pay attention), commanding with negative affect (e.g., showing frustration and directing the child to pay attention), dealing with distraction (e.g., asking a sibling to leave the room), expressing interest or value (e.g., encouraging the child to read this "very good" book), ignoring (e.g., continuing to read despite noticing the child's loss of interest), interpreting or explaining (e.g., talking about where the leaves come from in the natural materials activity box), moving on (e.g., following the child's suggestion to end the session), not noticing (e.g., continuing to read without noticing the child's loss of interest), personalizing (e.g., relating the activity to a child's prior experiences), playing along (e.g., briefly following the child's lead with a new focus before using a different strategy to reengage the child), pointing out detail (e.g., describing images in the book), quizzing (e.g., asking a child to identify an animal in the book), rationalizing (e.g., explaining that it's reading time now), setting consequences (e.g., telling the child the activity will be over if she doesn't pay attention), setting an endpoint (e.g., indicating that they only have two pages left), setting expectations (e.g., telling the child that during the reading she hope she will listen and ask questions), and supporting choice and control (e.g., asking if the child would like to be in charge of turning the pages). Finally, outcomes included: change in focus (e.g., the family switches to the next activity box), continued situational interest loss (e.g., after the parent response, the child continues to show signs of distraction), power struggle (e.g., the child shows frustration at not being able to make a decision about the activity), and re-engagement (e.g., the child shows clear signs of refocusing on the activity).

This combination of coding for situational interest loss, precipitating factors, parent responses, and outcomes allowed us to not only explore differences between the broad and specific interest groups in terms of number of interest loss moments but also how parents responded and how effective they were at re-engaging their children. Table 19 summarizes number of situational interest loss moments, outcomes, and parent responses across the seven families. For these analyses, we only included the activity and reading sessions. During the OMSI visits, children often moved quickly from one exhibit to the next, especially at the beginning of the visits. This behavior created a large number of situational interest loss moments with little opportunity for parents to respond or try to reengage their children. During the family choice sessions, which were often nature walks, it was much more difficult to determine moments of situational interest loss, since the walks usually included a large number of small interaction moments, such as comments about plants and flowers at the side of the path, with little expectation for ongoing focus around any particular object or task.

For this analysis, we grouped parent response strategies together that we felt were more active and did not include signs of negative affect. These included: commanding without negative affect, dealing with the distraction, expressing interest, interpreting or explaining, personalizing, playing along, pointing out details, prompting physical participation, setting expectations, quizzing, and supporting choice and control. We also identified a subgroup of these strategies that seemed more activity focused, including expressing interest, interpreting or explaining, personalizing, pointing out details, prompting physical participation, quizzing, and supporting choice and control.

Table 19. Situational interest loss, factors, outcomes, and parent responses, by family

	Interest loss	Outcome: Non reengage	Outcome: Re-engage	Response: Active and Positive	Response: Activity focused
Broad interests					
Maddy	8	62.5%	50.0%	9	8
Raymona	10	0.0%	100.0%	9	1
Darlene	21	23.8%	71.4%	42	28
Sabrina	17	29.4%	70.6%	23	13
Total	56	--	--	83	50
M	14.0	28.9%	73.0%	20.8	12.5
Specific interests					
Michelle	15	80.0%	26.7%	12	6
Tanisha	12	41.7%	50.0%	7	3
Emily	8	62.5%	37.5%	3	0
Total	35	--	--	22	9
M	11.7	61.4%	38.1%	7.3	3

Note. Columns for interest loss and parent responses show total number of coded instances per family. The interest loss outcome columns show percentages, calculated as the number of coded instances out of the total number of situational interest loss moments for each family. Only data from activity boxes and reading sessions included. Percentages for non-reengagement and reengagement could add up to more or less than 100% because occasionally the outcomes were ambiguous or there was evidence of multiple types of outcomes.

As summarized in Table 19, the number of situational interest loss moments was similar between the two groups, with the broad interest group having a slightly higher mean number of instances during the reading and activity box sessions (14.0) compared to the specific interest group (11.7).[8] However, how parents in each group responded and the outcomes of those responses were quite different. On average, children in the broad interest group reengaged after losing interest 73.0% of the time, while children in the specific interest group reengaged only 38.1% of the time. Parents in the broad interest group also used many more active and positive strategies for re-engaging their children on average compared to the specific interest group. They also used many more activity-focused strategies on average, although this was not an approach that Raymona used frequently. Again, we saw that evidence of broad sustained interests appeared to be associated with highly active and involved parenting and, furthermore, that parents who reported broad sustained interests were also more successful at re-engaging their children during the sessions when situational interest loss did occur.

[8] The totals and means were nearly identical when all session types were included, after adjusting for number of families and number of sessions in each group.

Awareness of interest

The interviews with parents provided an opportunity to compare how the broad and specific sustained interest groups differed in terms of parenting beliefs and values and how these differences might relate to patterns identified during the sessions. Important differences emerged from the coding related to parents' awareness of their children's interests, their perspectives on contexts of learning and interest development, the nature of their goals for children, and their beliefs about strategies for supporting interest, learning, and development. In the case of interest awareness, we coded instances during the interviews in which parents mentioned their children's interests, prior interests, or developing interest pathways. Similarly, we coded instances in which parents commented on their children's fears, phobias, or disinterests, such as those involving insects or bugs. For example:

> *She just has an interest in bugs. And the middle one, too. I don't know. She'll like, they both act scared if there's a spider in the house, ahh, you know, scary, but outside I guess is okay [laughing]. [Maddy, interview #1]*

Parents also made comments indicating their beliefs about how and where learning and interest develops and the resources available for supporting this development. We grouped these codes into two broad categories. The first category included comments about how experiences in the home and other everyday settings provide opportunities for learning and interest development. The second category included comments highlighting educational institutions and cultural centers as places of learning and interest development, such as schools, museums, science centers, zoos, and aquariums. For example:

> *Like, a random question [daughter] had the other day. [Speaking to daughters] Do you remember when you were wondering why the stars were following us home? And the moon? You were in the car and you were like, why are they following us? Remember, and then mommy went home and we went on Wikipedia and we took the laptop outside with the blanket and we watched the stars and the moon and mommy read articles, that you guys fell asleep to [laughing]. So, it's basically just relating the questions they have and the things they say to science. [Sabrina, interview #2]*

> *Just take them to, like, OMSI, or take them to the Children's Museum. Take them to the Zoo! Shoot, I had a membership to OMSI and the Zoo in 2009 but I just couldn't afford it after the memberships expired because we ran out of money. [Emily, interview #2]*

Also related to learning development, during the interviews we asked parents to describe their goals and aspirations for their children, both broadly and specific to science. These comments, and other related discussions throughout the interviews, were coded based on whether parents discussed academic goals for their children related to school; basic literacy goals, including reading, counting, shape and color recognition, and the alphabet; and broader life goals, such as independence, confidence, freedom to explore a variety of interests, or enjoyment of life. For example:

> *I want my daughter to be on honor roll in school. I want my daughter to be in the reading plus program. Like, I want her to know, I want her to know everything. I want her to know that you go through all this school and everything and it still continues. There's college, and you have the opportunity to do that if you do right in school. I want her to have her mind focused on school. I want her to leave college with a Master's degree so that I can be like, hey, look at my child or, you know, like, she never gave up. I really honestly want her to be someone really special and go to school and be interested in school and be happy when she goes to school. Not just like, oh, I have to go until 12th grade and then I'm done. [Tanisha, interview #1]*

> *Maybe, do shapes with them, alphabet, the numbers… The alphabet is very important, colors, just helping them learn how to read. Like the sounds and how to sound it out and stuff like that. [Emily, interview #1]*

> *I don't know, I don't know how to explain it. If she's good at school, she's good at it. If she's not, it is what it is. Do you know what I mean? I mean, that's how I feel. I had an extremely hard time in school, didn't understand school, not really college educated, and I got a good job. I just worked really hard. And I do good at what I do… I mean of course I want her to have an education and be smart but I guess her happiness and what makes her happy. And if having a college education makes her happy, you know, if money makes you happy then I guess what makes you happy, but I love what I do and I would never change it for the world. I just worked really hard and didn't give up. And that's I guess my goals for what I want for my kids is that, you know, you try, you try, and if it doesn't work you keep on trying, but there is always something better. [Michelle, interview #1]*

Finally, we coded instances in which parents mentioned specific strategies they believed support interest, learning, and development for their children. These strategies included: building on prior experiences (e.g., connecting with activities in past sessions), challenging children (e.g., providing age-appropriate challenges to keep children interested), monitoring attention span (e.g., keeping activities an appropriate length or noticing when children are beginning to lose attention), providing follow-up opportunities (e.g., scheduling children for a class related to their developing interests), having special time (e.g., valuing opportunities for one-on-one interactions with the child), supporting choice and control (e.g., letting children choose which activities to try or how long to spend on an activity), and having fun.

The differences in number of instances of these codes between the broad and specific interest groups were notable (Table 20). Parents in the broad interest group made many more comments indicating their awareness of their children's interests and interest pathways, as well as more comments about their children's fears and phobias. This group also made more comments about learning opportunities available in the home and in everyday settings and fewer comments about institutions, such as schools or museums, as places of learning and interest development. When asked about their goals and aspirations for their children, they were much more likely to discuss broad life goals, such as interest in a variety of topics, rather than specific academic goals or basic literacy goals.

Table 20. Interview code counts related to interest and learning goals, by family

	Awareness		Learning contexts		Goals for children			Strategies
	Child fears	**Child interests**	**Everyday**	**Institution**	**School**	**Basic literacy**	**Broad life**	**Total interest Support Beliefs**
Broad interests								
Maddy	3	17	0	2	0	1	3	20
Raymona	8	25	5	0	0	0	9	24
Darlene	4	24	3	0	1	1	3	19
Sabrina	0	11	2	0	0	1	3	15
Total	15	77	10	2	1	3	18	78
Specific interests								
Michelle	0	4	0	4	0	0	6	11
Tanisha	0	12	2	1	4	7	1	10
Emily	1	5	0	3	2	6	1	6
Total	1	21	2	8	6	13	8	27
Adj. total	1.3	28.0	2.7	10.7	8.0	17.3	10.7	36.0

Note. Adjusted subtotal for specific interest group assumes an additional family in this group (i.e., total counts were multiplied by a factor of 4/3).

Parents in the broad sustained interest group also made many more comments about specific interest support strategies. In other words, these parents appeared to be more aware of and more articulate about the types of strategies parents can use to support their children's interests, learning, and development compared to parents in the other group. This cluster of code categories suggests a relationship between parents' beliefs about where learning can occur and the nature of their goals for their children, their level of awareness and attention to the learning and interest development that is occurring in these settings, and their awareness of strategies for playing an active role in supporting their child's development.

Reflective parent orientation

The final dimension we compared between the two groups was the degree to which parents expressed openness to their own learning and were able to reflect upon themselves as parents. During the interviews, parents made comments about ways they have changed and grown as a parent, their interest in and surprise at interactions with their children, and their aspirations as a parent and the role they play in their children's lives. We grouped these comments into three categories: openness to learning as a parent, aspirations as a parent, and reflections on parenting. For example:

> *I was really interested, like it kind of opened my eyes to see what [daughter], you know, she really does have interests in different things than just, you know, oh, I know my alphabet, oh, I know how to spell my name. You know, she's kinda really liking to do other things… You know, we just read that book again about the log having all that in there and I know she doesn't like bugs but she was really into it. She thought she found one [a rotting log]… But she really likes that book now. [Darlene, interview #2]*

> *You know, anything I start with [daughter], with any of my kids, I just hope I do a good job, I guess, and that I'm doing the best I can to help them have a good job or have a fun time with it. And that I'm not building barriers and that I'm more so just being free with them and that we're learning together. [Raymona, interview #1]*

> *We've been taking parenting classes and reading books and stuff… Like, I try not to, like I don't want to impose all of my stuff on her but I guess we do that as parents anyways. But I'm trying to let her explore more, especially more than I did with her sisters [laughing], and like venture out and have her own ideas, the way she wants to do things. [Maddy, interview #1]*

Again, differences emerged between the broad and specific interest groups related to these three codes (Table 21). Consistently, parents in the broad interest group made more comments during the interviews indicating their openness to learning as a parent, while parents in the specific interest group made almost no comments in this category. Similarly, parents in the broad interest group were more likely to talk about their aspirations as parents, compared to the other group, although overall the number of comments in this category was small. Parents in the broad interest group made many more reflection comments than the other group, with the exception of Sabrina.

As another way of looking at reflective parent orientations, we also rated each interview holistically according to whether the parent was more or less reflective compared to other families and other interviews. Indicators of less reflective interviews included hesitancy or struggles answering reflective questions about the sessions or interactions with children and fewer and less concrete details about parent and child thoughts and actions. Indicators of more reflective interviews included no hesitancy responding to reflective questions, rich and varied details about parent and child thoughts and actions during sessions, more comments about parents' role in relationship to children's development and past and future experiences, more meta-reflections indicating surprise or interest related to children's behaviors and actions, and comments about lessons learned by the parent. As shown in Table 21, all of the interviews with parents in the broad interest group were classified as more reflective, while the vast majority of interviews with parents in the specific sustained interest group were classified as less reflective. Overall, parents in the broad interest group appeared to not only be more active in engaging their children during the sessions but also more reflective about these experiences, and more responsive to their children's developing interests.

Table 21. Code counts related to openness to learning and reflection, by family

	Interview comments			Interview ratings	
	Openness to parent learning	**Parenting aspiration**	**Parenting reflections**	**% Less reflective**	**% More reflective**
Broad interests					
Maddy	6	1	13	0%	100%
Raymona	19	4	14	0%	100%
Darlene	3	1	20	0%	100%
Sabrina	4	0	1	0%	100%
Total	32	6	48	--	--
Mean	--	--	--	0.0%	100.0%
Specific interests					
Michelle	1	0	3	100%	0%
Tanisha	0	0	7	50%	50%
Emily	1	1	0	100%	0%
Total	2	1	10	--	--
Adj. total	2.7	1.3	13.3	--	--
Mean	--	--	--	83.3%	16.7%

Note. Adjusted subtotal for specific interest group assumes an additional family in this group (i.e., total counts were multiplied by a factor of 4/3). Percentages calculated as the number of interviews classified as either more or less reflective, by parent.

Variation among families

As we noted earlier, although there were a number of critical differences between the broad and specific sustained interest groups, there were also many similarities and a high degree of variation across families. Two strong examples of this variation are the goal orientations that parents adopted during the sessions and the holistic parenting routines that were common during the interactions (Table 22). For each session, we coded overall goal orientations of the parents, based on their behaviors and actions. These goal orientations included: didactic, experience, interest, and task. Parents with a didactic focus appeared to be particular interested in communicating or reinforcing specific ideas compared to other families and other sessions. Parents with an experience focus appeared to be particularly motivated by experiencing the activity or session with their child and enjoying the focused time with their daughters. Parents with an interest focus appeared to be particularly oriented towards responding to their children's emergent interests during the session and following their children's lead. Finally, parents with a task focus appeared to be particularly intent on completing the activity or session tasks and following directions compared to other families and other sessions.

Table 22. Percentage of sessions coded for goal orientations, by family

		Goal orientation			
Parent	**Total sessions**	**Didactic focus**	**Experience focus**	**Interest focus**	**Task focus**
Maddy	4	100.0%	0.0%	50.0%	25.0%
Raymona	4	0.0%	50.0%	75.0%	0.0%
Darlene	4	100.0%	0.0%	0.0%	100.0%
Sabrina	3	33.3%	66.7%	33.3%	33.3%
Michelle	3	33.3%	0.0%	66.7%	33.3%
Tanisha	3	33.3%	33.3%	33.3%	33.3%
Emily	4	75.0%	75.0%	0.0%	25.0%

As shown in Table 22, there was a high degree of variation in goal orientation among the families. Darlene, one of the parents who reported broad sustained interest pathways in her daughter, for example, was consistently coded as having a task and didactic orientation, while Raymona, also in the broad interest group, was only coded for experience and interest orientations. And while these two parents appeared to have relative consistency in their orientations, other parents, such as Tanisha from the specific interest group, varied widely across the sessions, with no one goal orientation emerging as dominant. For these codes, the variation within the broad and specific interest groups appeared to be just as large as the variation between the groups.

Similarly, parents exhibited different patterns in terms of the range of overall strategies and parenting routines used during the sessions (Table 23). As described above, the parenting routines coding framework captured common patterns of parenting behaviors or parent-child interactions. Noticing, the most common routine overall, involved parents and children pointing out details in the activities or surroundings, such as pointing out a picture or object in the illustrations of a book. Quizzing, the second most common routine, included sessions in which parents frequently asked their children close-ended questions, such as prompting them to name an animal in a book or identify the color of an object in one of the activity boxes. Child questioning routines involved many interactions in which the child initiated the exchanges with a question and the parent responded. The co-investigation code included sessions in which parents spent extended periods of time co-investigating or co-playing in parallel with their children. The experimenting code captured sessions in which parents and children regularly suggested new things to try or test. Imagining included sessions in which pretend play were common. Personalizing captured sessions in which parents and children frequently made comments connecting to prior interests or experiences or making the activity personally relevant. Finally, coding an interaction in the category of play meant that parents and children were frequently playful or silly, such as tickling or making funny voices.

Table 23. Percentage of sessions coded for parenting routines, by family

		Parenting routines							
Parent	Total sessions	Child questions	Co-investigate	Experiment	Imagine	Notice	Personalize	Play	Quiz
Maddy	4	50.0%	25.0%	25.0%	25.0%	100.0%	25.0%	0.0%	100.0%
Raymona	4	75.0%	50.0%	25.0%	50.0%	100.0%	75.0%	0.0%	0.0%
Darlene	4	25.0%	0.0%	50.0%	0.0%	100.0%	75.0%	0.0%	75.0%
Sabrina	3	0.0%	66.7%	33.3%	0.0%	33.3%	0.0%	100.0%	33.3%
Michelle	3	66.7%	66.7%	33.3%	66.7%	100.0%	33.3%	33.3%	100.0%
Tanisha	3	66.7%	33.3%	0.0%	0.0%	66.7%	66.7%	66.7%	66.7%
Emily	4	25.0%	25.0%	0.0%	0.0%	75.0%	25.0%	25.0%	75.0%

Looking at patterns for individual families highlights the variation in parenting routines. Emily, for example, frequently used noticing and quizzing routines but rarely was coded for other parenting approaches. Michelle, in comparison, also regularly used noticing and quizzing routines but frequently incorporated a much broader range of strategies, such as child questioning, co-investigation, and imagining. Sabrina, in contrast to almost every other family, consistently used playing routines during all the sessions and it was clear during the interviews that being playful and having fun with her child was extremely important to her and central to her identity as a parent. She also rarely used noticing routines, which were common in every other family. Also in contrast to other families, Raymona was never coded as using quizzing routines. Instead, she frequently followed up on her daughter's questions and used strategies related to co-investigation, imagining, noticing, and personalizing. As with goal orientation, the variation in families was often greater within the broad and specific interest groups than between the groups.

Table 24. Percentage of sessions coded for goal orientations, by session type

		Goal orientation			
	Total No. Families	**Didactic focus**	**Experience focus**	**Interest focus**	**Task focus**
Activity boxes	7	42.9%	57.1%	42.9%	14.3%
Family choice	6	50.0%	50.0%	33.3%	16.7%
OMSI	5	80.0%	20.0%	60.0%	20.0%
Reading	7	57.1%	0.0%	14.3%	85.7%
M	6.25	57.5%	31.8%	37.6%	34.2%

Note. Percentages calculated as number of coded instances per number of families coded for that particular session.

Not only was there variations across families, but the context of the session appeared to have a strong influence on parent-child interactions and parenting strategies. Again, this can be seen clearly by focusing on parent goal orientations and parenting routines (Table 24, Table 25). For example, while the reading session was almost always coded as task focused, the other three sessions rarely were. The OMSI session was usually coded as both didactic and interest focused, in contrast to the other two session types, which general had a much more even spread across the goal orientation categories.

In terms of parenting routines (Table 25), the reading session frequently prompted child questioning, noticing, and quizzing. Only the OMSI visit prompted frequent imagining and pretend play, mostly in the market and the chipmunk dress-up areas. Personalizing was by far the most common during the family choice session, clearly aligned with the familiarity and comfort families likely felt in these chosen contexts and activities. Finally, the activity box sessions prompted a broad range of parenting routines and was the only session with more than 50% of families coded for co-investigation and experimenting. In short, each context supported different parent-child interactions, afforded and constrained parenting approaches, and provided different opportunities for parents and children to draw from their existing funds of knowledge.

Table 25. Percentage of sessions coded for parenting routines, by session type

		Parenting routines							
	Total No. Families	**Child questions**	**Co-investigate**	**Experiment**	**Imagine**	**Notice**	**Personalize**	**Play**	**Quiz**
Activity boxes	7	57.1%	71.4%	71.4%	28.6%	85.7%	28.6%	42.9%	57.1%
Family choice	6	33.3%	16.7%	0.0%	0.0%	66.7%	83.3%	33.3%	33.3%
OMSI	5	0.0%	40.0%	20.0%	60.0%	80.0%	0.0%	0.0%	80.0%
Reading	7	71.4%	14.3%	0.0%	0.0%	100%	57.1%	28.6%	85.7%
M	6.25	40.5%	35.6%	22.9%	22.1%	83.1%	42.3%	26.2%	64.0%

Note. Percentages calculated as number of coded instances per number of families coded for that particular session.

Discussion

This study documented the development of science-related interests in four-year-old girls from low socioeconomic backgrounds and provided initial evidence of potentially critical factors and processes shaping early childhood science-related interest development. Although our sample size was small, the intensive, in-depth video and interview data collected over time with the families and children allowed us to develop detailed descriptions of children's interests, their interactions with their parents, and parent reflections on these experiences; explore complex processes within interactions and nuanced relationships among parental beliefs, parent-child interactions, and children's interest pathways; and generate novel hypotheses about the factors and processes shaping science-related interest development in early childhood. The study also provided additional evidence, building on prior research, that enduring science-related interests do emerge in early childhood and that parents from low socioeconomic backgrounds have a variety of strategies and approaches, some shared across families and some highly unique, for fostering and supporting these interests in the moment and over time. During data analysis, we used the inductive coding of interviews with mothers to identify indicators of broad and specific sustained interests on the part of children and then explored differences in parent-child interactions and parent child beliefs between these two groups in order to develop hypotheses about the proximal and distal process that potentially support early childhood science interest development.

In the discussion below, we begin by summarizing key findings and exploring theoretical implications related to our research questions. We then suggest implications for educational practice and future research.

Early childhood science interest development

Researchers studying interest and interest development have struggled with defining and measuring interest (Renninger & Hidi, 2011). In this study, building on the four-phase model of interest development, we identified a variety of emergent indicators of interest and interest development. First, observing that all children began the sessions highly focused and engaged, we identified moments of situational interest loss, how parents responded to these moments, and the outcomes of those responses. Second, we used the in-depth interviews to capture parent reports of child interests that were sustained beyond the specific sessions. Third, we distinguished between two types of parent-reported sustained interests that were apparent in the interview data: (a) *specific* sustained interests, focused exclusively around the materials and activities presented during the sessions, and (b) *broad* sustained interests, which extended beyond specific materials and activities to more general topics or practices.

Because we intentionally created situations that revolved around science topics and practices, we made the assumption in this study that the sustained interests reported by parents potentially provided the foundation for longer-term interest in science topics and practices more generally. All of the reported interests did fall into the science concept categories used by Leibham and colleagues (2013), including life science and nature (e.g., leaves, rotting logs, insects, animals and sea life, plants and trees) and Earth science (e.g., rocks and gems, bubbles, water and the ocean). Children's reported interests also intersected with practices of science, such as using scientific tools, experimenting and testing, observing and comparing, and understanding the nature of science, including learning about famous scientists and methods of scientific investigation (National Research Council, 2009; NGSS Lead States, 2013).

These emergent indicators of interest and interest development both align with and extend the four-phase model of interest development. Our focus on situational interest loss during the sessions corresponds to the first phase of the model, triggered situational interest, defined as "a psychological state of interest that results in short-term changes in affective and cognitive processes" that is typically but not exclusively externally supported (Hidi & Renninger, 2006, p. 114). Our data highlight not only the importance of triggering situational interest, as occurred for all of the girls at the beginning of each session, but also the dynamics of temporary situational interest loss and re-engagement throughout the experiences as parents helped to keep their children focused on and excited about the activities. Similarly, we hypothesize that the *specific* sustained interests reported by three of the parents align with the second phase of the model, maintained situational interest, or "a psychological state of interest that is subsequent to a triggered state, involves focused attention and persistence over an extended episode in time, and/or reoccurs and again persists" and is typically but not exclusively externally supported (p. 114). We consider this maintained situational interest because children showed motivation to focus on and re-engage with particular materials and activities multiple times over the course of several weeks or months.

Hidi and Renninger (2006) defined the third phase of interest development, emerging individual interest, as "a psychological state of interest as well as the beginning phases of a relatively enduring predisposition to seek repeated reengagement with particular classes of content over time" (p. 114). They also argued that emerging individual interest is typically but not exclusively self-generated and can be supported externally, including support for increasing knowledge, challenges and opportunities, and encouragement to persevere when difficulties arise (p. 115). The four parent reports of *broad* sustained interests share many characteristics with this phase. In particular, broad sustained interests were characterized by re-engagement with "particular classes of content over time" (p. 114), rather than specific activities or materials, and were often initiated and driven by the children themselves. Furthermore, in describing these broad, sustained interests, the four parents often constructed narratives about connections with prior interests and experiences and future opportunities for supporting and developing these interests. These narratives provide additional evidence that the broad sustained interests may be indicators of long-term, emerging individual interests related to science.

What was not clear in the study, and remains an important focus of research on interest development, is the process for moving from one stage to the next (Renninger & Hidi, 2011; Renninger & Su, 2012). As we describe below, the study provided some evidence of the proximal and distal factors influencing the development of either maintained situational interest or emerging individual interest. However, it was not clear whether movement from triggered situational interest to emerging individual interest requires a period of maintained situational interest. In fact, it may be that some children, excited by the specific sessions, may have quickly moved into a phase of emerging individual interest connected to broader topics or practices. Our data suggest that parents may be critical to supporting this rapid interest development by connecting activities to prior interests and experiences; explicitly linking those activities to other ideas, topics, and practices; and providing and supporting a range of follow-up resources and materials. In this way, parents may help children create a network, both physically and cognitively, of ideas and experiences that support more robust and persistent interests. This idea of the importance of parents being aware of children's interests and interest pathways and helping share this awareness with their children is aligned with Renninger and colleagues' more recent emphasis on metacognitive awareness as a potentially important factor for moving across stages of interest development (Renninger & Su, 2012).

Alexander and colleagues (2013) similarly focused on the transition between situational interest and emerging individual interest in early childhood and posited that through regular, ongoing interactions, parents help "facilitate movement from a sustained situational interest to an emerging individual interest" (p. 10). Aligned with this hypothesis, our data suggest that how well parents are able to maintain triggered situational interest, including re-engaging children during moments of interest loss and distraction, and how they are involved with their children during these interactions possibly makes a critical difference between children remaining in a stage of maintained situational interest or moving to a broader, more enduring emerging individual interest phase. In other words, although clearly young children are predisposed to become interested in materials and objects in the world around them (Institute of Medicine & National Research Council, 2012; National Research Council, 2000a, 2000b), parents may play an important role in providing these interests with breath, depth, and persistence (see also Falk et al., 2014).

Proximal processes

The findings from this study also support prior notions of parent-specific proximal processes that shape children's developing interests. As noted previously, researchers have speculated on the variety of parenting behaviors and strategies that potentially influence interest development in early childhood, including showing excitement and interest; providing opportunities, resources, and experiences; encouraging and answering children's curiosity questions; offering information and explanations; communicating values and beliefs; and scaffolding experiences and balancing novelty and comprehensibility (Alexander et al., 2013; Barron et al., 2009; Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2007; Frenzel et al., 2010; Leibham et al., 2005; Tenenbaum & Leaper, 2003; Valle & Callanan, 2006). These researchers have also identified the potential roles these parenting actions might play in supporting interest development, such as: (a) modeling interest and enthusiasm, (b) encouraging and motivating children, (c) building knowledge and skills, (d) making experiences successful and enjoyable, and (e) enculturating children in ways of thinking and valuing.

In this study, by coding families as reporting either broad or specific sustained interests related to science on the part of their children and then comparing parent-child interactions and parent beliefs between these two groups, we found evidence for several of these parenting behaviors and the specific roles they may play in fostering emerging individual interests related to science. First, parents who reported broad sustained interest on the part of their children were coded for more expressions of positive affect and interest, including many instances of explicit encouragement, praise, and motivation, which likely model interest and enthusiasm for children. Parent positive affect may also suggest parental values related to science and learning and enculturate children into particular practices and interests. Second, parents' active involvement, including leading the activities, being involved and engaged, and supporting and diminishing choice and control, relates to scaffolding experiences and showing interest. These facets of active involvement may also model interest, enculturate children in ways of thinking and valuing, and help ensure that experiences are successful and enjoyable, especially when children encounter difficulty or challenges. Third, broad sustained interests were related to parents building science knowledge and skills, which corresponds to providing information and explanations. In the four-phase model of interest development, developing knowledge is an important characteristic of later phases of interest and may also be a way that parents can help their children succeed during learning experiences. Finally, parents' success at re-engaging their children when they showed signs of situational interest loss or distraction, as well as their use of active, positive, and activity-specific strategies for re-engagement, support speculation that parent encouragement and scaffolding is essential for helping children maintain situational interest and move toward developing individual interest.

We also found indirect evidence supporting the importance of children's questions in driving interest development. Specific to this aspect of parent-child interactions, researchers have speculated that developing interests may motivate children to ask curiosity questions (Hidi & Renninger, 2006), which in turn elicit interactions with adults and support further interest development (Alexander et al., 2008; Hidi & Renninger, 2006; Renninger, 2007). The study included many examples of children's questions, as well as examples of families in which child question-driven exchanges appeared to be an important interaction routine. More broadly, we found that extended exchanges, and particularly child-initiated extended exchanges, many of which included child questions, were much more common in sessions for the broad interest families compared to other families. This may be an indication of parents' encouragement and value for children's comments and questions and their responsiveness to children's interests. Returning to the roles of parenting actions above, this responsiveness may model interest, encourage and motivate children, and build knowledge and skills, thus helping to move children to deeper levels of interest development.

Parenting beliefs

Again, findings from this study support the limited prior research, as well as scholars' speculations, on relationships between parenting beliefs and values and child interest development. Prior studies have identified positive correlations between parents' science-related interests, beliefs, and values and those of children (Andre et al., 1999; Frenzel et al., 2010; Tenenbaum & Leaper, 2003). In this study, we were able to identify variation in parents' science interests, and especially science enjoyment, and show how these related to more parent involvement, more instances of parent positive affect and interest during parent-child interactions and, ultimately, parent reports of emerging individual science-related interests. In other words, the data suggest that children's interests are indirectly influenced by parents' interests, as mediated by expressed parental positive affect and interest during interactions. This is aligned with consistent findings that science enjoyment is a critical predictor and mediating variable for engagement with science for school-age children (Ainley & Ainley, 2011a, 2011b).

Reinforcing this finding, in phase 1 of this study (Chapter 2), we found that science enjoyment and personal value for science predicted frequency of science learning behaviors among the larger group of Head Start parents (*n* = 138), after controlling for a variety of demographic characteristics and child-rearing beliefs. Extending these findings, we hypothesize that parents' own science interests and enjoyment not only motivate them to engage in more science learning behaviors, but also to be more engaged and interested during science-related activities with their children. Through their own ongoing science learning, parents with higher enjoyment of science may also develop deeper funds of knowledge around science and be more able to build their children's science skills and understandings.

Several longitudinal studies with preschool children have also indicated that parent beliefs, including beliefs about academic stimulation, satisfying children's curiosity, providing interest-related materials and learning opportunities, consistency and structure, and the value of communication, are associated with the development of sustained interests in young children (Johnson et al., 2004; Leibham et al., 2005). Our research provides evidence particularly for the hypothesis that parenting beliefs about learning in general (e.g., academic stimulation, consistency and structure, and the value of communication) and supporting interests specifically (e.g., satisfying their children's curiosity and providing interest-related materials and learning opportunities) are critical for interest development. Again, the combination of parent interviews and videotaped parent-child interactions allowed us to explore possible mechanisms through which these beliefs influence proximal processes in children's lives. Specifically, we found evidence that for families that reported broad sustained interests on the part of their children, parents made more comments about awareness and value for learning in the home and in everyday experiences; indicated broader awareness of strategies for supporting interest, learning, and development; and expressed broad life goals beyond basic literacy and academic success. These parents were also more actively involved during the sessions, provided more guidance by diminishing and supporting choice and control, were coded for more instances of building science knowledge and skills, and were more successful at re-engaging children. Parents' value for learning outside of school and for supporting broad life goals, including interest development, may motivate them to be more actively involved in experiences such as those presented during the study and, over time, may allow them to develop a broader repertoire of successful strategies for engaging their children and supporting interest development.

Findings related to reflective parenting orientations provide a new lens on parenting and interest development and an important avenue for future research. Relationships among parent reflective orientations, parents' openness to learning, and children's interests and development are not surprising, given that research on teacher and professional learning has consistently emphasized the importance of reflection for effective practice (e.g., Cochran-Smith, 2009; Loucks-Horsley, 2010; Preskill, 1999). From this perspective, parents can be seen as educational professionals who ideally are continually thinking about their practice, prior successes and failures, and opportunities for improvement. This perspective may be particularly pertinent to supporting interest development, since parents are required to maintain a high level of awareness of their children's developing interests, both in the moment and over time, and explore a variety of strategies and opportunities for supporting these interests, all in the context of children's complex lives and numerous developmental changes.

Other contextual factors

In addition to these parenting beliefs and values, the interviews, field notes, and videotaped interactions revealed a number of other contextual factors that were not discussed in depth in this article. Previously, we briefly noted the apparent influence of the session context on parenting strategies and parent-child interactions. These contexts may influence parenting and interactions directly, such as the noise and novelty of the OMSI early childhood space that many parents reported adding some stress to their visit, or indirectly, such as parental expectations related to book reading that made it more likely for parents to adopt a task-oriented approach during these session. Sustained interests were reported by parents related to all four sessions and it is not clear from the data in this study how these issues might ultimately influence interest development. In addition to session context, parents mentioned a number of other factors during the interviews potentially related to interest, learning, and development. Common factors, in order of the number of times they were mentioned during the interviews, included: children's prior interests, siblings, reactivity to the research study, individual child traits (e.g., caring, friendly, emotional, shy, impatient, excitable, independent, stubborn, imaginative, funny, bossy, girly, has ADHD, doesn't like getting wet, likes to please, etc.), positive or negative experiences at school (for either the child or the parent), and parents' experiences with their own families. These may be important factors to consider in future research.

Implications

The results from this study provide a strong foundation for future research to understand the proximal and distal processes that shape early childhood science-related interest development, as well as the factors and processes related to interest development more broadly.

Future research

Although the sample size was small, the in-depth observations and interviews in this study allowed us to explore the complexities of parent-child interactions and how these relate to children's developing interests. The results, combined with prior research, begin to outline a compelling model for how parents influence the foundations of science interest development in early childhood. Parent enjoyment of science appears to not only be critical for how adults themselves engage in science learning activities but also how they provide opportunities for their children, facilitate engagement and learning during those experiences, and model science interest and positive values through their own behaviors and affect. At the same time, parents who are also more aware of their children's interests and interest pathways and more reflective of their own parenting beliefs and practices may be better able to notice emerging science-related interests, experiment with and identify effective parenting strategies for keeping children engaged in science-related activities, and support longer term, broader science interest development. Building on this exploratory study, this hypothesized model can be tested in future research in order to develop a more holistic understanding of how parents and caregivers guide their children towards positive developmental pathways as lifelong, science learners.

Specifically, results suggest the following hypotheses to be tested in future research: (a) Science-related emerging individual interests are more likely to be supported when parents regularly provide science-related activities and experiences. (b) Science-related emerging individual interests are more likely to be supported when parents show positive affect and interest, take an active role, respond to children’s questions and interests, balance choice and control with guidance and structure, and build knowledge and skills during these situations. (b) Children’s science-related emerging individual interests are positively associated with parents’ own science interests, mediated by parent enjoyment, interest, and active involvement during science-related activities and experiences. (c) Children’s science-related emerging individual interests are positively associated with parent awareness of children’s interests, reflective orientations, and openness to learning, mediated by parents providing science-related opportunities and resources and parents taking an active role, responding to children’s questions and interests, and building knowledge and skills during these interactions.

The research also suggests a number of questions to be explored in future studies. For example, what are the long-term differences between children who develop specific and broad sustained interests related to science? We tracked interest development over approximately 2 to 3 months but it is not clear how differences identified across families might persist and influence later development and behaviors. Also, how do parenting strategies shift as children continue to develop an emerging individual interest? In this study, we saw that highly active and directive parenting strategies related to broader extended interests on the part of children. However, it may be that in order to support further development of these interests, parents need to shift the balance away from directive strategies and focus more on supporting agency, independence, and self-efficacy, aligned with the notion of dynamic and responsive scaffolding (Azevedo, Cromley, & Seibert, 2004; Wood, 2001; Wood, Bruner, & Ross, 1976) and the changing needs of individuals at different stages of the four-phase model of interest development (Hidi & Renninger, 2006; Renninger & Hidi, 2011; Renninger & Su, 2012). Finally, are the patterns identified in the study similar for preschool boys, as well as families from different communities? Prior research has found differences between boys and girls in the focus of early childhood interests (e.g., Alexander et al., 2013, 2008; DeLoache et al., 2007), the duration and trajectory of these interests (Alexander et al., 2012; Leibham et al., 2013), and how parents respond to children's interests and preferences (Alexander et al., 2012). It is likely that certain proximal processes and contextual factors are universally important for both girls and boys, while others are more gender specific.

In order to address these hypotheses and research questions, it will be important to continue to explore methods for assessing science-related interest development (Alexander et al., 2013; Renninger & Hidi, 2011). This study in particular highlights the need to rethink parent reports as an interest development measure. Results suggest that parent reports, as evidence of parents' awareness of their children's interests and general orientation as a reflective caregiver, may be just as much a predictor of interest development as an indicator. Clearly, however, parent reports are a very efficient and age-appropriate approach to capturing the many possible unique and individual interest pathways that children might follow. As recommended by Renninger and colleagues (Renninger & Hidi, 2011; Renninger & Su, 2012), researchers will likely need to use a combination of parent reports (e.g., Alexander et al., 2012), child reports (e.g., Patrick, Mantzicopoulos, & Samarapungavan, 2009), and direct observations (Fisher et al., 2012; Ortiz, Stowe, & Arnold, 2001). Researchers must also grapple with the challenge of both capturing evidence of situational interest and engagement in the moment, as well as data on more extended interests, such as children's likelihood to re-engage with an activity or topic over time (Alexander et al., 2013).

Similarly, the study also emphasizes the need to value different approaches to parenting while identifying promising strategies for supporting children's developing science-related interests. In their seminal synthesis work on early childhood development, the National Research Council and Institute of Medicine (Institute of Medicine & National Research Council, 2012; National Research Council, 2000a) stressed the contextual and cultural nature of parenting and emphasized that there are many approaches to raising healthy children. Although our data suggest connections between some parenting beliefs and strategies and children's emerging individual interests related to science, there was also huge variation across families not related to these outcomes. In other words, even within the broad sustained interest group, parents found a variety of individual approaches for fostering their children's science-related interests.

Future research can continue to explore the cultural appropriateness and transferability of the proposed model of early childhood science-related interest development across families and communities. Following asset-based perspectives on education and parenting (Calabrese Barton, Drake, Perez, St. Louis, & George, 2004; Gutierrez & Rogoff, 2003; Lareau, 2003; Lemke, 2001; Rogoff, Mosier, Mistry, & Goncu, 1993; Rogoff et al., 2003), we believe it is critical to focus on strategies and approaches that build on the cultural practices and funds of knowledge within families, rather than apply assumptions and models of parenting from other contexts. In this study we focused particularly on identifying effective interest-development strategies for low socioeconomic families, rather than directly applying theories developed from research with middle- and upper-class communities. The research findings suggest promising strategies for other Head Start families to support their young children's developing science-related interests while still honoring the unique, culturally situated beliefs, values, perspectives, and realities within their communities.

Limitations

This study was designed with certain inherent boundaries and limitations. By intention, the sample size was small, focusing on understanding the experiences of a few Head Start mothers with their four-year-old daughters from one community. As a result, it is important to appreciate that findings from such a qualitative study are not generalizable in the traditional sense. Both Creswell (2013) and Charmaz (2006) emphasized that qualitative research, and especially constructivist grounded theory, is always situated within the specific perspectives and interpretations of the researcher and the unique experiences of the participants. As Charmaz argued, "rather than contributing verified knowledge, I see grounded theorists as offering plausible accounts" (p. 132). The in-depth findings from this study should, therefore, be considered tentative hypotheses that can be compared to other studies, in different settings and with different populations, and can motivate future research.

Throughout the study, we used a variety strategies to support the credibility and trustworthiness of the findings (Creswell, 2013; Maxwell, 2013), including prolonged engagement with families, keeping detailed field notes and capturing rich descriptive data, triangulating and comparing findings across families and across sessions, being explicit about our own theoretical frameworks and assumptions, searching for disconfirming or contradictory evidence as themes and findings emerged, member checking interpretations with families by gathering participants' perspectives on the video and interview data, acknowledging the role of the research in data collection and interpretation, and working to make participants as comfortable and relaxed as possible, such a videotaping families without a researcher present. Also important during analysis was peer feedback, including ongoing conversations between the first and second author and feedback from a third researcher familiar with the data collection but not directly involved in the study. Given the alignment of our findings with prior research on early childhood interest development, we believe the outcomes of the study have practical significance and will make an important contribution to ongoing efforts to study and support long-term science interest pathways for children and families.

CHAPTER 4:
GENERAL CONCLUSION

For this dissertation, I conducted a mixed-method investigation to explore the proximal processes shaping early childhood science-related interest development and begin to identify important contextual factors shaping these processes. In the first phase of the study, I conducted a quantitative, cross-sectional survey with 138 Spanish- and English-speaking parents and caregivers of Head Start children and collected information on child-rearing beliefs and science-related attitudes, interests, and learning behaviors. Descriptive analysis of responses indicated that, in general, parents had positive views of science, which was often associated with active practices, such as experimenting, inventing, discovering, exploring, and learning. Many participants also associated science specifically with the outdoors and biology-related topics, suggesting an opportunity to broaden awareness and appreciation of the variety of science fields. Multivariate analyses indicated that personally valuing and enjoying science were key predictors of the overall frequency of science learning behaviors, even after controlling for parent age, sex, ethnicity, education level, and beliefs about the importance of consistency and structure and communication. These results parallel findings from research on children's science interests and science learning behaviors (e.g., Ainley & Ainley, 2011a, 2011b) and suggest an important leverage point for supporting young children's science-related interest development. By increasing parents' interest in and value of science, community organizations and educational programs would likely increase the frequency of parents' science learning behaviors, such as watching a movie about science or visiting a science-related website, and, in turn, increase young children's exposure to science experiences and resources.

In the second phase of the study, I recruited seven English-speaking mother-daughter dyads, both from Head Start parent meetings and through additional contacts recommended by Head Start staff members, to participate in extended, in-depth qualitative data collection involving interviews with mothers and videotaped mother-daughter interactions during science-related activities. Each mother was asked to participate in one reading session at home, one visit to OMSI, one session engaging in a science-related activity with her daughter, one science-related session chosen by the family, and two in-depth parent interviews. In total, data included 27 hours of video (26 family sessions and 14 videotaped interviews), in addition to field notes and analytic memos. These data were iteratively analyzed following a constructivist grounded theory approach (Charmaz, 2006), during which detailed coding schemes were developed for both interaction and interview data, which were then used to develop and refine emergent themes describing factors and processes related to early childhood interest development.

Through the analysis of the phase 2 data, I identified evidence of children's emerging, science-related interests, highlighted parenting actions and behaviors during the sessions that appeared to be related to children's extended interests, and explored parent and child characteristics potentially shaping these proximal processes. Although all parents reported evidence of children's extended interests from the sessions, in three of the families it appeared that children's interests focused *specifically* around the activities and objects presented during the sessions, while in four of the families, parents reported extended interests on the part of children that were more *broadly* related to types of activities or topics. Comparing interviews and observations between these two groups suggested a variety of factors potentially related to broader, science-related interest development in early childhood, including parent enjoyment of science, active parent involvement during the sessions, parenting strategies for re-engaging children when they lost interest during sessions, parents' awareness of their children's interests, and reflective parent orientations.

Although these factors appeared to differ between families in which parents did and did not report broader sustained interests in their children, there also was a great deal of variation in parenting strategies and beliefs within the two groups. Some of this variation appeared to relate to the session context, which strongly influenced parent goal orientations and parenting routines. In addition, interviews with parents highlighted a variety of contextual factors, such as physical setting, activity type, siblings, experiences with school, and parents' experiences with their own families, which may be important in influencing young children's interests.

Findings from both phases suggest a possible model for early childhood science-related interest development that builds on and extends prior work and theory. This model can shape hypotheses and questions for future research. In this final chapter, I develop the theoretical foundations of this model, beginning with a review of the co-regulation model of emerging science interest, developed by Alexander and colleagues (2013). I then explore implications for future research, critiquing my hypothesized model based on Bronfenbrenner's process-person-context-time framework for understanding human development (Bronfenbrenner & Morris, 2007). Finally, I conclude with thoughts about how our current understanding of early childhood science-related interest development might inform the efforts of educators and community organizations supporting children and youth in low socioeconomic communities.

Modeling early childhood interest development

Through their research on interest development in early and middle childhood, Alexander and colleagues (Alexander et al., 2012, 2013) developed a co-regulation model of emerging science interest (Figure 1). The model is primarily based on longitudinal parent report data on the development of children's science-related interests and the distal factors shaping this development. My study of the proximal processes of early childhood interest provides additional detail for understanding more directly the role of parent-child interactions relative to this model and relationships between distal and proximal processes. Before proposing a revised version, I explain the original model in detail, focusing particularly on early childhood.

Co-regulation model of emerging science interest

The co-regulation model of emerging science interest builds on prior research but is primarily based on a four-year perspective longitudinal study "focused on the development of preschoolers' interests, the factors that potentially support interest, and the consequences of such interests" (Alexander et al., 2013, p. 2). During the study, the researchers recruited and followed 215 children over four years, beginning when they were four years old, collecting data regularly through parent questionnaires and interviews and home visits (Alexander et al., 2012, 2013; Johnson et al., 2004; Leibham et al., 2005; Neitzel et al., 2008). Similar to my dissertation, the researchers focused on the transition from maintained situational interest to emerging individual interest and built on both the four-phase model of interest development and Bronfenbrenner's bioecological model.

Based on findings from the longitudinal study, the researchers posited a co-regulation model of interest development, in which "socializing agents (e.g., parent, teacher) and child play interactive roles in the maintenance of interest, with parents playing larger roles in the early childhood years and children taking on more responsibility for interest regulation in the elementary school years" (Alexander et al., 2013, p. 5). As shown in Figure 1, during early childhood the researchers posited that children particularly influence their own development by expressing interest to their parents, seeking out opportunities related to their interests, asking curiosity questions, and developing self-awareness and self-concept, which allows them to begin to incorporate ideas about their interests into their own view of the self and use these self-perceptions to motivate behavior. Although not shown in the model, the researchers also emphasized the influence of gender on emerging individual interests, including the predisposition for boys to show early intense interests and the gendered beliefs and stereotypes of parents and teachers shaping interactions with children.

Transition from Phase 2 to Phase 3 – Emerging Science Interest

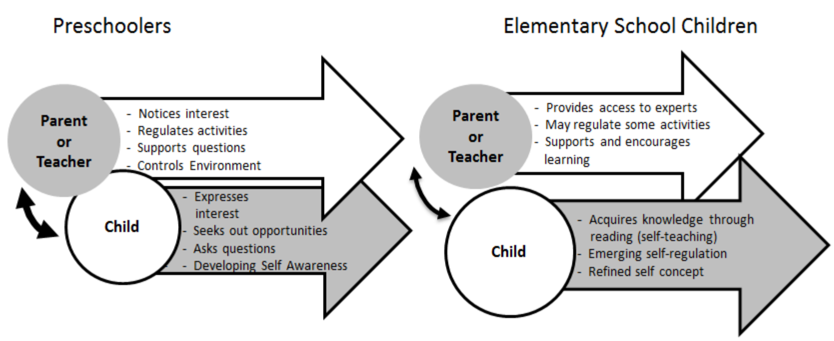

Figure 1. Co-regulation model of emerging science interest

Data from the longitudinal study highlighted the critical role that parents play in the development of young children’s interests. In parallel to the child factors described above, the researchers posited that parents support interest and interest development by noticing their children’s interests and, in response, regulating activities and how children spend their time, answering and supporting curiosity questions, and controlling the environment by providing new experiences and resources. Again not pictured in the model, the researchers also highlighted a number of parental beliefs that appeared to be related to children’s interest development, including beliefs about the importance of education, communication, consistency, time for unstructured play, and supporting children’s interests. Overall, they argued that the "primary resource for preschool children's interest development and maintenance is an involved parent or other caretaker, someone who notices what catches the child's attention and then supports the interest through activities, resources, and informal conversations" (Alexander et al., 2013, p. 10). Although the researchers did not directly collect data on parent-child interactions, based on previous research they hypothesized that parents might support interest and interest development in the moment by focusing attention, providing encouragement and helpful messages, answering curiosity questions, engaging in discussions, and co-constructing knowledge.

It is important to note that the parent and teacher behaviors specified by Alexander and colleagues as important for preschool interest development, including noticing interest, regulating activities, supporting questions, and controlling the environment, include both distal and proximal factors and are supported by the researchers' parent interview data to various degrees. For example, supporting questions can be seen as a distal parent beliefs, indicating the degree to which parents believe that supporting children's questions is important, as well as a proximal parent behavior, indicating the strategies parents use to actively support and encourage children's questions during parent-child interactions. Alexander and colleagues collected strong evidence of the correlation between parent beliefs related to children's questions and parent reports of children's interest development. However, they recognized that they do not have direct, observational evidence of the proximal factors related to children's questions (Alexander et al., 2013). Therefore, their co-regulation model is currently unclear in the way that distal and proximal factors are specified and the weight of the evidence underlying each aspect of the model.

Revised co-regulation model of emerging science interest

This dissertation study provides support for many aspects of the co-regulation model but also offers additional insights into the proximal processes related to early childhood interest development and the relationship between distal and proximal processes. Building on the work of Alexander and colleagues, I propose a revised co-regulation model of early childhood interest development, shown in Figure 2. Similar to the original model, the revised version emphasizes the co-regulatory and reciprocal relationships between parents and their children. However, in contrast to previous work, the revised model highlights and explicates the proximal processes during parent-child interactions that likely drive early childhood interest development, differentiates more explicitly between proximal processes and the more distal factors of parent and child characteristics, draws attention to the contextual factors that shape these processes, and posits four critical feedback loops previously implicit in the co-regulation model (parent learning, child interest development, parent provision of new opportunities, and child seeking out new opportunities). Below I describe each of these aspects of the revised model in more detail and how they relate to prior theory and research.

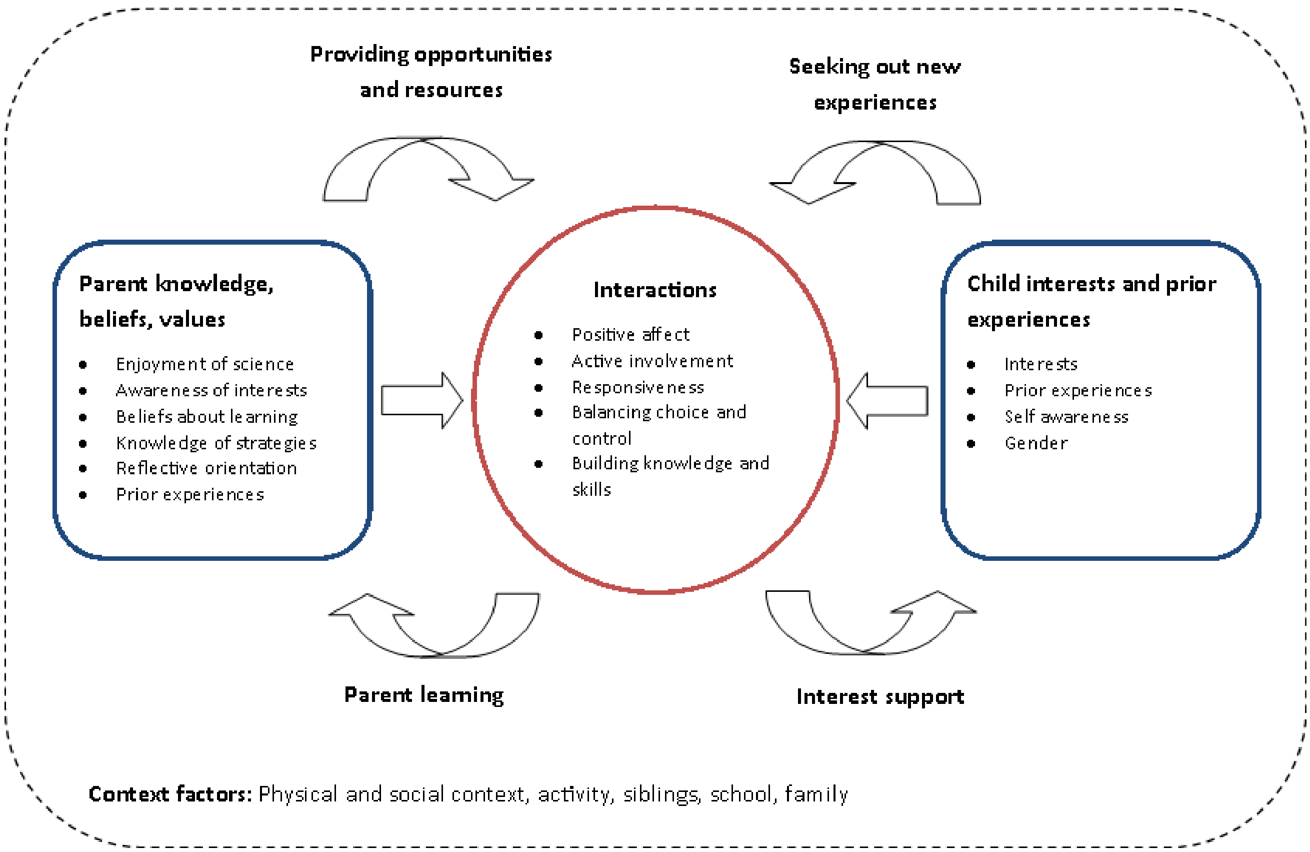

Figure 2. Revised co-regulation model of emerging science interest in early childhood

Aligned with the bioecological model of human development, the revised co-regulation model places proximal processes as the central driver of interest development, with other more distal factors operating through these "in the moment" interactions. By meticulously analyzing videotaped parent-child interactions, I found evidence for five interrelated aspects of parent behavior that are likely associated with the initiation and maintenance of interest in early childhood. The first is positive affect, or parents showing positive emotion and engagement during interactions. The second is active involvement, or parents being present and engaged during the interactions, taking a leadership role in directing and shaping experiences, actively initiating exchanges with their children, and working to reengage their children when they see signs of interest loss. The third is responsiveness, or parents responding to their children's questions and extending exchanges initiated by their children. The fourth is balancing choice and control, or parents not only being directive but also supporting their children's agency and following their children's lead in the moment when. Finally, the fifth aspect is building knowledge and skills, or providing new ideas, concepts, vocabulary, and skills, and helping children appropriate and use these during interactions.

These five aspects align well with the proximal processes hypothesized by Alexander and colleagues (2013). They also align with the four-phase model of interest development, suggesting mechanisms by which the three central dimensions of interest (Hidi & Renninger, 2006) are supported: positive affect (through parent enjoyment and engagement and successful scaffolding), knowledge (through building skills and knowledge and engaging in extended exchanges), and values (through positive affect and active involvement by the parent).[9]

The revised model also specifies interrelated characteristics of parents and children that appear to indirectly influence early childhood interest development through their effect on parent-child interactions. For parents, this includes (a) enjoyment of science, which likely translates into more positive affect and engagement during interactions; (b) awareness of their child's interests, which may influence children through the provision of new interest-related experiences and resources , (c) beliefs about learning, including beliefs about the relative importance of every day and institution-based learning experiences and goals for children's learning and development, which may shape how actively involved parents are during interactions and the roles they adopt during these experiences; (d) knowledge of strategies for supporting interest development, which affords and constrains the range of tools and approaches available to parents during interactions; (e) parents' reflective orientation, that is

[9] Recently, Renninger and colleagues (Renninger, Nieswandt, & Hidi, 2014) have posited a fifth dimension, self-efficacy, which, in the revised model, may be supported through parent responsiveness, balancing choice and control, and successful scaffolding.

their willingness and ability to reflect on their experiences as a parent and continue to learn and grow based on these experiences and feedback from their children, which may make it more likely that they will engage in learning feedback loops through their experiences with their children; and (f) their prior experiences, which, as with children, shape their own interests and their approaches to child-rearing. This set of parent characteristics relates to the parenting behaviors hypothesized by Alexander and colleagues in the original co-regulation model but focuses more specifically on parent beliefs, values, and experiences that shape these behaviors and influence parent-child interactions, based on data from this research study. The distinction between parent beliefs and parent interest-support behaviors is important because it provides insight into the ways that organizations and educational programs might influence early childhood interest development by targeting parent characteristics that directly influence parenting behaviors.

Similarly, the revised model outlines a series of child characteristics that appeared to indirectly influence parent-child interactions and interest development and maintenance. Although Bronfenbrenner's original ecological model (Bronfenbrenner, 1979) placed little emphasis on child characteristics, the more recent bioecological model (Bronfenbrenner & Morris, 2007) firmly acknowledges the important role that children play as agents in their own development and the reciprocal nature of the relationship between child development and their ecologies. Based on this dissertation research, and especially the parent interviews, children's interest and prior experiences appear to shape interactions with their parents and their own ongoing interest development. For example, in describing interests that extended from the research sessions, parents often mentioned how these built on children's prior experiences. Both this study and the work of Alexander and colleagues has provided evidence that children's prior interests and experiences influence parent-child interactions and ongoing interest development by motivating children to express their interests, ask curiosity questions, and seek out new interest-related opportunities and experiences.

The work of Alexander and colleagues, as well as prior research, also highlighted two important child characteristics included in the revised co-regulation model: gender and developing self-awareness. This dissertation research was conducted only with young girls and so there was no evidence of gender differences. However, during interviews parents often expressed gendered beliefs or stereotypes and there is strong evidence of gender-based differences in early childhood interest development research, as described above. Similarly, my research did not focus on children's developing self-awareness, but many studies have documented self-awareness, self-concept, and theory-of-mind as important aspects of development at this age (e.g., Goodvin et al., 2008; Ontai & Thompson, 2008; Perner, Mauer, & Hildenbrand, 2011; Thompson, 2006). As Alexander and colleagues argued (2013), self-awareness allows children to incorporate developing interests into perceptions of themselves, which in turn can motivate children to reengage in those topics or activities.

The revised model also makes explicit four different feedback loops, some of which are implicit in the original model. First and most obviously, ongoing child interest development and the transition from situational interest to emerging individual interest, is represented through the "interest support" feedback loop. As a proximal driver of interest development, parent-child interactions spark, reinforce, or diminish children's interests, shaping unique interest pathways over time. Second, feedback parents receive and incorporate from parent-child interactions informs how parents engage with children and provide future resources and experiences, as indicated by the "parent learning" feedback loop. As suggested by this study, the relative importance of this loop might be predicated on parents' awareness of their children's interests and their reflective orientation and openness to learning as a parent. Third, children seek out new experiences, which set the stage for new parent-child interactions. This loop emphasizes children as active agents and participants in shaping their own interest development. Finally, based on their beliefs, knowledge of their children, and orientations and values, parents provide opportunities and resources for their children, which again lead to new proximal processes and parent-child interactions. Overall, these four feedback loops provide a more nuanced framework for understanding the co-regulatory nature of the model and emphasize the ongoing relationship between what parents and children bring to experiences and how these experiences in turn shape parents and children and the provision of new opportunities for interest development.

Finally, the model makes explicit how the broader context of parent-child interactions, as well as the lives of the parents and children more generally, plays an important role in shaping ongoing interest development. Although contextual factors are an important aspect to any ecological model of development, especially when learning is viewed from a sociocultural perspective (e.g., Cobb & Bowers, 1999; Falk & Dierking, 2000; Lave & Wenger, 1991; Penuel &

Wertsch, 1995; Rogoff & Lave, 1999; Vygotskiĭ, 1978; Wertsch, 1998), in this study we only began to explore these factors in detail. As noted above, during interviews parents mentioned several potentially important factors beyond parent and child characteristics, including physical and social context, access and cost, the nature of the activities, siblings, parent-child experiences with school, and parent experiences with their own families. I have included these factors in the revised model primarily to acknowledge the importance of understanding broader context when investigating early childhood interest development. More research is needed to pinpoint the most critical contextual factors and understand how these shape more proximal processes.

An important contribution of this revised model is its suggestion of a more complex and active role for parents as learners within the interest development process. By understanding and conceptualizing the role of parents as more than a mere “input” in early childhood development, the revised co-regulation model challenges traditional “deficit” models of parental involvement in children’s learning that focus solely on what parents do relative to a narrow, school-sanctioned set of activities and involvement contexts (see for example Calabrese Barton et al., 2004). In contrast to this perspective, researchers taking an asset-focused view acknowledge the range of activities that make up and influence parental engagement; the social and cultural contexts and power structures that afford and constrain parents; the resources and social and cultural capital that parents leverage, in both traditional and nontraditional ways, to position themselves as active agents within their children’s education; and the beliefs, values, and orientations that influence their approaches to engagement and involvement (Calabrese Barton et al., 2004, 2004; Gutierrez & Rogoff, 2003; Lareau, 2003; Lemke, 2001; Rogoff et al., 1993, 2003). In other words, through the revised model I have tried to theorize the many factors and processes shaping parental engagement and position parents as important and dynamic actors within the arenas of parent engagement and early child hood interest development.

As a result, the revised co-regulation model posits that parents are not only responsive to their children’s interests and behaviors but also are active learners themselves, reflecting on their experiences with their children and learning, growing, and changing as parents. Furthermore, parents bring with them prior knowledge, experiences, interests, and values which in turn shape their interactions with their children. Unlike the work of Calabrese Barton and her colleagues cited above, we did not use cultural-historical activity theory as a theoretical lens and the focus of the study was not on the broader social, cultural, and historical contexts shaping the role that parents play in their children's developing science-related interests. However, data suggest that this may be an important perspective for motivating future research. For example, during the interviews parents often discussed how their prior experiences with their own families and with school have shaped their own ideas about being a parent and the goals they expressed for their children's learning and development. These orientations appeared to guide how they positioned themselves as parents relative to their children's learning and development, the ways they interacted with their children in specific contexts, and the resources and cultural tools they used during those experiences. At the same time, both macro- and micro-contextual factors, such as the OMSI environment, expectations related to science, and the home as a learning space, afforded and constrained parent roles and actions. By exploring these issues, future research can provide more nuanced understandings of the dynamic relationship between parent, child, and context. Research with families from other communities might also indicate the degree to which this parent learning feedback loop is unique to Head Start families, who may be primed to think about their role as parents through their participation in the Head Start program.

It is also possible to view the revised co-regulation model as an extension of the notion of scaffolding, originally proposed by Wood and colleagues (Wood, 2001; Wood et al., 1976) and building on the work of Vygotsky (Vygotskiĭ, 1978). In their seminal paper on adult-child "tutorial interactions," researchers defined scaffolding as "the adult 'controlling' those elements of the task that are initially beyond the learner's capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence" (Wood et al., 1976, p. 90). They noted a variety of critical parent scaffolding behaviors, including recruitment, such as eliciting interest in the task; reduction in degrees of freedom; direction maintenance, such as maintaining focus and motivation and encouraging children to "risk a next step" (p. 98); marking critical features; frustration control; and demonstration and modeling. They also noted that scaffolding by adults requires both a "theory of the task or problem," such as an understanding of how to complete an activity or the options available to a child in that context, and a "theory of the performance characteristics" (p. 97) of the child, such as an understanding of how well the child might be able to accomplish the tasks involved in the activity. According to the researchers, these two theories influence how the adult is able to provide feedback to the child and the types of feedback the adult chooses to provide based on what he or she feels will be most effective. Subsequent research on scaffolding has emphasized the dynamic relationship between these theories and adult feedback, with effective scaffolding characterized by changing feedback as children's needs and the nature of the task evolve (e.g., Azevedo et al., 2004; Wood, 2001).

Although this framework was originally developed to understand knowledge and task mastery in children, the revised co-regulation model suggests that it is equally applicable to interest development. Prior studies suggest that parent involvement and facilitation is critical to the development and maintenance of children's interest in early childhood. As Alexander and colleagues (2013) noted, at this early age children may not readily be able to regulate their own interest development. Therefore, from a scaffolding perspective, parents play a critical role in creating and structuring experiences that allow children to achieve levels of sustained interest development not possible otherwise. Similarly, there are important parallels between the parent scaffolding behaviors identified by Wood and colleagues, and those outlined in the revised co-regulation model. For example, this dissertation research suggests that highly involved and directive parenting strategies may be important for developing broader sustained interests that go beyond the specific activities or objects presented during parent-child interactions. During the research sessions, these strategies included diminishing children's choice and control or providing a more constrained set of choices, directing children's actions and behaviors, attempting to reengage children even when they appeared to be losing situational interest or suggested shifting to a new focus, and setting guidelines and limits. These behaviors are very similar to those outlined by Wood and colleagues, including reduction in degrees of freedom and direction maintenance.

Implications for research

The revised co-regulation model represents hypotheses, based on findings from this mixed-method study and prior research, about the critical factors and processes shaping science-related interest development in early childhood. More research is needed to test these hypotheses and explore the degree to which the model generalizes and transfers across populations and settings. One approach to identifying next steps and future research questions is to explore the extent to which this model meets Bronfenbrenner's criteria of a process-person-context-time (PPCT) model of human development (Bronfenbrenner & Morris, 2007). The PPCT framework suggests that in order to fully understand a particular aspect of human development, researchers must account for proximal processes that are ongoing and shape development, personal factors that serve as both inputs and outputs in the system, more distal contextual factors at all levels (e.g., micro and macro) that are moderated and mediated by proximal processes, and temporal factors that shape the changing relationships among these three aspects throughout development.

Aligned with this framework, the revised co-regulation model of emerging interest in early childhood focuses particular attention on the proximal processes of parent-child interactions and provides evidence for parent actions and behaviors that shape this development, which have previously been hypothesized by researchers but not directly documented. The revised model also emphasizes the personal characteristics of parents and children and how these serve as inputs to proximal processes, influencing the nature of parent-child interactions, as well as outputs of these experiences, including support for children's developing interests and feedback shaping how parents continue to engage with their children and provide opportunities and resources. The revised model does begin to account for contextual factors at different levels, although these are clearly under-theorized and more research is needed to better describe contextual factors and understand how they relate to personal characteristics of parents and children and the proximal processes of parent-child interactions.

The revised model implies ongoing temporal processes by depicting four feedback loops among parents, children, and parent-child interactions. Again, this aspect of the model is under-theorized and more research is needed to understand how these processes and factors change over time, both in terms of children's development, as depicted in the original co-regulation model, and in terms of the stages of interest development, as theorized by Hidi and Renninger (Hidi & Renninger, 2006; Renninger & Hidi, 2011). It will also be important to explore the degree to which the revised model is supported by longer-term research, following children and parents over several years and especially as they make the transition into formal schooling. As noted above, part of this future research will need to focus on better understanding the transition between phases of interest development, and especially the transition from maintained situational interest to emerging individual interest connected to broader topics and activities, evidenced by some families in this study.

More broadly, it will be important to test how aspects of this model generalize to different families, including families with young boys and those from different racial, ethnic, and socioeconomic backgrounds. Much of the prior research on early childhood interest development has been conducted with white, middle-class families (e.g., Alexander et al., 2013). In this study, I focused specifically on mother-daughter dyads from low socioeconomic and diverse racial and ethnic backgrounds. Aligned with an asset-based perspective, my focus on families from low socioeconomic backgrounds was intended to identify promising parenting strategies and develop a theoretical model appropriate for the cultural backgrounds and economic realities of these families, rather than transferring beliefs and assumptions about parenting from other contexts. Similarly, the motivation for focusing particularly on girls was to identify promising approaches to addressing the widespread and persistent gender disparities in science participation. Given the limitations of these decisions and the small sample size, however, an important next step will be to test the revised co-regulation model with a larger group, including families with both boys and girls.

Another outstanding question in the literature is whether interest development in early childhood is primarily parent or child driven. Alexander and colleagues (Alexander et al., 2012, 2013) found evidence for a child-initiated model of interest development, rather than a parent-initiated model. In other words, it appeared that parents primarily responded to interest expressed by their children, subsequently supporting those interests and providing more interest-related experiences. Citing prior research (Holden, 2010), they hypothesized that "parents must either purposefully or accidentally create environments in which some types of interests are more likely to be triggered than others" (Alexander et al., 2013, p. 11). In this study, parents reported extended interests that were directly connected to prior interests, extended interests that appeared to be related but not directly connected to prior interests, and a few extended interests that seemed to be primarily due to participation in the study and the parent-child interactions that resulted. The video data also emphasized mechanisms through which parents might more directly and purposefully initiate children's interests, such as showing value for and interest in a topic themselves or explicitly connecting a new topic or activity to a child's related prior experiences. More research is needed to understand these possible pathways, although it is likely that the reciprocity and co-regulation between parents and children are more critical than the actual moment of interest initiation. In fact, interests might never truly be sparked from scratch but may always be an outgrowth of related prior interests and experiences as part of a long-term, ever-changing pathway of interest development.

Finally, an important avenue of future research is to better understand how the parental beliefs identified by Alexander and colleagues (2013), including beliefs about importance of education, communication, consistency, time for unstructured play, and supporting children's interests, connect with the parental beliefs and orientations identified in this study. It may be that the two sets of beliefs are aligned and can be reconciled or that each study has identified some unique beliefs that may be important in different contexts. Clearly, both models emphasize parents' beliefs about their children's learning development and how best to support their children (e.g., beliefs about learning, beliefs about the importance of education, communication, consistency, and time for unstructured play) and both emphasize parent beliefs and knowledge directly related to interest development (e.g., awareness of interests, knowledge of interest support strategies, and beliefs about the importance of supporting children's interests). In contrast to the original version, the revised model of co-regulation highlights parents' own beliefs and interests related to science, as well as parents' reflective orientations and openness to growing, changing, and learning in parallel with their children. This new focus on parent reflection may be particularly important for guiding educational programs and community organizations focused on supporting early childhood learning and development.

Limitations

As noted in Chapter 3, this study, like all research, has inherent limitations and boundaries. Both phases were situated within a specific community with specific families and phase 2 in particular was conducted with a small number of Head Start mothers and their four-year-old daughters. In both phases, I used a variety of strategies for supporting the validity, reliability, credibility, and trustworthiness of the findings, including establishing a theoretical framework and using previously developed measures with strong validity evidence in phase 1 and gathering input and feedback on emerging findings and interpretations in phase 2 from both participants and other researchers not directly involved in the study (Allen et al., 2007;

Creswell, 2013; Maxwell, 2013; National Research Council, 2002; National Science Foundation & Department of Education, 2013; Shadish, Cook, & Campbell, 2001). Whenever possible, I have grounded my findings within prior literature, clearly indicating where study outcomes support prior research and theory and where they suggest new directions or new interpretations. Nevertheless, the findings from this dissertation must be considered tentative hypotheses, to be compared to other studies, with different populations and in different settings, and used to motivate future research. This approach to validity and generalizability in fact is a hallmark of scientific research, with findings supported and contradicted through a variety of studies that gradually build converging evidence that is robust across settings and over time (Shadish et al., 2001). My hope is that the research findings from this study, and the co-regulation model developed above, will serve as important next step in the long-term effort to understand and support early childhood science interest development.

Strategies for supporting parents and families

Although the sample size for the second phase of the study was small, the findings suggest some promising strategies for educational programs and community organizations that align with prior research on family support and child interest development. In this final section, I discuss three potential leverage points for increasing science-related interest development in early childhood: (a) developing parents' own enjoyment of science, (b) supporting reflective parenting, and (c) honoring the diversity of parenting strategies and approaches across families and communities.

Phase 1 of this mixed-method study suggests that for parents, as with youth and students (Ainley & Ainley, 2011a, 2011b), enjoyment and personal value of science are critical factors motivating engagement and learning. In the multivariate analyses described in chapter 2, the model with these two variables predicted approximately 39% of the variance in reported frequency of science learning behaviors, such as how frequently parents reported watching a science-related TV show or reading a science-related book. Both factors were strongly and positively related to science learning behaviors, even after controlling for age, gender, ethnicity, college science courses taken, beliefs about the importance of science, and parenting beliefs about the importance of consistency and communication. Furthermore, in phase 2 parents that reported broad, sustained science-related interests in their children sparked by the sessions also reported higher levels of science enjoyment and were observed expressing more instances of positive affect during interactions with their children.

These findings suggest that parents that enjoy and value science more may foster science-related interests in their children by providing more opportunities for engaging with science-related activities and learning resources and by communicating positive affect and the value of science to their children during interactions. Based on these results, an important educational strategy for supporting early childhood science-related interest development may be to provide parents with opportunities to engage with science in fun, low-risk environments (National Research Council, 2009). For example, Head Start programs might offer hands-on science activities during family or parent nights and science centers might organize special events for parents with young children that encourage parents to experience science in new ways. Given that phase 1 suggests that many parents may have a relatively narrow perspective on what counts as science, it will likely be important to make explicit connections between these activities and science more broadly so that parents associate their positive memories and feelings about these experiences with science and can help make these same connections for their children.

Another promising strategy for supporting early childhood science-related interest development is to promote reflective parenting orientations, encouraging parents to be aware of and responsive to their children's growing and changing interests. Research on educators, professionals, and organizations has long emphasized the importance of reflection and professional learning practice (e.g., Cochran-Smith, 2009; Loucks-Horsley, 2010; Preskill, 1999). Given this, it is surprising that more attention has not been paid to how parents reflect on their experiences with their children and how they learn and adapt as their children develop. In this study, parents that reported broad, sustained science-related interests on the part of their children also made more reflective comments and more comments about their aspirations and openness to learning as parents. Although this aspect of parenting may not uniquely contribute to interest development, it may be especially important for the early phases of fostering interest, as children are just becoming engaged in an activity or topic but still need significant support to deepen, extend, and recognize these interests (Alexander et al., 2013; Hidi & Renninger, 2006). Similarly, reflective parenting orientations may be important for helping parents provide responsive support and scaffolding for their children, directing experiences at times but also allowing children space and freedom to pursue their interests, develop a sense of agency and self-efficacy, and begin to internalize interests as part of their emerging identities (Hidi & Renninger, 2006; Renninger & Hidi, 2011; Renninger & Su, 2012; Wertsch & Hickmann, 1987a).

In comparison to parent enjoyment, promoting reflective parenting orientations may be a challenging task for educators and community organizations. Fortunately, many strategies have been developed and tested in other professional settings that might be effective for parent support programs (e.g., Loucks-Horsley, 2010; Pattison, Cohn, & Kollmann, 2013; Preskill, 1999). For example, professional development programs for classroom teachers often promote professional learning and reflection by using artifacts of practice, such as videos of classroom interactions (Loucks-Horsley, 2010). Similarly, committee organizations such as Head Start could use video clips of parent-child interactions to promote discussions with parents during parent nights or classes. In fact, several parents that participated in phase 2 commented that they appreciated how the study, including watching short video clips during the interviews, allowed them to think about their role as parents and consider ways they might improve. However, as in teacher professional development, parents will need support engaging in these types of conversations and reflective discussions. Educational programs and community organizations will also have to be realistic about the time and energy that these parents have for reflection, given that these families often juggle complex schedules, multiple jobs, and limited free hours. Working collaboratively with educators and program managers, researchers can help identify strategies that align with current Head Start and committee organization practices, such as use of the Parenting Interactions with Children: Checklist of Observations Linked to Outcomes (PICCOLO) assessment and reflection tool (Roggman, 2013), and science-specific programming that supports a wide range of developmental outcomes (e.g., Education Commission of the States, 2014).

These two strategies can be pursued while still honoring the many unique and culturally specific approaches to parenting observed across families and communities. In this study, I found initial evidence that parents can support broad, sustained science-related interests through a variety of approaches. For example, while all parents that reported broad interests in their children shared certain approaches to interacting with their children and beliefs about parenting, they also varied substantially in their goal orientations and dominant parenting routines. These findings are aligned with the notion that there are many successful ways to raise children and that assumptions about “effective” parenting are often based more on cultural norms and values than research evidence (Gutierrez & Rogoff, 2003; Institute of Medicine & National Research Council, 2012; National Research Council, 2000a; Rogoff et al., 1993). As noted by the National Research Council and Institute of Medicine (2000a), "succinct formulas for good parenting have been replaced by an appreciation for the many ways in which parents adjust what they do in response to the needs and characteristics of their children, the conditions in which they live, and the circumstances of their own lives" (p. 227).

Unfortunately, informal and formal learning institutions have often privileged the knowledge, discourses, and practices of white, middle-class communities, failing to "recognize the science related practices associated with individuals from other groups" (National Research Council, 2009, p. 112), including low-income, Latino and Spanish-speaking communities (Ceballo, Huerta, & Epstein-Ngo, 2010; Garibay, 2009). Given that parenting is a highly personal and culturally situated endeavor, honoring and building on the practices and beliefs of parents and families, rather than undermining and marginalizing these practices, is critical for building trust and creating successful educational interventions (Institute of Medicine & National Research Council, 2012; National Research Council, 2000a). Ultimately, it may be important to shift from focusing on changing parents to helping parents and communities develop “dexterity” using strategies and repertoires of practice to support their children’s science learning and interest development across a variety of settings (Gutierrez & Rogoff, 2003). Findings from this study suggest that early childhood science-related interest development can be supported while still honoring different child-rearing approaches, beliefs, and values.

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APPENDICES

Appendix A: English Head Start Parent Questionnaire

Head Start Parent and Caregiver Questionnaire

Oregon State University and the Mt. Hood Community College Head Start program are working on an exciting community research project to try to understand how parents and caregivers can support their children's everyday learning and development before their children enter school. We invite you to fill out this questionnaire and share your knowledge and experience as a parent or caregiver. We will use what we learn to better support other families like yours with young children.

The questionnaire should take no longer than 20 minutes. We don't believe you will experience any risks or discomforts from participating in this project. You may not benefit directly but the information you share will help us and the Mt. Hood Community College Head Start program understand how to support children's everyday learning before they enter school. If you complete the questionnaire fully, you will receive two free admission tickets to the Oregon Museum of Science and Industry (OMSI).

All of your responses will be kept as confidential as possible and if the results of this project are published, your name or other identifying information will not be made public. However, you should know that there is always a small chance that this information will be shared accidentally. Participation is voluntary. You may skip any questions that you don't want to answer and you can decide not to continue the questionnaire at any point. Choosing not to participate will not affect your relationship with the Head Start program.

If you have any questions about this research project, please contact Scott Pattison or Lynn Dierking using the email addresses and phone numbers provided below. If you have questions about your rights as a participant, please contact the Oregon State University Institutional Review Board (IRB) Office at 541.737.8008 or by email at IRB@oregonstate.edu.

Your ideas are important to us. We hope you will be willing to share your knowledge and experience and support this research.

Scott Pattison
Oregon State University
spattison@omsi.edu
503.797.4673

Lynn Dierking (study principal investigator)
Oregon State University
dierkinl@science.oregonstate.edu
541.737.1823

Head Start Program

To begin, we'd like to know how you have participated in the Mt. Hood Community College Head Start program.

1. Which of the following Mt. Hood Committee College Head Start programs have you or your child participated in?
(Please mark all that apply.)

☐ **Full Day Head Start and Early Head Start** (children 18 months to 5 years of age, 5 days per week)

☐ **Part Day Head Start** (children 3 to 5 years of age, 4 days per week, 3 ½ hours per day)

☐ **Home-Based Early Head Start** (children birth to 3 years of age, weekly home visits, group meeting twice a month)

☐ **Home-Based Head Start** (children 3 to 5 years of age, weekly home visits, group meeting twice a month)

☐ **Parents As Teachers** (children birth to 5 years of age, monthly home visits, group meeting once a week)

Experience as a Parent or Caregiver

Next we would like to hear a little bit about your experience as a parent or caregiver. There are no right or wrong answers. Please respond as honestly as you can. For these questions, you can think primarily about your child who is currently in head start or early head start.

2. How many children's books would you estimate are currently in your home?

3. In an average week, how often do you read with your child?
(Please mark only one.)

- ☐ More than 2 times each day
- ☐ 1-2 times each day
- ☐ More than 3 times per week but less than once per day
- ☐ 1-2 times per week
- ☐ Less than once a week

4. What is the average amount of time your child spends engaged in play at home each day?

a) Average number of hours on a typical weekday:

b) Average number of hours on a typical weekend day:

5. How often do you do the following activities with your child?
(Please mark only one box per row.)

	Greater than 8 times a year	*4-7 times a year*	*1-3 times a year*	*Less than once a year*	*Never*
a) Visit a museum or art exhibition	☐	☐	☐	☐	☐
b) Attend a music concert	☐	☐	☐	☐	☐
c) Go to a zoo or aquarium	☐	☐	☐	☐	☐
d) Go to the theater or a play	☐	☐	☐	☐	☐
e) Go to the movies	☐	☐	☐	☐	☐
f) Go shopping or to the mall	☐	☐	☐	☐	☐
g) Visit OMSI or another science center	☐	☐	☐	☐	☐
h) Attend a sports event or game	☐	☐	☐	☐	☐
i) Go to a festival or community event	☐	☐	☐	☐	☐
j) Visit the library	☐	☐	☐	☐	☐
k) Go hiking or other outdoor activities	☐	☐	☐	☐	☐

6. How important are each of the following in your home life?
(Please mark only one box per row.)

	Very Important	*Important*	*In the middle*	*Not very important*	*Not at all important*
a) Consistency: Providing consistent and predictable discipline, expectations, and rules for your child	☐	☐	☐	☐	☐
b) Order: Maintaining a neat and clean home	☐	☐	☐	☐	☐
c) Structure: Emphasizing structured activities and routines for your child	☐	☐	☐	☐	☐
d) Organization: Planning and organizing your child's schedule and activities	☐	☐	☐	☐	☐
e) Routine: Maintaining regular schedules and routines for your child	☐	☐	☐	☐	☐
f) Exploration of new ideas: Encouraging your child to be curious and explore new topics and ideas	☐	☐	☐	☐	☐
g) Exchange of information: Sharing ideas with your child and encouraging your child to share ideas with you	☐	☐	☐	☐	☐

7. Similar to the previous question, how important are each of the following in your home life?
(Please mark only one box per row.)

	Very Important	*Important*	*In the middle*	*Not very important*	*Not at all important*
a) Family discussions: Regularly talking with your child and having conversations as a family	☐	☐	☐	☐	☐
b) Expression of personal opinions: Allowing your child to have their own ideas, values, and opinions	☐	☐	☐	☐	☐
c) Exploring controversial issues: Discussing challenging or sensitive topics with your child	☐	☐	☐	☐	☐
d) Goal setting: Setting goals for your child's growth, development, and learning	☐	☐	☐	☐	☐
e) Cooperation: Working together with your child, sharing family jobs and tasks, and encouraging family cooperation	☐	☐	☐	☐	☐
f) Reading: Regularly reading to your child and encouraging your child to practice reading	☐	☐	☐	☐	☐

8. To what extent do you feel your child's participation in the following activities is important?
(Please mark only one box per row.)

	Very Important	*Important*	*In the middle*	*Not very important*	*Not at all important*
a) Special lessons (for example: art, music)	☐	☐	☐	☐	☐
b) Additional academic activities (for example: science fairs)	☐	☐	☐	☐	☐
c) Team activities (for example: sports, cheerleading)	☐	☐	☐	☐	☐
d) Family activities (for example: trips, meals)	☐	☐	☐	☐	☐
e) Household chores	☐	☐	☐	☐	☐
f) Play	☐	☐	☐	☐	☐
g) Socializing with friends	☐	☐	☐	☐	☐

You and Science

The next questions focus on your personal thoughts about science. Again, there are no right or wrong answers. Please respond as honestly as you can.

9. When you hear the word "science," what does it mean to you?

____

____

____

10. We are interested in what you think about the need for science skills in the job market today. How much do you agree with the following statements?
(Please mark only one box per row.)

	Strongly agree	*Agree*	*Disagree*	*Strongly disagree*
a) It is important to have good scientific knowledge and skills in order to get any good job in today's world.	☐	☐	☐	☐
b) Employers generally appreciate strong scientific knowledge and skills among their employees.	☐	☐	☐	☐
c) Most jobs today require some scientific knowledge and skills.	☐	☐	☐	☐
d) It is an advantage in the job market to have good scientific knowledge and skills.	☐	☐	☐	☐

11. The following question asks about your views towards science. How much do you agree with the following statements?
(Please mark only one box per row.)

	Strongly agree	*Agree*	*Disagree*	*Strongly disagree*
a) Some concepts in science help me to see how I relate to other people.	☐	☐	☐	☐
b) There are many opportunities for me to use science in my everyday life.	☐	☐	☐	☐
c) Science is very relevant to me.	☐	☐	☐	☐
d) I find that science helps me to understand the things around me.	☐	☐	☐	☐

12. Similar to the previous question, how much do you agree with the following statements?
(Please mark only one box per row.)

	Strongly agree	*Agree*	*Disagree*	*Strongly disagree*
a) I generally have fun when I am learning science topics.	☐	☐	☐	☐
b) I like reading about science.	☐	☐	☐	☐
c) I enjoy acquiring new knowledge in science.	☐	☐	☐	☐
d) I am interested in learning about science.	☐	☐	☐	☐

13. How often do you do these things?
(Please mark only one box per row.)

	Very often	*Regularly*	*Sometimes*	*Hardly ever*	*Never*
a) Watch TV programs about science	☐	☐	☐	☐	☐
b) Borrow or buy books on science topics	☐	☐	☐	☐	☐
c) Visit web sites about science topics	☐	☐	☐	☐	☐
d) Listen to radio programs about advances in science	☐	☐	☐	☐	☐
e) Read science magazines or science articles in newspapers	☐	☐	☐	☐	☐
f) Attend a science club	☐	☐	☐	☐	☐
g) Visit a science museum like OMSI	☐	☐	☐	☐	☐

14. What are other activities you like to do related to science?

____

____

About You

Finally, please tell us a little bit more about yourself.

15. What is your sex? *(Please mark only one.)*

☐ Female

☐ Male

16. What is your age? ______

17. Counting yourself, how many adults live in your household? ______

18. How many children in each age category below live in your household?
(Please indicate a number for each age category, even if that number is zero.)

a) 0 to 3 ______

b) 4 ______

c) 5 ______

d) 6 to 9 ______

e) 10 to 12 ______

f) 13 to 15 ______

g) 16 to 18 ______

19. What do you spend most of your time doing for work, either paid or unpaid?

______

20. What is the zip code where you live? ______

21. Now we'd like to ask about your race and ethnicity. *For this questionnaire, race and ethnicity are different. Please answer BOTH questions below about Hispanic origin and race.*

a) Are you of Hispanic, Latino, or Spanish origin? *(Please mark one or more boxes.)*

☐ No, not of Hispanic, Latino, or Spanish origin

☐ Yes, Mexican, Mexican American, Chicano

☐ Yes, Puerto Rican

☐ Yes, Cuban

☐ Yes, another Hispanic, Latino, or Spanish origin (please indicate) _________________

b) What is your race? *(Please mark one or more boxes.)*

☐ White

☐ Black, African American, or Negro

☐ American Indian or Alaskan Native

☐ Asian Indian

☐ Chinese

☐ Filipino

☐ Samoan

☐ Other Pacific Islander (please indicate) _______________

☐ Japanese

☐ Korean

☐ Vietnamese

☐ Other Asian (please indicate) _______________

☐ Native Hawaiian

☐ Guamanian or Chamorro

☐ Some other race (please indicate) _______________

22. What language(s) do you and your child speak <u>most often</u> at home with your family? *(Please mark one or more.)*

☐ Spanish

☐ English

☐ Some other language (please indicate)___________________________

23. What is the highest degree or level of school you have <u>completed</u>?
(Please mark only one.)

No schooling completed

- ☐ No schooling completed

Nursery or preschool through grade 12

- ☐ Nursery school or kindergarten
- ☐ Grade 1 through 11
- ☐ 12th grade (**no diploma**)

High school graduate

- ☐ Regular high school diploma
- ☐ GED or alternative credential

College or some college

- ☐ Some college credit (**no degree**)
- ☐ Associate's degree (for example: AA, AS)
- ☐ Bachelor's degree (for example: BA, BS)

After bachelor's degree

- ☐ Master's degree (for example: MA, MS, MEng, MEd, MSW, MBA)
- ☐ Professional degree beyond a bachelor's degree (for example: MD, DDS, DVM, LLB, JD)
- ☐ Doctorate degree (for example: PhD, EdD)

24. If you have been to college, how many college-level <u>science courses</u> have you taken?

____

Thank You!

Thank you so much for taking the time to share your thoughts.

This questionnaire is part of an ongoing research study to understand how parents and caregivers support their children's learning and development. We are currently looking for parents and caregivers who are willing to participate in additional research activities, including a phone conversation about their experience with a young child, videotaped play sessions with science activities, and a visit to the Oregon Museum of Science and Industry (OMSI).

If you are willing to help with these activities, please write your name, email address, and telephone number below. *If you provide this information your responses to this questionnaire will still be confidential.*

Name: ______

Email address: ______

Telephone number: ______

Is there anything else you would like to tell us related to any part of this questionnaire?

______

______

______

Thank you again for helping us support families with young children.

Scott Pattison
Oregon State University
spattison@omsi.edu
503.797.4673

Lynn Dierking (study principal investigator)
Oregon State University
dierkinl@science.oregonstate.edu
541.737.1823

Appendix B: Spanish Head Start Parent Questionnaire

Cuestionario para Padres y Tutores de Head Start

Oregon State University y el Mt. Hood Community College Head Start están trabajando en un interesante proyecto de investigación para entender cómo los padres y tutores pueden apoyar el aprendizaje y desarrollo de sus niños antes de entrar a la escuela. Le invitamos a llenar este cuestionario y compartir su conocimiento y experiencia como padre o tutor. Sus comentarios serán utilizados para entender cómo apoyar a otras familias con niños pequeños como la suya.

Este cuestionario no debe de tomar más de 20 minutos y está diseñado para que usted no experimente ningún riesgo o incomodidad. Usted no será beneficiado directamente pero la información que proporcione nos ayudará a entender cómo los padres y tutores pueden apoyar el aprendizaje y desarrollo de sus niños antes de entrar a la escuela. Si usted completa el cuestionario completamente, recibirá dos entradas gratuitas al Museo de Ciencia e Industria de Oregón (OMSI).

Todas sus respuestas serán tratadas como confidenciales y si los resultados de este estudio son publicados, su nombre u otra información identificable no se harán públicos. Sin embargo, usted debe de saber que siempre existe una pequeña posibilidad de que esta información sea compartida accidentalmente. Su participación es voluntaria. Usted puede saltarse preguntas que no quiera contestar y puede decidir no continuar con el cuestionario en cualquier momento. Si usted decide no participar, esto no afectará su relación con el programa de Head Start.

Si usted tiene cualquier pregunta acerca de este proyecto de investigación, por favor contacte a Scott Pattison o Lynn Dierking a las direcciones y teléfonos indicadas abajo. Si tiene preguntas acerca de sus derechos como participante, por favor contacte a la oficina de Oregon State University Institutional Review Board (IRB) al 541.737.8008 o por correo electrónico a IRB@oregonstate.edu.

Sus opiniones son importantes para nosotros. Esperamos que apoye esta investigación compartiendo su conocimiento y experiencias.

Scott Pattison
Oregon State University
spattison@omsi.edu
503.797.4673

Lynn Dierking (investigador principal)
Oregon State University
dierkinl@science.oregonstate.edu
541.737.1823

Programa Head Start

Para empezar, nos gustaría saber cómo ha participado con el Programa Head Start de Mt. Hood Community College

1. ¿En cuál de los siguientes programas de Mt. Hood Committee College Head Start ha participado usted o su niño(a)?

(Por favor marque todas las opciones que apliquen.)

☐ **Full-Day Head Start and Early Head Start / Programa de Todo el Día y de Educación Temprana del Head Start** (niños de 18 meses a 5 años de edad, 5 días a la semana)

☐ **Part Day Head Start / Programa de Medio Día del Head Start** (niños de 3 a 5 años de edad, 4 días a la semana, 3½ horas al día)

☐ **Home-Based Early Head Start / Programa de Visitas a la casa de Educación Temprana** (niños desde el nacimiento a 3 años de edad, visitas semanales a casa, reuniones en grupo 2 veces al mes)

☐ **Home-Based Head Start / Programa de Visitas a la casa del Head Start** (niños de 3 a 5 años de edad, visitas semanales a casa, reuniones en grupo 2 veces al mes)

☐ **Parents As Teachers** (PAT) / Padres Como Maestros (niños desde el nacimiento a 5 años de edad, visitas mensuales a casa, reuniones en grupo 1 vez por semana)

Experiencia como Padre o Tutor

Ahora nos gustaría saber un poco sobre su experiencia como padre o tutor. No hay respuestas correctas o incorrectas. Por favor responda lo más honestamente que pueda. Para responder estas preguntas, piense principalmente en el niño(a) que actualmente está en Head Start o en Early Head Start

2. ¿Cuántos libros de niños calcula que actualmente hay en su casa?

____

3. En una semana típica, ¿qué tan frecuentemente lee con su niño(a)?
(Por favor marque solo uno.)

- ☐ Más de 2 veces al día
- ☐ 1 a 2 veces al día
- ☐ Más de 3 veces por semana pero menos de una vez al día
- ☐ 1 a 2 veces por semana
- ☐ Menos de una vez por semana

4. ¿Cuál es el promedio de tiempo que su niño(a) pasa jugando en casa al día?

a) Horas promedio en un día común <u>entre semana</u>: __________

b) Horas promedio en un día común <u>de fin de semana</u>: __________

5. ¿Qué tan frecuentemente realiza las siguientes actividades con su niño(a)?
(Por favor marque solo un cuadro por columna.)

	Más de 8 veces al año	*4 a 7 veces al año*	*1 a 3 veces al año*	*Menos de una vez al año*	*Nunca*
a) Visitar un museo o exhibición de arte	☐	☐	☐	☐	☐
b) Ir a un concierto musical	☐	☐	☐	☐	☐
c) Visitar un zoológico o un acuario	☐	☐	☐	☐	☐
d) Ir al teatro o ver una obra teatral	☐	☐	☐	☐	☐
e) Ir al cine	☐	☐	☐	☐	☐
f) Ir de compras o a una plaza comercial	☐	☐	☐	☐	☐
g) Visitar OMSI u otro centro de ciencias	☐	☐	☐	☐	☐
h) Atender a un juego o evento deportivo	☐	☐	☐	☐	☐
i) Ir a un festival o evento comunitario	☐	☐	☐	☐	☐
j) Visitar la biblioteca	☐	☐	☐	☐	☐
k) Tomar una caminata o hacer otras actividades al aire libre	☐	☐	☐	☐	☐

6. ¿Qué tan importantes son en su casa los siguientes aspectos?
(Por favor marque solo un cuadro por columna.)

	Muy importante	*Importante*	*En el medio*	*No muy importante*	*Nada importante*
a) Consistencia: Mantener disciplina, expectativas y reglas consistentes y predecibles para su niño(a)	☐	☐	☐	☐	☐
b) Orden: Mantener una casa limpia y ordenada	☐	☐	☐	☐	☐
c) Estructura: Enfatizar en tener actividades y rutinas estructuradas para su niño(a)	☐	☐	☐	☐	☐
d) Organización: Planear y organizar los horarios y actividades de su niño(a)	☐	☐	☐	☐	☐
e) Rutina: Mantener horarios y rutinas regulares para su niño(a)	☐	☐	☐	☐	☐
f) Exploración de nuevas ideas: Impulsar a su niño a que sea curioso y explore nuevos temas e ideas	☐	☐	☐	☐	☐
g) Intercambio de información: Compartir ideas con su niño(a) e impulsar a su niño(a) a compartir ideas con usted	☐	☐	☐	☐	☐

7. Tal como en la pregunta anterior, ¿qué tan importantes son en su casa los siguientes aspectos?

(Por favor marque solo un cuadro por columna.)

	Muy importante	*Importante*	*En el medio*	*No muy importante*	*Nada importante*
a) Discusiones familiares: Hablar regularmente con su niño(a) y tener conversaciones en familia	☐	☐	☐	☐	☐
b) Expresión de opiniones personales: Permitir a su niño(a) tener sus propias ideas, valores y opiniones	☐	☐	☐	☐	☐
c) Explorar temas controversiales: discutir temas difíciles o sensibles con tu niño(a)	☐	☐	☐	☐	☐
d) Definir objetivos: Definir objetivos para el crecimiento, desarrollo y aprendizaje de tu niño(a)	☐	☐	☐	☐	☐
e) Cooperación: Trabajar en conjunto con tu niño(a), compartiendo las labores y tareas familiares y promoviendo cooperación familiar	☐	☐	☐	☐	☐
f) Lectura: Leer regularmente a tu niño(a) e impulsar a su niño(a) a practicar su lectura.	☐	☐	☐	☐	☐

8. ¿En qué medida siente que es importante la participación de su niño(a) en las siguientes actividades?

(Por favor marque solo un cuadro por columna.)

	Muy importante	*Importante*	*En el medio*	*No muy importante*	*Nada importante*
a) Clases especiales (por ejemplo: de arte, música)	☐	☐	☐	☐	☐
b) Actividades extraescolares (por ejemplo: ferias de ciencia)	☐	☐	☐	☐	☐
c) Actividades en equipo (por ejemplo: deportes, equipo de porristas)	☐	☐	☐	☐	☐
d) Actividades familiares (por ejemplo: viajes, comidas)	☐	☐	☐	☐	☐
e) Household chores Labores de casa	☐	☐	☐	☐	☐
f) Juego	☐	☐	☐	☐	☐
g) Socializar con amigos	☐	☐	☐	☐	☐

Usted y la Ciencia

Las siguientes preguntas se enfocan en sus ideas respecto a la ciencia. Reiteramos, no hay respuestas correctas o incorrectas. Por favor responda lo más honestamente que pueda.

9. ¿En qué piensa cuando escucha la palabra "ciencia"?

10. Nos interesa saber qué piensa de las exigencias de habilidades científicas en el mercado laboral. ¿En qué medida está usted de acuerdo con las siguientes afirmaciones?

(Por favor marque solo un cuadro por columna.)

	Completamente de acuerdo	*De acuerdo*	*En desacuerdo*	*Completamente en desacuerdo*
a) Hay que tener sólidos conocimientos y habilidades científicas para obtener un buen empleo en el mundo actual.	☐	☐	☐	☐
b) Generalmente los empleadores aprecian los conocimientos y habilidades científicas entre sus empleados.	☐	☐	☐	☐
c) En la actualidad, la mayoría de empleos exigen cierta base de conocimientos y habilidades científicas.	☐	☐	☐	☐
d) Tener buenos conocimientos y habilidades científicas constituye una ventaja en el mercado laboral.	☐	☐	☐	☐

11. La siguiente pregunta se relaciona con sus opiniones sobre las ciencia. ¿En qué medida está usted de acuerdo con las siguientes afirmaciones?
(Por favor marque solo un cuadro por columna.)

	Completamente de acuerdo	*De acuerdo*	*En desacuerdo*	*Completamente en desacuerdo*
a) Algunos conceptos científicos me ayudan a observar cómo me relaciono con otras personas.	☐	☐	☐	☐
b) En la vida cotidiana, tengo muchas oportunidades para utilizar la ciencia.	☐	☐	☐	☐
c) La ciencia es muy importante para mí.	☐	☐	☐	☐
d) Me doy cuenta que la ciencia me ayuda a comprender las cosas que me rodean.	☐	☐	☐	☐

12. Tal como en la pregunta anterior, ¿en qué medida está usted de acuerdo con las siguientes afirmaciones?
(Por favor marque solo un cuadro por columna.)

	Completamente de acuerdo	*De acuerdo*	*En desacuerdo*	*Completamente en desacuerdo*
a) Generalmente, me divierto aprendiendo temas de ciencias.	☐	☐	☐	☐
b) Me gusta leer sobre ciencia.	☐	☐	☐	☐
c) Disfruto adquiriendo conocimientos de ciencia.	☐	☐	☐	☐
d) Me interesa aprender sobre ciencia.	☐	☐	☐	☐

13. ¿Con qué frecuencia realiza usted las siguientes actividades?
(Por favor marque solo un cuadro por columna.)

	Muy frecuente-mente	*Regular-mente*	*A veces*	*Casi nunca*	*Nunca*
a) Ver programas de TV sobre ciencia	☐	☐	☐	☐	☐
b) Pedir prestados o comprar libros sobre temas científicos	☐	☐	☐	☐	☐
c) Visitar sitios web sobre temas científicos	☐	☐	☐	☐	☐
d) Escuchar programas de radio acerca de los avances de la ciencia	☐	☐	☐	☐	☐
e) Leer revistas o artículos de ciencia en el periódico	☐	☐	☐	☐	☐
f) Atender a un club de ciencias	☐	☐	☐	☐	☐
g) Visitar un museo de ciencia como OMSI	☐	☐	☐	☐	☐

14. ¿Qué otras actividades relacionadas con la ciencia le gusta hacer?

Acerca de Usted

Finalmente, cuéntenos un poco sobre usted.

15. ¿Cuál es su sexo? *(Por favor marque solo uno.)*

- ☐ Femenino
- ☐ Masculino

16. ¿Cuál es su edad? ______

17. Contándose usted, ¿cuántos adultos viven en su casa? ______

18. ¿Cuántos niños en cada categoría de edad viven en su casa?
(Por favor indique un número por cada categoría, aún cuando el número sea cero.)

a) 0 a 3 ______

b) 4 ______

c) 5 ______

d) 6 a 9 ______

e) 10 a 12 ______

f) 13 a 15 ______

g) 16 a 18 ______

19. ¿En qué trabaja la mayor parte de su tiempo? Puede ser pagado o no pagado.

______

20. ¿Cuál es el código postal de donde vive usted? ______

21. Ahora nos gustaría preguntarle acerca de su raza y etnicidad
Para este cuestionario, raza y etnicidad son diferentes. Por favor conteste AMBAS preguntas acerca de su raza y etnicidad.

a) ¿Es usted de origen hispano, latino o español? *(Por favor marque uno o más cuadros por columna.)*

- ☐ No, no soy de origen hispano, latino o español
- ☐ Sí, mexicano, mexicano americano, chicano
- ☐ Sí, puertorriqueño
- ☐ Sí, cubano
- ☐ Sí, otro origen hispano, latino o español (por favor indique) ____________________

b) ¿Cuál es su raza? *(Por favor marque uno o más cuadros por columna.)*

- ☐ Blanca
- ☐ Negra, Africana Americana o Negroide
- ☐ Nativo Americana o nativo de Alaska
- ☐ India asiática
- ☐ China
- ☐ Filipina
- ☐ Samoana
- ☐ Otra de las islas del Pacífico (por favor indique)____________
- ☐ Japonesa
- ☐ Coreana
- ☐ Vietnamita
- ☐ Otra asiática (por favor indique)_______________
- ☐ Nativa de Hawái
- ☐ Guameña o Chamorro
- ☐ Alguna otra raza (por favor indique) _______________

22. ¿Qué idioma(s) habla usted y su niño(a) más frecuentemente en casa con su familia? *(Por favor marque uno o más.)*

☐ Español

☐ Inglés

☐ Otro idioma (por favor indique)____________________________

23. ¿Cuál es el nivel escolar más alto que ha completado o el título más avanzado que ha recibido?
(Por favor marque solo un cuadro.)

No ha completado ningún grado

- ☐ No ha completado ningún grado

Pre-escolar o pre-kinder hasta grado 12

- ☐ Pre-escolar o pre-kinder
- ☐ Grado 1 al 11
- ☐ Grado 12, **SIN DIPLOMA**

Graduado de escuela secundaria o preparatoria

- ☐ Diploma de escuela secundaria o preparatoria
- ☐ GED o examen equivalente

Universidad o algunos créditos universitarios

- ☐ Algunos créditos universitarios, **SIN DIPLOMA**
- ☐ Título asociado universitario *(por ejemplo:AA, AS)*
- ☐ Título de licenciatura universitaria *(por ejemplo:BA, BS)*

Después del título de licenciatura universitaria

- ☐ Título de maestría *(por ejemplo: MA, MS, MEng, MEd, MSW, MBA)*
- ☐ Título profesional más allá de un título de licenciatura universitaria *(por ejemplo: MD, DDS, DVM, LLB, JD)*
- ☐ Título de doctorado *(por ejemplo: PhD, EdD)*

24. Si usted ha tomado cursos universitarios, ¿cuántas clases de ciencia ha tomado?

____

¡Muchas gracias!

Muchas gracias por tomarse el tiempo de compartir sus ideas.

Este cuestionario es parte de un estudio para comprender cómo es que los padres y tutores apoyan el aprendizaje y desarrollo de sus niños. Actualmente estamos buscando padres y tutores que tengan interés en participar en más actividades de investigación, tales como una conversación telefónica acerca de su experiencia cuidando de niños pequeños, videograbaciones de sesiones de juego con actividades científicas, y una visita al Museo de Ciencia e Industria de Oregón (OMSI).

Si usted está interesado en ayudar con estas actividades, por favor escriba su nombre y su dirección de correo electrónico o teléfono abajo.*Si usted nos da esta información, sus respuestas a este cuestionario se mantendrán confidenciales.*

Nombre: ______________________

Dirección de correo electrónico: ______________________

Teléfono: ______________________

¿Hay algo más que le gustaría agregar o decirnos con respecto alguna parte de este cuestionario?

____

____

____

Gracias de nuevo por su participación y apoyo a familias con niños pequeños.

Scott Pattison
Oregon State University
spattison@omsi.edu
503.797.4673
Lynn Dierking (investigador principal)
Oregon State University
dierkinl@science.oregonstate.edu
541.737.1823

Appendix C: Generic Interview Guide #1

Interview #1 Guide (Generic)

Interview goals (aligned with research questions)

- Proximal processes: Provide a check on researcher's interpretations of interactions, highlight important proximal processes from parents' perspectives, and explore how documented proximal processes relate to other ongoing parent-child interactions.
- Contextual factors: Explore parental beliefs and values as potentially important contextual factors.
- Science interests: Explore relations between parents' science-related interests and beliefs and the nature of parent-child interactions.

General interview instructions

- Follow the interview guide below, rewording questions or asking additional questions as appropriate to explore parental beliefs and perspectives.
- Probe for depth and clarity as needed.
- Capture interviews with both video camera and audio recorder (audio recorder as backup).

Introduction

I hope you had a good time reading and visiting OMSI with your daughter. Now I really want to hear more from you about your experience as a parent. As with the questionnaire, there is no right or wrong answer. I want to learn from you, so be as honest and open as you can. At a few points during our conversation, I'm also going to show a few short video clips of you reading and visiting OMSI with your daughter, so you can tell me more about your experience. And as a reminder, you are free to skip any questions you don't want to answer or end the conversation at any time.

Any questions before we begin?

Reading *To begin, let's talk about the reading.*

1. ***Please tell me what you remember from reading with your daughter. What sticks out in your mind?***
2. ***As a parent, what were you thinking about while reading to [child]?***
    a. ***Probe if not mentioned: What were you trying to do while reading to her? What were you hoping would happen?***
3. ***What are some things that [child] did that you noticed while reading to her?***
    a. ***Probe: Did you try to change what you were doing as a result?***
    b. ***Probe if not mentioned: What about the books seemed to interest your daughter? (Probe if not mentioned: Why do you think that is?)***
4. ***Was this reading similar to or different from other times you read with [child]?***
    a. ***Probe if appropriate: If it was different, in what ways?***
    b. ***Probe if appropriate: If it was similar, in what ways?***
    c. ***Probe if not mentioned: Are these the kinds of books you usually read with your daughter? Do you think you would read these kinds of books again?***

Now I'm going to show you a short video clip of you reading to your daughter so that you can tell me more about your experience [show 1 minute video clip.]

5. ***Now that we've watched the video, can you please tell me what was happening during this experience?***
    a. ***Probe if not mentioned: What were you thinking about at the time?***
6. ***Did you notice anything about [child] that you didn't notice or remember before?***
7. ***[Other video clip specific questions.]***

OMSI visit

[Same questions as reading session]

General questions

Okay, only a few more questions. Now I'd like to ask about your experience as a parent more generally.

8. ***As a parent, what hopes or expectations do you have for your daughter's learning and development?***
9. ***What do you think parents can do to help support children's learning and development at this age?***
10. ***Do you have any questions about being a parent of a young child?***
11. ***Anything else you'd like to tell me related to what we talked about?***
12. ***Do you have any questions for me?***

Thanks so much for your help. Now let's go ahead and schedule the final three sessions.

Appendix D: Generic Interview Guide #2

Interview #2 Guide (Generic)

Interview goals (aligned with research questions)

- Proximal processes: Provide a check on researcher's interpretations of interactions, highlight important proximal processes from parents' perspectives, and explore how documented proximal processes relate to other ongoing parent-child interactions.
- Contextual factors: Explore parental beliefs and values as potentially important contextual factors.
- Science interests: Explore relations between parents' science-related interests and beliefs and the nature of parent-child interactions.

****The primary difference between interview #1 and #2 is that the second interview focuses more explicitly on science-related interests and how parents support the development of these interests for their children.****

General interview instructions

- Follow the interview guide below, rewording questions or asking additional questions as appropriate to explore parental beliefs and perspectives.
- Probe for depth and clarity as needed.
- Capture interviews with both video camera and audio recorder (audio recorder as backup).

Introduction

I hope you had a good time with the activities and during the [family-choice session]. As with our last conversation, I really want to hear more from you about your experience as a parent. Again, there is no right or wrong answer. I want to learn from you, so be as honest and open as you can. At a few points during our conversation, I'm also going to show short video clips of you and your daughter, so you can tell me more about your experience. And as a reminder, you are free to skip any questions you don't want to answer or end the conversation at any time.

Any questions before we begin?

Activities *To begin, let's talk about the activity boxes.*

13. ***Please tell me what you remember from doing the activity boxes with your daughter. What sticks out in your mind?***
14. ***As a parent, what were you thinking about while doing the activities with [child]?***
    a. ***Probe if not mentioned: What were you trying to do while doing the activities with her? What were you hoping would happen?***
15. ***What about the activities seemed to interest your daughter?***
    a. ***Probe if not mentioned: Why do you think that is?***
    b. ***Probe if not mentioned: Do you think anything about the experience stuck with your daughter or affected her later?***
16. ***Were these activities similar to or different from other activities you do with [child]?***
    a. ***Probe if appropriate: If it was similar, in what ways?***

b. ***Probe if appropriate: If it was different, in what ways?***

Now I'm going to show you a short video clip of you doing activities with your daughter so that you can tell me more about your experience [show 1 minute video clip.]

17. ***Now that we've watched the video, can you please tell me what was happening during this experience?***
    a. ***Probe if not mentioned: What were you thinking about at the time?***
    b. ***(Ask parent to point out specific moment in video, if appropriate.)***
18. ***[Other video clip specific questions.]***

Family choice

[Same questions as activity session]

19. **You selected this as a science-related experience having to do with [topic or focus]. Why did you think it was related to science?**
20. **Do you think your daughter was interested in the science parts of the experience?**
    a. **Probe if not mentioned: Why do you think that is?**
    b. **Probe if not mentioned: Do you think anything related to the science stuck with your daughter or affected her later?**
21. **Did you do anything in particular to connect the experience to science for your daughter?**
    a. **Probe if appropriate: If so, why did you do that?**

General questions

Okay, almost done. As with our previous conversation, I'd like to end with a few more general questions.

22. ***As you know, even four-year-olds like your daughter are already interested in many things about the world. In your opinion, what can parents do to help get their children interested in things or help support their children's existing interests when they are young?***
23. ***As a parent, is there anything you hope your daughter will be interested in?***
    a. ***Probe if not mentioned: Why would you like her to be interested in this?***

One of the many things we are focused on during this project is to understand how parents can help their children get interested in SCIENCE when they are young.

24. ***As a parent, do you have any hopes or aspirations for your daughter related to science?***
25. ***Thinking back over everything we did together during this project, what are some of the most important things that happened that have gotten your daughter interested or might help get her interested in science?***
26. ***Have you shared anything about this experience with friends or family?***
27. ***In your opinion, what do you think parents can do to help get children interested in science when they are young?***
28. ***Besides what a parent can do, what else do you think affects whether or not young children get interested in science?***
    a. ***Probe if not mentioned: Do think there are any challenges for young girls specifically in getting interested in science?***

29. ***Anything else you'd like to tell me related to what we have talked about?***
30. ***Do you have any questions for me?***

Thanks so much for your help! Let me get you your OMSI membership.

Appendix E: Note on Phase 2 Video Coding

The approach to coding at multiple levels used in this study was motivated by both a need to identify broader, ongoing patterns of proximal processes, as recommended by Bronfenbrenner, as well as coordinate analysis of proximal and distal processes. Bronfenbrenner's ecological and bioecological models of human development (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007) distinguish between progressively more distal levels of children's developmental ecosystems. For example, the microsystem includes the "pattern of activities, roles, and interpersonal relations experienced by the developing person in a given setting with particular physical and material characteristics" (Bronfenbrenner, 1979, p. 22). In comparison, the macro system is defined as the consistencies in the form and content of lower-order systems (micro-, meso-, and exo-) that exist, or could exist, at the level of the subculture or the culture as a whole, along with any belief systems or ideology underlying such consistencies" (Bronfenbrenner, 1979, p. 26). Even in more recent publications (e.g., Bronfenbrenner & Morris, 2007), however, Bronfenbrenner provided few concrete recommendations for coordinating the analysis of these different levels, beyond asserting that the influences of factors and processes in more distal ecological levels will be mediated and moderated by factors and processes in more proximal levels.

Other researchers have suggested multiple levels of influence on children's development but have more explicitly addressed the need to coordinate analysis across these levels. For example, in early work on adult scaffolding and adult-child interactions, Wertsch and colleagues (Wertsch & Hickmann, 1987b; Wertsch, McNamee, McLane, & Budwig, 1980; Wertsch et al., 1999), articulated an approach to coordinating the analysis of specific child and adult actions with broader situation goals, definitions, and interpretations that signal the influence of more distal levels of the learning ecology, including parent beliefs and sociocultural context. Building on the work of Soviet psychologists, including Vygotsky and Leontiev, Wertsch and colleagues (1999) outlined three interrelated units of analysis for understanding adult-child interactions and contextual factors influencing these interactions: (1) activity, or the broad category of situation or context with associated norms and motivations, such as formal schooling or household economic activity; (2) action, or the set of behaviors of an individual or group within a particular instance and setting that are directed towards a particular goal, such as a student completing a math problem in a particular classroom on a particular day; and (3) operations, or the specific behaviors that make up goal-directed actions, such as a student raising her hand or writing on her worksheet. All of these units of analysis occur within what Bronfenbrenner called the microsystem. However, each provides a unique perspective on the influence of different ecological levels. As Wertsch and colleagues argued and explicated in their research (1999), two families might perform very similar actions (e.g., reading a science-related book), but the adults might use very different operations to accomplish these actions (e.g., minimizing interruptions or frequently engaging in conversations with children about images in the book), thus suggesting very different activity contexts and motivations (e.g., reading as an adult-directed basic literacy activity or reading as a broader, jointly-directed learning experience).

Comparing across research studies conducted by Wertsch and his colleagues over the years highlights the particular importance and utility of coding and analysis at the activity level. In early publications (e.g., Wertsch & Hickmann, 1987b; Wertsch et al., 1980), the researchers coded primarily at the operations level in order to identify aspects and patterns of adult regulation that appeared to be related to children's development of task-specific skills. In these cases, very little attention was paid to the sociocultural context and factors influencing these interactions and, particularly, the facilitation and scaffolding approaches and techniques used by parents. In contrast, in Wertsch et al. (1999), the researchers focused on understanding how adults' culturally situated interpretations of the task (in this case, a session in a research laboratory in which adult-child dyads were asked to replicate a small model of a farm) influenced their behaviors and interactions with their children. Although all dyads completed the same task (i.e., action), there were substantial differences in the operations used by adults. Based on these differences, the authors inferred distinctions in the participants' motivations and perceptions of the task context (i.e., activity).

In a similar way, we attempted to code both specific parent and child actions ("micro parent and child behaviors"), as well as broader patterns of behaviors (" holistic parent-child interaction characteristics") that might indicate particular parent motivations, goals, orientations, or situation definitions, which in turn would suggest ways in which more distal factors, such as social and cultural norms and parenting beliefs, indirectly influenced proximal processes related to early childhood science interest development.