# INVESTIGATING SCIENTIFIC CURIOSITY IN YOUNG LEARNERS: A MULTIPLE CASE STUDY OF A FIVE-YEAR-OLD, A SIX-YEAR-OLD, AND A SEVEN-YEAR-OLD

by

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# DEDICATION

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# Chapter I: Introduction

## Statement of Problem

Curiosity is not only a propensity exhibited by young children as they discover, explore, and learn about their immediate environments, but also a characteristic valued by scientists (Simon, 2001). Within the realm of education, curiosity becomes an important characteristic given the mission of the Education and Human Resources division of the National Science Foundation (NSF). According to this mission statement, education needs to provide opportunities for people to excel in all areas and levels of science, technology, engineering, and mathematics in formal and informal settings in order to develop a diverse and knowledgeable workforce and citizenry (NSF, *n.d.*). *A Framework for K-12 Science Education* (NRC, 2012), developed by the National Research Council (NRC), reinforces the NSF's mission to educate students to become well-informed citizenry, appreciative of scientific enterprises, and scientifically skilled by teaching science for all. Furthermore, the National Science Teacher Association (NSTA) and the National Association for the Education of Young Children (NAEYC) partnered in 2014 to develop a mission statement for early elementary children. This partnership stated that curiosity in the younger ages aids in the development of the foundation for future sustained, scientific interest that may support life-long science learning (NSTA, 2014). Curiosity, as seen through these large organizations that initiate and support educational reform, is viewed as something that can help sustain interest in students as they progress through kindergarten to the twelfth grade. If the missions and goals of the NSF, NSTA, NAEYC, and NRC recognize the value of scientific curiosity, then curiosity perhaps may be deserving of more attention in elementary science education research.

The interest in educational research pertaining to curiosity in students is cyclical (Loewnstein, 1994), having waxed and waned over the years. More recently, curiosity associated with science learning of students has begun to see a revival. This increased interest in research on children's curiosity has occurred in step with research on science motivation (Osborne, Simon, & Collins, 2003; Zimmerman, 2012). As with motivation in science, curiosity tends to decline the more schooled a child becomes (Goodwin, 2014), although there is no definitive answer as to why this happens.

Current cognitive development research has presented an idea that children are born as "little scientists" (Gopnik, 2004). As such, prior to entering formative schooling, infants and toddlers explore their environments, manipulate objects, and observing the immediate surroundings through trial and error. This exploration can occur with or without the encouragement of adults. However, when encouraged and supported by adults, children tend to take greater risks with unknown objects and places (Engel, 2015). As a child nears three or four years of age and enters prekindergarten, curiosity buttresses up to more formalized education. Due to the stress of propelling all students through a mandatory curriculum, opportunities to pursue curiosity often decline against the push of formal curriculum (Engel, 2011). When curiosity no longer holds a prominent place in the learning environment, academia shifts from a desire to understand the unknown (Engel, 2011) to a pressure to learn the agreed-upon body of knowledge (Uzun, 2014).

With such a steeped history of research in curiosity and the associated benefits of this particular characteristic (Loewnstein, 1994), curiosity becomes a contemporary issue. If classrooms and teachers are unintentionally discouraging curiosity, the potential to stifle it in a child progressing from lower elementary grades (kindergarten to second grade) to upper

elementary grades (third to fifth grade) increases. By devoting energy to understanding the experiences that spark a child's curiosity and incorporating them into the current educational system, education will successfully achieve the missions of the NSF, NSTA, and NRC.

**Positionality**

After 10 years of working as an elementary classroom teacher, I have observed many facets of the current educational system in Texas. Through my participation within the bounds of this system, I have witnessed first-hand the learning and discovery of knowledge of hundreds of students in kindergarten through 5th grades. One observation that has resonated with me is the difference between the captivation and interest of younger children compared to older children with regard to natural science phenomena. The interest and curiosity of lower elementary students (kindergarten, first, and second grades) appears to be more visible and tangible than that of the upper elementary students (third, fourth, and fifth graders) who seem to express dread at the very thought of the subject of science.

However, my own personal upbringing has provided a majority of the impetus for this study. I have been privileged with a family that provided interactions and experiences where curiosity in the natural world and, consequently science, was encouraged. Through formal and informal learning environments, and from a very young age, my earliest memories of knowledge acquisition have included scientific discoveries made by accident or through guidance. Throughout my childhood, teachers, mentors, and my parents encouraged a growing, and at times, insatiable thirst for knowledge, wonder, and experiences. Trips to the library in first and second grade would result in stacks of self-selected, nonfiction books on a particular subject, such as sea otters or constellations, much to the chagrin of my mother who had the pleasure of carting the books from the library to the house.

To this day, the innate drive to satiate my curiosity continues. Early in my career, while still developing my personal teaching philosophy, I realized a burning need to share my ongoing curiosity with my third-grade students in hopes of fostering their own curiosity. In a sense, it has become a personal mission to home in on the topics that spark curiosity in each of my students so that I may continue to nurture their individual curiosities. However, as others have noted (Engel, 2015; Loewnstein, 1994), when my students advance grade levels, I have observed a replacement of intrinsic curiosity and wonderment with a perceived desire to learn only the domain-specific knowledge of science.

**Research Questions**

My positionality led me to the creation of this study in an attempt to determine what a population often neglected in science education research finds worthy of curiosity. In broad terms, this research is an investigation of curiosity in the young learner. By adding to a limited body of research with this subset of students, this study seeks to provide answers to the following research questions:

1. What are young learners curious about that may possibly influence future science learning and education?
2. When a natural phenomenon captivates a young learner's scientific curiosity, what actions follow?
3. What are characteristics of experiences young learners bring with them from outside of their schooling that may influence scientific curiosity?

**Study Significance**

Existing literature on curiosity and interest within elementary science education reveals a dearth of studies on young learners and their personality traits that may indicate

interest or curiosity in science. Within this body of literature exists a large corpus of research on upper elementary students in third to sixth grades (Butler, 1999; Morais, 2014; Na & Song, 2014) as well as on pre-kindergarteners (Gelman & Brenneman, 2004; Gerde, Schachter, & Wasik, 2013; Peterson & French, 2008; Piekny, Grube, & Maehler, 2014). Yet, studies with early elementary students (kindergarten to second grade) remain a relatively unexplored population. Furthermore, as published studies have continued to illustrate a decline in positive attitudes towards science (Milne, 2010; Osborne et al., 2003; Palmer, 2004), research focused on science interest has overshadowed research on curiosity. This study is situated within this intersection of research on curiosity in science education and on the curiosity of children from five to seven-years old.

**Definitions**

For the purpose of this research, the following definitions are used:

**Science.** Any natural phenomena, observable or abstract, that provides a framework to situate learning experiences within is science.

**Young learners.** Early elementary, or young learners, are children within the age ranges typically associated with kindergarten (five years of age) through second grade (seven years of age) within the United States school system.

**Curiosity.** Curiosity is defined here as an independent and intrinsic passion for increased knowledge constructed on an individual level.

**Scientific curiosity.** Scientific curiosity is one of the many facets of curiosity that is a desire for information only related to natural phenomena.

**Interest.** As an internal yet observable association between a person and an activity, interest may be generated from feelings of desire, need, or even capabilities of the person engaged in the experience.

**Experience.** Experiences refer to formal or informal, planned or unplanned, graded or participatory interactions with an environment that allow for meaning-making to occur.

**Learning.** Viewed through a constructivist lens, learning is a cognitive process that involves the creation, evolution, or redefinition of knowledge

**Schooling.** Predominately referring to a building with four walls separating those within from the outside, schooling is associated with a teacher-student dynamic that requires attendance while moving students through obligatory curricula.

**Environment.** Referring to the context or setting, environment may be formal (i.e. a public education classroom), informal (i.e. a museum exhibit), or everyday (i.e. a local park).

**Experimentation.** A systematic investigation where a child manipulates his or her environment to test a hypothesis.

**Discovery.** A haphazard exploration of an environment where a child engages in random or chaotic investigation of a phenomenon.

**Sustained Interest.** Sustained interest is a persistent interest of a phenomenon which lasts for an extended period of time or resurfaces periodically.

**Questioning.** Typically worded with “why” or “how”, questioning is an interaction between the child and a more knowledgeable other in order to satisfy curiosity.

## Chapter II: Review of the Literature

With research focused on what curiosity looks like before five years of age and how to capitalize on curiosity in teenagers, a significant opportunity to understand curiosity in young learners is lost. The purpose of the study is to add to the body of research on scientific curiosity in young learners as they interact in non-school environments. Curiosity has fascinated scholars for millennia. However, curiosity was not systematically studied by scholars until the 1950s by scholars such as D. E. Berlyne (1954) and William James (1890/1950). Consequently, behavioral and educational studies on curiosity increased after the 1950s. While the literature on curiosity is robust, the available literature on scientific curiosity (a desire for information related to natural phenomena) is limited, especially in the younger ages. A thorough examination of the literature on the theoretical framework, young learners, curiosity, experiences, learning, schooling, and education provides lenses to inform this study.

### Theoretical Framework

Since curiosity is a personal and independent endeavor in which a person constructs knowledge on an individual level, situated learning theory (Greeno, Smith, & Moore, 1992; Lave & Wenger, 1991; McLellan, 1996; Orgill, 2007) provides the theoretical framework for this research. Situated learning theory is rooted in the work of John Dewey (1938) and Lev Vygotsky (1987). As with social constructivism (Vygotsky, 1987), situated learning theory consists of a process where meaning is constructed from real, daily activities in conjunction with social relationships. Unlike social constructivism, situated learning theory describes how prior knowledge creates connections with informal or authentic experiences. Lave and Wenger (1991) explain that through the process of participation in a learning activity,

students construct their own knowledge from the combination of prior and current experiences. This knowledge then "emerges from our own actions in relation to others" (Korthagen, 2010, p. 99) to create connections within experiences.

Social interactions and collaborations (McLellan, 1996) are essential to this knowledge acquisition as are authentic contexts (Scott, Asoko, & Leach, 2007). As a person progresses through learning, the learner changes roles from novice to expert on a particular topic he or she is immersed in as a result of cognitive apprenticeship (Collins, 2006). Furthermore, gaining knowledge is most effective if it occurs within a supportive social context (Bell, Maeng, & Binns, 2013). Lave and Wenger (1991) state this idea eloquently: "learning is an integral part of generative social practice in the lived-in world" (p. 35).

As is the nature of experiences, this process of cognitive apprenticeship may result in unintended contextual learning. Consequently, the nature of experiences should be associated with specific contexts (Gee, 1997). These contexts should not be too decontextualized or too contextualized (Korthangen, 2010). An appropriate context would provide enough familiarity to be comfortable to a person but unfamiliar enough to allow for learning to occur.

## Young Learners

Early elementary students, or young learners, are children within the age ranges typically associated with kindergarten through second grade within the United States school system. Children within this range can be five to seven years of age. A large body of research on both upper elementary students and pre-kindergarteners exists, but a lack of studies on children in early elementary grades. However, by relying on research focused on pre-kindergarten children, researchers are able to make some assumptions on the curiosity of young learners.

In pre-kindergarten, children typically are naturally and actively curious about the world immediately around them (Driver, 1985). Children in this age range are filled with numerous questions and tend to gravitate towards novelty in order to reconcile new information with existing information. Absorbing new information like sponges, pre-kindergarten children enjoy the novel experiences (Chouinard, 2007; Gopnik, Meltzoff, & Kuhl, 2000; Schulz & Bonawitz, 2007). The existing interest and curiosity of a pre-kindergarten child deepens as he or she interacts with the surrounding environment through play. This play leads to specific knowledge acquisition which in turn leads to developing curiosity in one or more topics (Leibham, Alexander, Johnson, Neitzel, & Reis-Henrie, 2005). Yet, as these children become indoctrinated into formal education within the confines of school and the science taught therein, these characteristics diminish (Engel, 2009).

## Curiosity

Currently, no agreed-upon operational definition of curiosity (Jirout & Klahr, 2012) exists in the fields of psychology, philosophy, or education. However, Loewenstein's (1994) review of curiosity describes two distinct waves of interest in research on this concept. The first wave, occurring prior to the 1960s, focused mainly on determining the underlying causes of curiosity. The second wave of curiosity research began in the 1970s and was driven by behavioral psychologists attempting to quantify and measure curiosity. Within both waves, curiosity developed into a complex construct.

Yet, prior to researchers' interest in curiosity, early philosophers such as Cicero and Aristotle focused on curiosity. The writings of these philosophers provide a lens for this research's definition of curiosity. Loewenstein (1994) summarizes the focus of Aristotle's view on curiosity as "an intrinsically motivated desire for information" (p. 76) and Cicero's

view as "a passion, with the motivational intensity implied by the term" (p. 76). From this stance, curiosity is an intrinsic passion for increased knowledge.

**Recent Ideas**

Despite the lack of an agreed-upon definition (Engel, 2009), enough researchers have provided common characteristics of curiosity to provide a framework. Curiosity can be thought of as a desire (Kashdan et al., 2009) to know more information about a topic and is elicited by ambiguity, complexity, or novelty (Litman, Collins, & Spielberger, 2005). Breaking this down further, curiosity can be thought to have two dimensions: scientific and common (Jirout & Klahr, 2012). The dimension of scientific, originally coined by James (1890/1950) refers to an intense desire for specific information, but is not domain specific. However, Harty and Beall (1984) defined scientific curiosity as a desire for information only related to the domains of science. On the other hand, common curiosity is concerned with noticing novelty and the feelings that this new or different experience elicits. This dimension of curiosity can be fleeting since it is tied to the novelty of an environment.

Some researchers have delineated other dimensions of curiosity (Berlyne, 1954; Chak, 2007; Litman et al., 2005; Lowenstein, 1994), which include perceptual, epistemic, specific, and diverse. Perceptual curiosity, as proposed by Berlyne (1954), is similar to common curiosity in that it is a visual or auditory exploration of the novel. Epistemic curiosity, also proposed by Berlyne (1954), is an intellectually motivated behavior that seeks to resolve an intellectual uncertainty by acquiring additional knowledge. Epistemic can be likened to scientific curiosity (Jirout & Klahr, 2012), while specific curiosity is a "desire for specific knowledge or information" (Jirout & Klahr, 2012, p. 128). Specific differs from epistemic in that this type seeks to satisfy a need to know a singular fact instead of a body of

information. The fourth type of curiosity is diverse, which is a desire to seek out stimulation due to boredom (Berlyne, 1954). Even though epistemic and scientific curiosity are similar constructs, for the purposes of this study, scientific curiosity was chosen since it is the older of the two terms.

**Curiosity in Young Learners**

Even though there are numerous dimensions of curiosity, epistemic and scientific are the ones most likely to indicate an ongoing interest in science learning. Children are born as little scientists (Gopnik, 2004, 2012; Henrichs & Leseman, 2014) ready to investigate and explore their surroundings to figure out how the world works. In addition, children are naturally curious from birth (Piaget, 1952). By investigating the world around them, young children seek out information to help them resolve cognitive disequilibrium resulting from novel experiences. When encountering information that does not fit within an existing theory of the world, a child will strive to find information that fills in a cognitive gap between the child's theory of the world and the new knowledge acquired (Jirout & Klahr, 2012). Behaviors such as problem-solving indicate that a child is using epistemic curiosity to resolve information gaps. Depending on the intensity of the epistemic curiosity, the process of encountering a new idea, seeking out information to fill the cognitive gap, and then resulting in knowing typically leads to more questions (Gerde et al., 2013; Loewenstein, 1994), and the cycle of curiosity continues. For example, a child observing a line of ants marching across the pavement may be curious about where they are headed. Following the trail of ants may lead the child to a grassy patch where the line of ants seemingly disappears. But what do the ants do if something blocks this procession? This curiosity may lead the child to placing twigs in the middle of the line to observe what happens. Twigs may lead to

leaves or to rocks or another variety of materials to investigate what the ants will do. Through this process of investigation, the child seeks to resolve a cognitive gap.

In preschool, children constantly exhibit a curiosity for the natural world around them (Chak, 2007; Jirout & Klahr, 2012). Through their propensity to explore, four-year-olds are motivated to acquire new knowledge despite conceptual conflicts. Typical behaviors that may indicate curiosity include child-initiated experimentation or exploration and discovery (Chak, 2007). A child repeatedly attempting to sink a toy boat at a sink or float table by systematically changing a variable illustrates a child-initiated experiment. Exploration and discovery differ from child-initiated experimentation because as the child explores the environment, he or she investigates in a haphazard manner unlike the systematic manipulations in experimentation. To an outside observer, these behaviors may take on the appearance of play (Siry, 2013) since these behaviors may be repetitive, random, or even chaotic, but through these activities children begin to develop their scientific processes (Piekny et al., 2014).

In upper elementary, students are still driven by their own curiosity (Agranovich & Assaraf, 2013). When class experiments capitalize on fourth, fifth, and sixth graders' natural inquisitiveness, children view science content as engaging and relevant. Even when the content being taught is perceived as difficult, if the student is curious about the science learning, he or she will show greater persistence in the completion of classwork than uninterested peers (Agranovich & Assaraf, 2013). Often times, however, curiosity is not permitted to drive the curricula so curiosity moves to the periphery.

Relying on studies that have demonstrated science interest through levels of curiosity (Agranovich & Assaraf, 2013; Chak, 2007; Jirout & Klahr, 2012) in students younger and

older than early elementary students, science educators may assume that curiosity still serves as an indicator of interest in natural phenomena and science (Siry, 2013; Yoon & Onchwari, 2006). When students show a greater inclination to learn more about a topic to satisfy their scientific curiosity (Loewenstein, 1994), teachers may know that the student is curious through the observation of the student's interest in the topic.

**Observable Characteristics**

As an intrinsic characteristic, curiosity is difficult to directly observe. However, several observable traits have been linked to identifying curiosity: sustained interest, questioning, and discovery and exploration. These traits may be observed in isolation or in any combination thereof during an instance of curiosity. While there may be more observable traits than these listed, the majority of research indicates that these are the most prevalent.

**Sustained interest**. While some research has posited that curiosity is an indicator of interest (Siry, 2013; Yoon & Onchwari, 2006), others have argued the converse (Luce & His, 2015), or even the lack of the differentiation between the two constructs (Grossnickle, 2016). Almost from the beginning of published research, the use of curiosity and interest as synonyms (Bowler, 2010; Silvia, 2006) has interwoven these two constructs until it is difficult to disentangle them. Unlike curiosity, interest is an observable behavior that persists over time (Krapp, 2002; Silvia, 2006) on a particular content (Hidi, 2006). Similar to curiosity, interest must include knowledge and positive feelings towards the specific content (Hulleman, Durik, Schweigert, & Harackiewicz, 2008). According to Grossnickle (2016), this persistent interest over an extended period of time is what sets interest apart from curiosity. However, since curiosity and interest have been inextricably linked for decades, it is difficult to determine where curiosity stops and interest begins.

**Questioning.** One directly observable way young learners demonstrate an increased curiosity in science is through questioning. Closely tied to curiosity (Chak, 2002), questioning allows young learners to express what grabs their attention in the world around them. Questioning also provides a way for children to seek information (Harris & Koenig, 2006) from more knowledgeable others. Through this behavior, children pursue answers by asking others or adults to help satisfy their scientific curiosity (Chak, 2012). However, this behavior can be quickly squashed in an environment inhospitable to questioning (Engel, 2015). When a hospitable environment is created and fostered, children's questions provide a dual purpose. First, the questions clue others in to the curiosity of the young learner. Second, the questions perpetuate a sustained interest in the topic by capitalizing on the natural curiosity of these budding scientists (Gerde et al., 2013).

As anyone with experience with young children knows, five- to seven-year-olds ask innumerable questions, especially when they are motivated to learn about a topic (Callanan & Jipson, 2001; Engel, 2009; Mantzicopoulous, Patrick, & Samarapungavan, 2008). This sense of wonder found in children's "why" questions is probably one of the easiest indicators of ongoing interest. These questions may be spontaneous, random outbursts such as "why do men go bald but women don't?" while walking to a playground, or these questions may be situated within the context of a conventional conversation. For example, a discussion on arachnids may yield a question on what is the biggest spider and where does it live. However the questions come to pass, they provide a window into the interests of a child for the observer while satisfying the child's natural curiosity. For instance, the questions verbalized by a child about community helpers alert the recipient (e.g. adult) to the curiosity of the young learner. At the same time, the child uses these questions to elicit information about the

topic to help satisfy the curiosity. A child who is constantly drawn to nature outside will use questions directed towards others to help learn about the variety of flora and fauna in the immediate environment during explorations.

**Discovery and exploration**. Other behaviors that typically indicate scientific curiosity are discovery and exploration. Discovery and exploration involve processes in which a child interacts with an environment at his or her own pace (Johnson, Ershler, & Bell, 1980). These may include a degree of adult guidance (Howes, 2008) or may be self-directed (Ramey-Gassert, 1997). Additionally, both discoveries and explorations may be conducted repeatedly (Kim et al., 2012) until the young learner is satisfied with the experience (Chak, 2012). Both observable behaviors provide experiences that foster curiosity leading to greater, sustained interest (Ramey-Gassert, 1997).

Discovery, sometimes mistaken for play especially in informal contexts (Ramey-Gassert, 1997), provides a way for a child to demonstrate many of the characteristics of science. Through forming and testing hypotheses, young learners will try novel theories of the world and incorporate those into his or her schemas. Conducting repeated trials helps a child involved in exploration interact with natural phenomena and make sense of the experience. Furthermore, through these discovery-based activities, a child will use the information gathered to either accept or reject scientific ideas and assumptions of the world (Ramey-Gassert, 1997).

While more observable in children closer to five than seven, young learners engage in repeated explorations to answer questions, satisfy curiosity, and acquire new knowledge. Howes (2008) describes a year-long, student-directed exploration where kindergarteners engaged in daily interactions and observations with an ant farm. Through their independent

observations, the class explored a wide range of scientific concepts from insects to habitats to needs of living things. One table group became interested in how ants built their tunnels. By systematically destroying one of the tunnels, the children, through their own explorations, learned that the ants would rebuild a tunnel for use. In another study involving a kindergartener and a sink or float tank, Siry (2013) described an instance of repeated trials where a young boy spent most of the morning placing a toy boat under the water being poured by other students to observe it sink to the bottom and then spring back up to the surface of the water. Both of these examples illustrate explorations that allowed the students opportunities to notice patterns in the natural world and draw generalizations from those patterns.

Repeated explorations, especially when they are student-directed, demonstrate interest in science since they require the persistence and engagement of the young learner (Rinke, Gimbel, & Haskell, 2013). Discovery-based learning and student-directed explorations provide ways for children to interact with phenomena (Worth & Grollman, 2003) and are directly observable behaviors of scientific curiosity. These two behaviors encourage children to investigate and answer their own wondering questions (Siry, 2013).

## Experiences

Experiences can trigger curiosity and also be viewed as the anchor to learning and consequently education. These experiences are essential since they provide the foundation to interaction with the world and self while providing meaning (Schubert, 2010). A person's experiences are invaluable and necessary (Rich, 1977), but it is the responsibility of the learner to put the experiences to use.

Experiences may be mis-educative or educative according to Dewey (1938). Mis-educative experiences are ones that stop, prevent, or distort future experiences from providing learning. These disconnected experiences tend to form part of the curricula that constitutes schooling. To be educative, experiences must continually expand on the learning a person has received. Through this continuity, meaning is constructed as old experiences are linked with subsequent ones (Dewey, 1938).

Learning is best accomplished through first-hand interactions with phenomena (Dewey, 1899/1964). Through this contact with reality, learning becomes contextualized. However, the responsibility of the instructor, mentor, teacher, or guide is to discover what experiences are of interest to the young or inexperienced (Dewey, 1897/2010b) while still aware of the child's scientific curiosity. As a learner becomes more adept at putting experiences to work for him/herself, a mentor (teacher, guide, or instructor) may encourage the learner to pursue what is meaningful and holds attention.

Experience, combined with reflection, is the "sine qua non for knowing something" (Uzun, 2014, p. 619). It does not matter if the experiences are internal with no visible characteristics, such as those stemming from emotionally charged encounters (feelings of failure, success, nervousness, etc.) or external which may be observed by others, such as a daily interaction with a friend. Through these shared experiences, we are able to discover our history (Illich, 1970): who we are, where we have come from, and what we have become (Schubert, 2010). Therefore, curricula need to incorporate experiences as part of the fabric of any learning situation to be meaningful for students. The experiences should provide rich opportunities for the potential of curiosity and learning.

## Learning

As an abstract concept, learning has the advantage of a long lineage that spans the globe. From Confucius onwards to Plato and Socrates, learning has played a dominant role in societies. However, learning has different definitions to various groups of people in an assortment of contexts or hemispheres, making it impossible to tease out one universal definition of learning (Wagner, 2015).

Learning, in westernized countries, may be interpreted through a behavioral lens with conditioning to achieve desired outcomes. Learning, through a constructivist lens, is a cognitive process that involves the creation, evolution, or redefinition of knowledge (Jacob, 2012; Wagner, 2015). Bound within the confines of schooling, learning can be disconnected and limited (Resnick, 1987). When allowed to be personal and spontaneous, learning is a result of human interactions within environments and other selected contexts sparked by instances of curioisty (Gîmbuţă, 2011).

Context, as an important component for learning, is always situational (Bruner, 2014). The richness of an environment and the quality of the interactions within determine the amount of incidental learning (Illich, 1970). With better quality and richness, context increases the opportunities for educative experiences (Dewey, 1938).

Learning is a moving target and is at the mercy of outside forces that influence the context. Political, social, economic, and technological forces can all shift learning one way or another (Wagner, 2015). Despite this moving target, learning is central to what we do every day to become productive human beings both at work and personally (Wagner, 2015). Learning is an innate ability that provides access to remember that which is already within us (Uzun, 2014). As such, the majority of learning does not require teaching (Illich, 1970).

However, all too often, outside forces often perpetuate the myth that learning on one's own is foolish and learning is only a result of direct instruction (Illich, 1970).

When viewed as an unforeseen possibility, learning becomes a gift (Diego, 2015). Knowledge is ever-changing and no longer consists of a solid body of information to master. There is no way one person can learn all the available knowledge in the world (Dewey, 1899/1964). Therefore, viewing learning as a competition in which the goal is to store and accumulate as much as possible is an obsolete notion. Learning is a product of participation within a complex world (Dewey, 1937/2010c). Like the fluid nature of knowledge, learning must shift and change to reflect the complexity of its environment. The ultimate purpose of learning is "to permit the intrinsic wonder and value which attach to all realities" (Dewey, 1904/2010a, p. 199) and instill these experiences within the learner resulting in a desire for life-long learning. Therefore, a working definition for learning is a cognitive process that involves the creation, evolution, or redefinition of knowledge.

## Schooling

Surprisingly a term with a negative connotation, *schooling* predominantly refers to what happens in a building with four walls separating those within from the outside (Cunningham, 2012). While there is no physical blueprint for such a place where schooling is constructed or conducted, it is a place associated with formality and organization (Wagner, 2015). Typically, schooling is associated with an "age-specific, teacher-related process requiring full-time attendance" (Illich, 1970, p. 26) so that pupils may move through an obligatory curriculum. The purpose of such an institution is primarily to impart information regarding a certain point of view (Carson & Wilson, 1984) in order to skill a people, typically youth, to enter the workforce (Cunningham, 2012; Diego, 2015; Resnick, 1987).

According to Cunningham (2012), schooling existed to promote religion. The purpose of schooling then shifted to help form social class identity and mobility. Fluctuating once more, the purpose became to further set apart the educated elite from the uneducated. Changing again, schooling became a way to save poor people from their social conditions. Finally, schooling became what it has been for several decades: a place to prepare the work force for integration into the economic world (van de Werfhorst, 2014). In this system, schooling went from being conducted predominantly in the home or as an apprenticeship to small neighborhood-oriented approaches to economically based systems (Tyack, 1974).

Schooling, as an economically based system, operates on a cyclical model of circulation. Within this model, people are educated through schooling. In this formal, hierarchical system, future citizens progress through specific curricula to work towards a certificate (Cunningham, 2012; Diego, 2015; Illich, 1970). Once a certificate of graduation or completion is bestowed, pupils become citizens with the knowledge necessary to function within the economic system (Diego, 2015). Fueling the economy, citizens raise their own families to send through the circulation model of schooling, thereby perpetuating this system.

Another way to view this system of schooling is as a cause-and-effect model. This model requires effective teaching, meaning that each teaching moment is bound and corresponds to the imposed standards that ultimately feed into an economic model (Diego, 2015). No matter which model, either cause and effect or circulation, schooling is designed to limit the limitless. Both models are hard to break in our current environment since schooling is dependent on funding to function (Illich, 1970).

Schooling consists of decontextualized, compulsory education (Rogers, 2004) guided by performance standards and sets of rules (Cunningham, 2012; Gîmbuţă, 2011). These

institutions can come in a wide variety, including free, community, and military schools (Carson & Wilson, 1984) and serve as a place of socially imposed, rigid, compulsory instruction (Diego, 2015). Schooling imposes the wills of those in positions of power on the pupils (Cunningham, 2012). By dictating when a pupil can eat and what can be eaten, what type of speech is appropriate or inappropriate, what physical movement is allowable, and even when to talk and when to be silent, this teacher-led environment conditions people that all learning must come from institutions (Illich, 1970). This conditioning destroys one's desire to grow independently, possibly resulting in people who close themselves off to outside learning and pursuing curiosity since this type is not a part of institutional schooling. By pushing the continued use of this institutional system, the natural inclination to grow and learn is prevented and often leads to mis-educative education (Dewey, 1938).

It is important to note that schooling is different from school in several ways. Schooling is a collective experience where pupils are guided through prescribed activities considered proper to produce expected results (Carson & Wilson, 1984); schools are a time and place in which people come together to share in an exchange of teaching and learning (Diego, 2015). Anyone can choose to learn or take the role of teaching. These places can be anywhere and may actually be likened to Illich's (1970) learning webs.

Schools are just one of many forms of education (Schubert, 2010). Unlike schooling, school does not require effective teaching driven by standards but through impossible, unforeseen, teaching moments (Diego, 2015). Schools may happen anywhere within the community including informal and non-school environments and are therefore a genuine extension of community life (Dewey, 1899/1964). These places of knowledge exchange are not set apart from daily life, but are incorporated since society comes together to work for

common goals. Through this system, the "joy of knowing something to one's satisfaction" (Illich, 1970, p. 42) is possible to obtain because this form of education is not dependent on an economic model. Schooling does not equate to education, but schools can promote education when allowed to flourish and prosper.

## Education

Unlike experience, learning, or schooling, education is much more difficult to define. Additionally, this concept also carries both negative and positive associations depending on the context. Going back to Dewey (1899/1964), education depends on experiences leading to more education through subsequent experiences. Further defined, education is the process of knowledge acquisition for problem solving (Dewey, 1938), while Uzun (2014) added that "all education is an event" (p. 377). These events develop awareness and enlarge, deepen, and extend knowledge of phenomena in the natural world, as well as interpersonal understandings (Peters, 1979).

Education is indelibly linked with learning; yet, education has to be intentional, deliberate, and result-oriented. Therefore, education is also linked with schooling. When tied with schooling, education is viewed as the result of instruction (Illich, 1970). When coupled with schooling instruction that is presented through a narrow and one-sided lens (Dewey, 1899/1964; van de Werfhorst, 2014), education tends to impose standardized curricula along with a message of universal morality (Uzun, 2014); thus, education is viewed negatively and also limits curiosity.

Woodson (2016) acknowledges this view of education, but cries out against it with a message concerning education: "Real education means to inspire people to live more abundantly, to learn to begin with life as they find it and make it better" (Woodson, 2016, p.

24). Imparting information onto others is not enough and is not education. Merely memorizing information to gather up knowledge is not enough. This is not education since there is little meaning, naught to connect with, and results in slight improvement. Education needs to include purposeful activity. Studying nature, art, history, and science (Dewey, 1899/1964) provide avenues for greater participation in communities and lead to diverse ways of thinking and doing (Uzun, 2014).

Education is not an "act of depositing certain information into empty receptacles" (Uzun, 2014, p. 618), but rather education needs to be claimed as rightfully belonging to each individual (Rich, 1977). When viewed as a right to be worked for and not freely given, education provides opportunities for the development of human potential and curiosity. By combining continuous, self-directed learning with character building, while honoring trainings necessary to the realities of daily life (Dewey, 1899/1964), education can return to what it once was: complex, life-long, and unplanned (Illich, 1970).

For education to be accessible for all, everyone must participate in the process of teaching and learning. This will only be achieved by separating learning from governmental control or by deschooling (Illich, 1970). People learn most of what they know without the direction of a teacher. People learn to love, play, and speak without government intervention and social control. In addition, education differs from one individual to another (Woodson, 2016). Recognizing that one size does not fit each and every person and that learning is possible in every moment and every situation is one step closer to fostering curiosity.

## Conclusion

As young learners continue to interact in informal environments, curiosity develops. While curiosity consists of several different types, scientific curiosity focuses on a driving

desire for specific information related to science. Naturally curious from birth, young learners exhibit scientific curiosity through the observable characteristics of sustained interest, questioning, and discovery and exploration. Through interactive experiences, young children participate in situated learning that may foster scientific curiosity. Since schooling in the Western world tends to focus on prescribed curricula with little room for deviation, scientific curiosity may be better observed away from a four-walled building but in informal or non-school contexts where education deepens a child's knowledge of a phenomenon. With all of these caveats to curiosity, what are young learners curious about, what do these children do to pursue curiosity, and what experiences may influence scientific curiosity?

# Chapter III: Research Design

## Methodology

Since the focus of this study was a specific and unique system (Stake, 2000), one that was concerned with the scientific curiosity in young children, a multiple case study methodology was used. A multiple case study is a qualitative research methodology that encourages the use of multiple lenses to explore and observe specific phenomena. By using an "empirical inquiry that investigates a contemporary phenomenon within its real-life context" (Yin, 2008, p. 18), a descriptive case study approach enabled the researcher to collect very detailed observations. These robust observations allowed for the exploration of how and why questions (Yin, 1989).

A multiple case study exists within a bounded system of time, place, or individuals (Smith, 1978). For multiple case studies, setting applicable bounds is important. The researcher bounded this study within a specific time frame (a series of no more than ten interactions within eight months) with a limited number of participants (three children and six adults) but not by place since that was out of the researcher's control. Each participant and his or her parents (cases) provided the researcher with various lenses to explore the presence or absence of scientific phenomena.

A multiple case study methodology also enabled the researcher to incorporate varied data sources (Stake, 2000; Yin, 1989). The descriptive data collected through opened-ended research methods (Lincoln & Guba, 1985) were not aimed at making generalizations beyond the cases. Instead, this descriptive case study focused on the information-rich cases in order to understand the complexity (Creswell, 2007; Yin, 2008).

## Methods

This study observed instances of scientific curiosity in three participants over the course of six to ten interactions. Due to the nature of this research, there was a variety of contexts and settings which comprised the interactions. The section describes how participants were recruited, descriptions of each case, data collection procedures, and data analysis.

### Research Context

No one context existed in this study. Rather, the families interacted within contexts that were interactive and engaging to the young children. These interactions were situated in places that were reflective of the types each family visited. The intent of this decision was to limit the novelty in a context so that the focus of the study did not shift from investigating scientific curiosity to investigating children in new contexts. However, the researcher recognized that a potential for novel contexts might have occurred during this study since the majority of data collection occurred during summer months and these contexts might support, foster, or hinder scientific curiosity. Furthermore, the interactions within these various environments, typical or novel, helped elicit curiosity, since curiosity occurs any place where a child's interest is captivated to a point where a thirst for knowledge emerges. While each family had some similar contextual characteristics, the details of each context varied with each family of participants.

**Setting.** The settings for data collection occurred in multiple places of familiarity for each family. These types of settings included family living rooms, backyards, trips in the car, and various places: parks, grocery stores, museums, and zoos. Because the design of this

study relied on familiarity over novelty, observations were conducted in places and situations normally part of a typical family interaction.

**Recruitment.** Participants were recruited using purposive sampling through a combination of selection criteria and connections until fulfillment was attained. The selection criteria required no more than two children in each age group from five to seven years old for a total of up to six participants and the parents/parents for each selected child participant. Connections included word-of-mouth, e-mails, texts, and social media. This recruitment process lasted several months. Potential participants' initial interest in the study waned after the researcher informed the potential participants of the requirements of the study and especially the need for an adult present at all times. Through personal connections and acquaintances, eventually the Lovegood, Clark, and Smith families (pseudonyms used for all people mentioned) agreed to participate in the study. These three families enabled the researcher to study one five-year old, one six-year old, and one seven-year old.

**Gaining trust.** Since the children were younger than seven years old, two populations of participants were used: young children and the parents. The primary participants, and the main focus of the study, were the young children. The secondary pool of participants were the parents of each of the young children. Therefore, the study consisted of three young children and at least one corresponding parent for each young child.

A rapport and trust needed to be established with both sets of participants prior to any data collection. Since parents were the gatekeepers to the primary participants, the young children, and also the ones responsible for communicating with the researcher about potential interactions where scientific curiosity may be observed, trust with them was crucial. Without trust between these gatekeepers, the researcher would not have had access to the primary

participants. Trust was also vital to the researcher-primary participant relationship. Young children may either be very open or very guarded upon initial meetings. If the later occurs, one of the only ways to establish a working relationship with a young child is by laying the groundwork for trust. To foster this relationship, several face-to-face informal, conversational meetings were conducted after selection of participants for the study within the living rooms. The amount of initial, face-to-face interactions differed with each child, but since the participants were recruited through personal connections, no more than two initial meetings were needed to lay the foundation for a relationship. The focus of each interaction was to build trust and communication between the researcher, the child, and adult participants. In addition, families had varying time commitments and constraints that made scheduling difficult. Every effort was taken to work with each family to find a balance between the time needed for the researcher and the time constraints of the family.

**Procedure**

Once participants were recruited, parents were provided a packet to review the study. The packet contained a cover letter (Appendix B) briefly describing the purpose of the study, a parent permission form (Appendix C) pertaining to the child's participation, a parent consent form (Appendix D) pertaining to the parent's participation in the study, and a media release form (Appendix E) for photographs and audio files. The researcher was also available to personally answer any questions and address concerns the participants had.

After all consenting documents were signed, introductory sessions were conducted with the purpose of developing rapport between both the parents and the children. During these introductory interactions, data were collected through memos and observations that were later transcribed. These sessions were conducted in the home (a place of comfort and

familiarity). While the activities in which the researcher and child engaged were unique to each child participant, they included completing a Legos set, playing with toys, and drawing. The intent and importance of these introductory sessions were to begin to create space for the child and parent to develop trust with the researcher.

**Participants**

In total, three children participants completed the study with their parents (pseudonyms used for all people mentioned). One male, Ezekiel, was five at the time of the study. Avery, aged six, and Michelle, aged seven, were the two females in the study.

**Lovegood family.** At the beginning of the study, Ezekiel had just turned five years-old. His mother was a member of a book club with the researcher six years prior. While the researcher had met Ezekiel after birth, his family had moved away and the friendship between the researcher and his mother dissipated so Ezekiel never knew the researcher. During the recruitment process, the researcher elicited potential participants through a post on Facebook to which his mother responded.

With curly brown hair and dark brown eyes set amongst fair skin, Ezekiel was a stylish five-year old who proudly wore his shoes on the wrong feet and a black, leather jacket. He loved constructing and deconstructing Legos by following the "constructions." He would observe something, typically from a movie or video on the internet, and reconstruct what caught his eye using a hodge-podge of toys and other house-hold items. Quiet at first, Ezekiel quickly warmed up and would easily dominate the conversation until he became tired from concentrating on the latest Lego construction. At that point, he would slip back into the quiet and introspective child. As the summer progressed, Ezekiel settled into familiarity with

the researcher and would expect that the first and last moments of the day were spent in the playroom surrounded by his latest creations.

The youngest of three, Ezekiel was from a self-described "nerdy family" where everyone's individualities were celebrated. While his older two sisters were homeschooled, Ezekiel had yet to formally begin schooling. Instead, his parents fostered his social skills with others through play dates with children his mother would supervise during the day.

Ezekiel's mother grew up in the world of drama and the arts so she encouraged excursions to plays and other such outings. While she never completed a degree, she joked that she completed a degree in life. In addition to homeschooling her children and being the care-giver of others, Ezekiel's mother, Tori, was a certified yoga instructor and a talk show host on a local Christian station. His sisters Sara and Beth, both in their teens, were very involved in dance, music, and church. However, they would both smother their brother with love frequently. Ezekiel's father was technology-minded with a Bachelors' in computer science and engineering. He was employed fulltime in the industry during the duration of data collection. At one point during the study, Ezekiel's mother stated that Ezekiel had the best of both parents: creativity from his mother and an engineering-mind from his father.

**Clark family.** Avery's mother and the researcher had been friends for twenty years and the researcher had known Avery since she was hours old. During the recruitment time frame when a call for participants went out via word of mouth, text, email, and social media, the Clark family was the first to volunteer to participate. Three years prior to the study, the Clark family lived within two miles of the researcher and it was not uncommon that many nights during the week were spent together at the Clark's home. However, the Clark family moved an hour and half away. Therefore, visits between the family and the researcher

became once a month at best but often would occur once every two months. The prior relationship with the Clark family meant that even though the researcher did not need initial interactions before the commencement of the study to build trust, she did need one initial visit to socialize and play with the children.

Blonde-haired with blue eyes, Avery was a tall, lanky six-year-old female. Typically shy when meeting adult strangers and the oldest of two children, Avery loved to play inside with her younger brother and her toys. Although she enjoyed the idea of being outside in nature, when she encountered any form of creepy-crawly or winged-critter, she would escape indoors if possible. For as long as her mother could remember, Avery was especially terrified of bees for some unknown reason. In addition, Avery was a very observant child and would adopt the worries, fears, or hesitations of others when it came to animals of the non-furred variety. Enrolled in private school from age of three until six, Avery was eager to do most any activity, lesson, or experience where she could learn. This included reading books from her tablet to visiting museums in the area. While not a fan of any of the sports she had tried, Avery did enjoy being a Girl Scout in a local troop in her neighborhood throughout the school year.

In a family of four, Avery was the oldest child with a brother three years younger than her. David, the younger brother, loved to be in the room where everything happened unless situations were not going his way or he was emotional. When exhaustion or hunger overtook him, sibling activities would switch from what Avery wanted to do to what her brother desired in order to placate him. Her father, a self-taught computer programmer, worked in town for a technology start-up writing code and designing applications. He was always eager to answer any of his children's queries from "why do we have to do that?" to

"how many moons are there?" Never one to simplify explanations, he would answer as factually and detailed as he deemed appropriate for the age levels. Avery's mother held an associate's degree in paralegal studies and worked from home for an internet-based company so that she could raise her children instead of placing them in daycare. Patient and yet firm, Avery's mother encouraged independence and exploration unless the proposed idea would create a large mess. Providing her children with a mixture of activities to do away and at home, Mrs. Clark ensured that her children remained active throughout the summer.

**Smith family.** The Smiths' have been friends with the researcher since the days of undergraduate studies. However, since they lived on the opposite side of the Metroplex and especially since traffic had increased significantly in the area, up until the beginning of the study, both parties would see each other once a year at most. While the researcher knew Michelle since birth, she had not seen or interacted with Michelle since she was two. Therefore, there was one day devoted to an initial interaction but Michelle's outgoing personality quickly accepted the researcher as a trustworthy person.

A spunky, blonde haired seven-year-old with chopped bangs, Michelle was very creative and preferred to pursue artistic activities such as drawing and coloring. The oldest of three with a fourth on the way, Michelle preferred to be engaged in joviality. Telling jokes, sharing funny stories, or singing to songs made-up on the spot were all activities frequently occurring throughout all the interactions. With her scraggly smile, front tooth missing, Michelle would fabricate intricate worlds in the backseat of the van or in the backyard. When Michelle made a connection to a lesson or fact learned in school with what she was doing during an interaction, she enjoyed sharing nuggets of knowledge she had learned from the teachers at her classical charter school.

Michelle's mother was a Christian musician and an assistant worship leader at her church with a bachelor of arts and a Certificate from the Berklee College of Music in Songwriting. Already a mother of three, she found she was expecting a fourth during the study to which Michelle was excited. Michelle's father obtained a law degree from Harvard University and worked as a general counsel for an investment company. When he was home on the weekends or came home from work, he would inquire as to what Michelle had been up to for the day. In addition to her mother and father, Michelle had two brothers. Austin was four years old and Cole was one year old. The brother nearest in her age always wanted to be included in what Michelle was doing and she was almost always obliging. With the oppressive summer heat and the nap time schedule of the youngest, most of the interactions occurred in or around the home.

**Data Collection**

Once all parties in the study felt comfortable with the developing relationship, an initial semi-structured interview with the child participant commenced. This interview did not exceed 30 minutes and followed the initial interview protocol (Appendix F). During this semi-structured interview, the researcher asked the child participant to talk about what he or she was curious about, describe the home environment, and ask about what the child preferred to do in a variety of settings. These interviews were digitally recorded and transcribed at a later time.

A one-hour, semi-structured interview with the parent participant was conducted between one and three days after the child interview. This semi-structured interview asked for information on the home environment, activities that the family participated in, places the family typically went, and asked the parent to provide example of times when the child

exhibited curiosity. In addition to the question stems provided in the initial interview protocol (Appendix F), questions developed from the responses of the child were also included. Since those questions could not be created until after the interview with the child, interviews with the parents could not occur immediately following the conclusion of the child interview.

After the conclusion of the initial parent interview, the researcher and parent worked together to create an open line of communication to allow for invitations for the researcher to accompany the family during interactions to various places as well as participate in some daily family activities. For all three families, texting was the preferred method of communication. Typically, the adult participant shared any planned interactions for the family to schedule these with the researcher at this time. To create the most complete picture of scientific curiosity in young learners, the duration of the observation matched the duration of the excursion to provide opportunities for descriptive data collection (Creswell, 2007). For example, the observation of a trip to the petting zoo lasted for the entire stay at the zoo. This meant that the shortest interaction for any of the participants was 32 minutes and the longest was five hours. As a result, the researcher blocked out the entire day on her calendar so that any interaction was not cut short due to other personal commitments.

During these interactions, field notes, observations, photographs taken by both the researcher and the child, and other artifacts such as drawings were collected as multiple data sources (Yin, 2008). Photographs taken by the researcher and adult participants focused on instances of the child demonstrating scientific curiosity while photographs taken by the child focused on what the child found interesting during an excursion or interaction. With approval, conversations that occurred between the researcher and the child were digitally recorded and transcribed at a later time.

Data were collected from multiple sources. In addition to the child and parent interviews, data came from the researcher's field notes, photographs, and transcriptions of recorded conversations collected during excursions to various places. Parents contributed to the data collected by sharing instances of observed scientific curiosity during excursions through conversations with the researcher as well as photographs they took. The children participated in data collection by taking photographs and conversing informally with both the researcher and the other family members. Forms of data collection varied for each participant since family excursions and durations differed.

**Interview.** Each child and parent in the study was interviewed at least one time (Appendix F). All three child semi-structured interviews had the same initial structure and the same purpose. The purpose of the interview was to investigate, in the child's own words, what types of phenomena he or she found interesting. Questions were used to explore what captured the child's interest, sustained it, and caused him or her to ask more questions about it. These interviews did not last longer than 30 minutes.

The parent interview was not administered until after the child interview was conducted. The decision to conduct the child interview first prevented parent responses from influencing the interview of the child. However, the semi-structured interview paralleled the child's interview, except for the addition of questions that focused on parenting. The parent interview did not exceed two hours in duration. As the interview progressed, responses from the child's interview informed follow-up questions.

**Field notes.** The field notes collected in the data collection varied depending on the type of interaction selected. In situations where it made sense, a notebook was used to take notes as the instances of curiosity happened. These focused on the inferences made in part by

the researcher. Not all interactions were conducive to note taking. In these situations, an audio recorder was utilized with transcriptions made after the fact. However, in some instances, neither note-taking nor audio-recording sufficed. In these instances, the researcher used either an audio-recorder or notebook to quickly recapture the interaction after it concluded.

**Observation memos**. By using information compiled from both child and parent initial semi-structured interviews, the researcher was observant to trends and persistent questions during interactions. It was the intention of the researcher to remain more of an observer than a participant. Yet, there were times when the participants elicited the researcher into more of a participant role. When this occurred, the researcher included observations on the interactions of all parties involved.

Due to the nature of interactions, observation memos were gathered through the use of notes when possible and the use of an audio recorder when not. Unlike field notes, these memos used factual information gathered through the senses. Similar to field notes, the observations were collected when possible during the interactions. Occasionally, the observations were written at the conclusion of the interaction due to the nature of the activity. Since young children are active and engaged in their environments, audio recorders and photographs taken by the researcher were used to capture instances of scientific curiosity as well.

In order to determine what defines scientific curiosity during observations, the researcher looked for observable characteristics of curiosity including sustained interest, discovery and exploration, and questioning as determined through the literature. These behaviors indicated potentially developing or persistent curiosity. In order to focus on

scientific curiosity, these outward behaviors were limited to natural phenomena in relation to general science as it is found in schooling.

**Artifacts**. A variety of artifacts were collected in order to add to the multiple data sources for each participant. As with both the field notes and observations, these artifacts varied depending on each participant. Artifacts included drawings and books. These data were collected as they arose and were not collected for each excursion, interaction, or child.

**Coding and Analysis**

In order to protect the confidentiality of all participants during and after the study, participants' names and all other family members (including family surnames) were given a pseudonym on all data: transcripts, field notes, memos, and photograph captions. Since this study relied on a variety of data sources, including visual, media releases were required in addition to human subject approval by the Institutional Review Board for participation in the study. Any participant, adult or child, had the option to withdraw from the study at any time with verbal request made via email, phone, written, or in person. For the purposes of confidentiality in visual data, photographs containing the faces of both the adult participants and young children participants remained visible but the faces of passersby were cropped out or covered within the photographs.

**Inter-coder agreement.** Both the written and visual data were analyzed for each child participant initially. The data were then analyzed as a whole, written data set and visual data set across all participants to see if any overarching categories or themes emerged. As categories and themes emerged, a process of peer-reviewing helped increase the trustworthiness of data analysis. Through this process, peer-reviewers received sets of data as well as the list of codes. These colleagues coded at least 10% of the data for each participant

until the interrater reliability reached 80%. Then the author coded the rest of the data independently. This process increased the interrater reliability.

**Coding.** Since this research used multiple-sources of data, written and visual, they were analyzed qualitatively to look for general categories and themes. The cases in this study had unique data sets for each child/parent dyad. Therefore, the analyses of these data sets concentrated on descriptive data not aimed at making generalizations, but focused on the information-rich complexities present in each case.

***Written data.*** For the data collection, written data consisted of interview transcripts, observation memos, conversation transcriptions, and field notes. Prior to any analysis, interview transcripts, observations notes, conversation transcriptions, and field notes were formatted to include line numbers. Once each document was prepared in a similar manner, conceptual categories were coded for as they arose *a priori* (Miles, Huberman, & Saldana, 2014). These conceptual categories were created by identifying similar words and phrases (in the case of interviews, field notes, or textual artifacts) or events within the data. The conceptual categories were categorized into larger themes that described the phenomenon emerging.

***Visual data.*** The visual data in the data collection included photographs taken by either the participants or the researcher and a few drawings created by the children. As with the rest of this study, each case had a degree of variance in the visual data collected since visual images depicted what a person was aware of or noticed as part of the everyday world (Ball & Smith, 1992). This type of data were crucial to the study because the world is a "seen world, available to most of its participants via the medium of vision…and plays an indispensable role in the conduct of our daily lives" (Ball & Smith, 1992, p. 1) while

capturing an instant. Visual data produced by the child, photographs or drawings, enabled outsiders (in this case the researcher) to explore the ideas of very young children who may not have obtained the complex vernacular needed to concisely describe his or her thoughts (Cherney, Seiwert, Dickey, & Flichtbeil, 2006).

Visual data (i.e. photographs, drawings) were analyzed similarly to that of textual data, where the images were first examined for what was included to see what conceptual categories arose (Harper, 2000). The photographs and drawings created by the child participants provided insight on how he or she interpreted curiosity (Frith, Riley, Archer, & Gleeson, 2005) as conceptual categories emerged. The visual data were analyzed for each child in isolation to see what conceptual categories emerged and not used to make generalizations across all participants. As with the textual data, conceptual categories were combined into larger themes as the study progressed and more visual data were collected. These themes provided a visual description of scientific curiosity.

**Member-checking.** To add to the strength of the data analysis, the children helped with member-checking by participating in conversations about the collected visual data. This added layer of analysis provided the researcher with additional insight into what the young children were curious about. Descriptions of the child participants were also read to the child who was then encouraged to provide comments and suggestions. During this time, the children provided a pseudonym first name and family surname.

Adults also participated in member-checking when they had conversations with the researcher about the photographs provided from the parent perspective. As with the conversations with the children, this process enabled the researcher to have conversations concerning instances where the parent perceived scientific curiosity was occurring. The

adults were provided the family descriptions and transcriptions of interviews and interactions as they were written. The parents offered comments and suggestions to these written documents to continue to support trust between the researcher and families. By using this process, parents were assured that their family and child were presented in accurate but favorable ways.

# Chapter IV: Results

This chapter presents the research on scientific curiosity in a five-year-old, six-year-old, and seven-year-old through the lens of a multiple case study. Furthermore, this study sought to answer three research questions: (1) what are young learners curious about that may possibly influence future science learning and education, (2) when a natural phenomenon captivates a young learner's scientific curiosity, what actions follow, and (3) what are characteristics of experiences young learners bring with them from outside of their schooling that may influence scientific curiosity. The organization of this chapter is divided into two sections: within group and across group themes. Coding for themes was conducted individually for each case and then the entire data set (all three cases) were reanalyzed to identify universal themes. In addition to a parent interview and the initial interview for the participant, 36 interactions (10 for Michelle Smith, 10 for Avery Clark, and six for Ezekiel Lovegood) were coded for emerging themes.

## Within group

Since this was a multiple case study, the primary analysis occurred at the individual case level prior to any analysis across cases. Therefore, the first results presented in this chapter will focus on the individual cases.

### Case 1: Lovegood family

While not the first family to begin or complete data collection, this family included the youngest participant: Ezekiel. Located in a city in the northeastern part of the Metroplex, Ezekiel and his family lived in a two-story brick home with five bedrooms, a giant playroom upstairs, and a large living room with a breakfast bar separating it from the kitchen downstairs. Most of the interactions either began or ended in the playroom surrounded by

Legos in various stages of construction and homeschooling educational materials. The playroom was a large carpeted space divided in half with an old, leather sectional couch. Pillows appeared to be strewn about in the space between the front of the sectional and the television, but were actually a fort that needed defending according to Ezekiel. Behind the couch was a little yellow table no larger than three feet by three feet. This table was often where Ezekiel could be found upon the researcher's arrival. However, if he was not busy there, he would be laying on his stomach on the carpet in front of the table arranging various, unrelated toys into a recreation of a stage or machine in a movie.

While most interactions began upstairs in the playroom, the first interaction (the solar eclipse) began downstairs at the kitchen table. Dark wood, with barstool height, high backed chairs, the kitchen table sat in an alcove next to the back door. For the two older sisters, this is where school happened on a daily basis. On the day of the total solar eclipse of 2017, this kitchen table transformed into a flurry of activity as all three children rushed to complete their individual solar viewers so they would not miss the event. Curtains drawn tight to keep out the oppressive August summer sun, the pendulum light above the table illuminated the workspace. Next to the kitchen table the off-white backdoor, scuffed down at the floorplate from years of use, led out to the backyard. The backyard, with a welcoming patio near the back door, was small and surrounded with faded wooden fence paneling. A gas grill sat up against the garage and was flanked by an outdoor loveseat with two chairs and a table. Wilted from the summer sun, plants sat on one side of the loveseat. In the far corner opposite the back patio was a wooden playset with a yellow slide and Ezekiel would take off towards the playset whenever he set foot in the backyard. A gate leading to the family van sat on the left side looking out towards the playset.

In contrast, the majority of the six interactions required driving some place. The family van sat eight when the back seat was raised. Though most of the time, this seat was stowed. Ezekiel's car seat was placed in the center seat on the middle row under the drop-down DVD player. Old enough to buckle himself in, Ezekiel had a ritual upon entering the van. Once he stepped on the foot well, Ezekiel would press the button to close the sliding door and slide into his car seat. He would reach for his headphones prior to fastening his buckles. After his mother asked him if they were snug and tight, Ezekiel would politely ask to watch his movie. During the remainder of most car rides, he would be absorbed in the world of his favorite animated movie. On occasion when one of his sisters was in the car sitting next to him, Ezekiel would share his movie by allowing her to rest her head on his car seat next to the headphones.

The third interaction with the Lovegood family occurred at Hawaiian Falls, a family water park located ten minutes from their house. Every summer the family would buy season passes and try to go about once a week to help break up the dog days of summer. A wave pool was situated in the middle of the park with a splash pad for younger ones near the entrance to the wave pool. Six large water slides surrounded the wave pool shooting squealing children and gleeful teenagers down into long shallow pools of water. A lazy river, Ezekiel's favorite, snaked around the perimeter of the park with two entrances directly opposite of each other.

The family attended a community theater production to view *The Nutcracker* ballet for the fourth interaction. The theater was recently built and fused modern architecture with warm and inviting spaces. Walking up a winding, raw wood staircase with steel pipe rails led patrons past exposed HVAC ducting and lightly colored wood panels mounted to the wall

resembling a xylophone. Once inside, the theater was an intimate space seating no more than 150 patrons. The balcony, where the Lovegoods sat, only had two rows containing 15 seats each. The family sat at the end of the first row of the balcony next to a very low banister. Standing up, the banister only came to Ezekiel's waist which was approximately two feet from the ground. The velvet green, cushioned theater chairs would stay down when enough weight was applied to them, but collapsed on Ezekiel many times throughout the show forcing his legs up over his head. Despite Ezekiel's discomfort, as long as his mother kept her toes on the front of the cushion, he remained focused on the events of the stage down below him.

Typical of evening shows, the ballet ended at 9:30 which made it a late night for a five-year-old. Yet, everyone still needed to eat prior to bed. A visit to local hamburger restaurant was in order. Walking into the loud restaurant, Ezekiel knew exactly what he wanted: fries and an Oreo shake. He then waited patiently until all orders were placed and it was time to find a seat. As with the Lovegood's kitchen table, the tables and chairs at the restaurant were all high off the ground. Ever the trooper, Ezekiel followed his sister, Sara, to a table near the side of the restaurant and folded his legs underneath him to raise himself up to the height of the table top.

The sixth and final interaction involved the entire family. Even Ezekiel's father took the day off work to go to the Perot Museum of Nature and Science. Located near the heart of Dallas, the Perot Museum's main campus was constructed in 2012. The museum's four floors included exhibits on birds and their adaptations, dinosaurs of Texas, rocks and minerals, energy, space and weather, the human body, engineering, animals, the science behind sports, and visiting exhibits. A 54-foot, glass encased escalator provides a direct route

to the third floor. The other route, Ezekiel's preferred way, involved one of three see-through, glass elevators allowing the riders the ability to observe the elevator pulley systems. Museum staffers were located throughout each exhibit with small relocatable tables containing hands-on artifacts relating to the exhibit. In the dinosaur exhibit, Ezekiel touched a mastodon tooth and held a mammoth's tooth. Ostrich, emu, and hummingbird eggs awaited him in the bird exhibit. A gemologist was ready to talk to Ezekiel and his family about minerals that fluoresce in the rock and mineral exhibit. Much to the chagrin of his sisters, Ezekiel was meticulous as he moved through each exhibit ensuring that he did not miss anything of interest.

Through the six interactions it became apparent that Ezekiel was curious about the way the world worked. His demonstrated sustained interest when he built and rebuilt Legos as well as when he recreated what he had seen elsewhere with a hodge-podge of toys. While Ezekiel exhibited other behaviors of curiosity (questioning and exploration/discovery), more of the interactions illustrated instances of sustained interest. These interactions included the solar eclipse viewing, playing upstairs, and the trip to the Perot Museum of Nature and Science.

**Case 2: Clark family**

The Clark family lived approximately an hour west of the Metroplex in a town located on a river. They purchased a home in a gated community with a security guard on duty at all times. Since the gated community was actually an additional thirty-minute drive from the town, five of the ten interactions were set within the boundary of the neighborhood.

The home, a two-story brick house, was located near the western bounds of the neighborhood near the marina on the river bank. The neighborhood was nestled within the

horseshoe bend of the river as it meandered its way south to the Gulf of Mexico. Deer freely roamed among the pecan groves and Mexican free-tailed bats cartwheeled through the air during dusk. The soundtrack of summer was laced with the drone of locusts and single engine aircraft from the local airport. Few sidewalks existed in the neighborhood and the ground dropped sharply away from the road into ditches on either side. This made the task of walking the neighborhood a little treacherous when near any main roads. What the neighborhood lacked in sidewalks, it made up for in old, established trees providing shade from the summer sun.

Concrete floors and ten-foot high ceilings adorned the Clark's four-bedroom house. When interactions happened in the home, they typically occurred around the island in the center of the large kitchen with Avery perched on a stepstool or around the six-person dining room table. Mrs. Clark reupholstered the seat cushions earlier in the year and Avery's was covered with material depicting *Frozen* while her brother's chair showed the characters from the Marvel comic books. These chairs were reserved and only the blessing of the owner of each chair would be able to grant an outsider the right to sit down on one of them. Two large windows faced the backyard and the blinds were pulled up to let some natural light in as well as to keep an eye on the two dogs in the backyard.

On the southern side of the neighborhood, but too far away to walk, lay the Brazos River. A metal playset stood out in the blazing sun with a merry-go-round and a see-saw in addition to a swing set and slide on one side of the parking lot with the river on the opposite side. Tall trees provided shade over the parking lot which was constructed of crumbling asphalt. A road barrier separated the deteriorating parking lot from the sandy path leading down to the river. The yellow sand, clearly imported, engulfed feet as visitors trudged down

through it to the bank below. After a twenty-yard walk through the sand, your feet touched river rocks polished smooth through years of water overflowing its banks in times of floods. On the day the Clarks ventured down to the river (first interaction), the water flowed quickly as it had just rained for three days prior. Little white caps appeared over the surface of the water as it flowed over snags below. Spiders and water striders scurried over the rocks as our shadows passed over them. Occasionally, a splash could be heard and a glance would reveal the ripples moving outward from a fish that had jumped out of the river. Cedar and live oak trees lined the opposite bank, stretching upwards to the blue, clear sky. Sometimes a hot wind would blow but during most of the time at the river, the air was stagnant and oppressive.

As with the river, most of the interactions required a minimum of twenty minutes in the family SUV. Old but reliable, the family vehicle seated five but rather uncomfortably. The bench seat in the back had a car seat on each side leaving only the middle seat available for a very small person wedged in between. Littered with toys and books, the family vehicle made the commute to and from school each day and was the predominant means of transportation for any sort of errand. The trunk contained a treasure trove of shoes, socks, clothing items, and toys as well. When the car started up, a Disney soundtrack immediately started playing but if there happened to be silence, a request from the back would ask for music. Tablets were permitted in the car on rare occasions. Most of the time, Avery and her brother, David, would spend a car ride either playing with toys, reading books, or singing along to songs playing in the car. Sometimes Avery conversed with her mother.

Fossil Rim Animal Park was a 45-minute drive from the Clark's home located further down the same river of their neighborhood (interaction six). With over 1,000 animals comprising 50 species, the drive-thru animal park provided the Clark family with a way to

get out of the house but still beat the heat. The nine-and-a-half-mile drive through the 1700 acres enabled Avery and David to feed animals such as the Addax or white tailed deer from the back seats of their SUV. Half way through the trek was a gift shop and café at the top of the hill looking out over the reserve. A small petting zoo was near the cafe. Avery and David brushed many Boer and Nubian goats, listened to various types of parakeets, gazed at tortoises, and gawked at ostriches all the while stretching their legs before piling back in the car to continue the journey. The driving tour ended with a viewing of cheetahs and white rhinos. As the family exited the park, a stampede of wildebeest crossed the field to the left of the vehicle sending dry, red soil into the air.

On another sweltering summer day, the family drove to Big Rocks Park (interaction seven). Located on the banks of the Paluxy River, Big Rocks Park provided a natural jungle gym for children to run, hop, play, and climb. Flood waters millions of years ago created large boulders that littered the north side of the river as it cut through the limestone. Normally crowded during the summer, the park was scarcely populated the day the Clarks visited. The river was dammed ten years ago to the west of the rock formations to create a shallow pool for swimmers and anglers. Slowing down the natural current of the water combined with the drought conditions of the state allowed slimy, green algae to form on the rocks downstream of the dam. Each step through the shallow waters sent up plumes of fine silt clouding the clarity as well. Snowy white egrets stalked prey further downstream but occasional ventured closer to the few people lounging in the shallows. As the sun beat down, Avery and David slipped, slid, and fell as they waded through the river much to the chagrin of their mother who attempted to strategically keep them out of the river by leaving swimsuits at home.

For the sixth interaction, one of the Clark's family friends was out of town for a week and needed the Clark family to watch over the house. In addition to bringing in the mail and feeding the cats and dogs, there were chickens and a homestead garden that required tending. While taking care of domestic pets was nothing new to the Clark family who had two dogs and three cats, egg-laying hens presented a learning curve. The house was located just outside the front gates of the Clark's neighborhood. Set back on several acres in a neighborhood with various stages of construction, the house was surrounded by mesquite trees and tall grasses. The barn-red chicken coop, a condominium compared to ones bought at livestock supply stores, housed seven Plymouth Rock hens. The first story of the coop had cabbage dangling from a basket suspended from the ceiling and seed in a long, rectangular tray on the opposite side next two a water container. A wooden ladder connected the first floor with the second floor. Lined with peel-and-stick linoleum and nesting boxes, the second floor was equipped with an air conditioner and heater. Half of the roof was hinged so that it could be lifted up to gather the eggs out of the nesting boxes. The raised bed garden created a "u" around the chicken coop with all types of summer vegetables growing. Pumpkins and squash were planted along trellises on the far side of the coop. The family drove to the house daily during the week to collect eggs, feed and water the chickens, and tend the garden.

The eighth interaction took place at the Fort Worth Museum of Science and History. The Clarks arrived right as the museum opened and were one of the first families in the museum. David wanted to head straight to the traveling exhibit about the world of *Dora the Explorer* even though the family had visited the same exhibit several times. Once the children were ready to move on, the family headed back down the stairs towards the dinosaurs. This permanent exhibit was a favorite of the family. Avery and her brother giggled

as they jumped around in front of an interactive screen with digital velociraptors playing peek-a-boo. Behind the wall was a dinosaur lab where the children colored blackline copies of alamosaurus, pterodactyl, and tyrannosaurus. The children would then take the paper to a scanner located on the back walls, press a button to scan it, and then turn around to watch their animated coloring walk, roar, and flap across the screen. By the end of the trip to the museum, Avery and David returned to this exhibit twice until their mother reminded them that they needed to save coloring pages for other museum visitors. The exhibit on energy sources of Texas was located right next to the dinosaurs. An interactive, miniature city captured the attention of the children for several minutes as they worked with other children to power a city using alternative forms of energy. But the dinosaur dig beckoned and in short order the family was outside sweating as the children used brushes to swipe away sand covering castings of dinosaur bones. The trip to the museum ended with a parent's dreaded trip to the gift shop but Mrs. Clark's wallet made it out unscathed.

The final and tenth interaction with the Clark family was to Acton Nature Center. Originally federally owned land, the nature center was managed by the Hood County Master Naturalists and Master Gardeners. Five miles of trails traversed over seasonal wetlands, through groves of live oaks, and next to restored blackland prairies. Lathering on sunscreen and dousing each other in bug repellant, the Clarks made their way down the shortest trail. While walking, Avery recorded videos and took photos of what she saw. Purple flowers stood out vibrantly from the yellow-green grasses. Cicadas hummed in the distance and woodpeckers echoed through the trees as they pecked bug-riddled branches. A canopy of tall, oak trees arched over the trail at the halfway point on the mile and a half trail. Several owl houses were nailed up onto trunks of trees in the grove. In the middle, a lean-to, constructed

by a local Boy Scout troop, invited Avery and David inside. Spider webs glinted in the sunlight and the grove provided a cool respite from the blazing sun. While resting in the shade, a decision was made to turn around and go back the same way instead of venturing forward. The trek back to the car seemed shorter than it did earlier except for stop on the trail to watch the leaves fold on a touch-me-not plant (*Mimosa pudica*).

Interactions with Avery illustrated all of the behaviors of curiosity delineated by previous studies: exploration/discovery, questioning, and sustained interest. In all of the interactions, Avery questioned. Interactions that were less structured enabled Avery to explore and discovery (Brazos River, Fossil Rim Animal Park, making oobleck, Big Rock Park, and kitchen science activities). Sustained interest occurred in both structured and less structured interactions such as making crystals and attending the Fort Worth Museum of Science and History. Technology was also a characteristic of all of the interactions except for the visit to Fossil Rim and the trip to the Fort Worth Museum of Science and History.

**Case 3: Smith family**

The Smiths lived just northwest of Dallas in a large suburb. Their grey-bricked two-story house sat at the beginning of a cul-de-sac. The front yard was almost non-existent, taken up by most of the driveway but did have one tree of medium height on the north side. A few low-growing shrubs led you from the driveway to the front door. A small, cloth sign welcomed you to the house as if flapped gently in the breeze. The red front door, framed by a tall archway, stood out from the grey brick. A quick knock was answered promptly by the sliding of the lock and the creak of the door as it swung open on its hinges.

Entering the house, a stairway greeted visitors with family portraits printed on canvases hung diagonally up the stairs. The front room, sparsely decorated, housed a billiard

table littered with drawings and scribbles from the three children. Beyond that was a playroom with large windows facing out into the backyard. The playroom was in a constant state of disarray during the summer and served as one of two main sources of entertainment during the heat of each day. Board games sat on shelves up to the ceiling on one wall. The opposite wall had clear plastic bins filled with various art supplies. Artwork and unframed photos framed the windows. The living room sat on the opposite side of the house and held the second main source of entertainment: a large, flat-screened television positioned in front of the never-used fireplace. A coffee table sat between two leather sofas arranged in an "l" shape.

Between the two rooms lay the galley kitchen and informal dining room. The kitchen table, covered with an orange and yellow checked table cloth, sat in front of three large windows facing the backyard. A highchair and five chairs were placed around the table with placemats set on top of the table cloth in front of the chairs. Most of the interactions (fourth, fifth, and the seventh through tenth) at the house happened at that table. Sunlight streamed through the windows glinting off of the shiny black appliances. A pink plastic stepstool sat in front of the deep basined stainless steel sink. The brown granite countertops hid little drips of liquid from the two oldest children pouring their own drinks into sippy cups.

The kitchen led into the backyard: a medium sized space gently sloping downward to the canal below. A wooden-slated fence surrounded two sides of the backyard while a black wrought-iron fence delineated the other two sides of the backyard. With a large, wooden play scape and pavers covering a quarter of the yard, cooler days were spent outside beneath a large shade tree. A wooden gate next to a small exercise trampoline led to the front yard and a wrought-iron gate with a rusty latch led out to the communal canal.

The neighborhood was very large and built around a series of canals lined with sidewalks and bridges that crisscrossed over them. The landscaping around the system of canals was carefully and judiciously maintained by the home owners' association. Red-eared sliders, egrets, and a variety of ducks called the canals their home. The sidewalks lining the water were always bustling with joggers, people walking their dogs, and children running ahead of their parents. Where cars zoomed over bridges, long tunnels underneath kept pedestrians safe from traffic. To a child, these tunnels were constructed perfectly to convey echoes. The trees and shrubs were strategically planted for esthetics and each one had a small metallic circle engraved with an identification number nailed into the trunk. The grasses and other small plants, such as flowers, were native to the area and required less care and water than the larger vegetation.

The very first interaction for the entire study was at Fritz Park Petting Farm. A little petting farm set in the middle of a larger city park provided families something free to do during the summer months. The small area was nestled underneath large shade trees and sat down the side of a hill. Within the boundaries of the farm, Michelle and her brothers were able to pet a donkey, brush a goat, hold a chicken, pet several rabbits, and watch a peacock. In addition to the animals, there was a coloring barn where Michelle and Austin drew with sidewalk chalk, colored with crayons and sat on a step observing a Texas spiny lizard basking in the sun.

Interaction three took place in a public aquarium, Estuarium, housing over 31 aquariums with 100 different species of animals found in the Gulf of Mexico. Consisting of a boardwalk over a marsh, exhibit halls, and touch tanks, the aquarium was full of aquatic life on display. Most of the individual tanks listed the animals found in the tank as well as a

description of the animal and its habitat beside the tank on the wall. Exhibit halls were dimly lit so that the animals were clearly visible in the backlit aquariums. A large hand sanitizer bottle sat at the beginning of the line for the touch tanks with a sign encouraging anyone wishing to touch an animal to use the sanitizer. Cow-nosed sting rays, with barbs removed, starfish, and hermit crabs were available to touch in the tanks. All around, children squealed and parents conversed as hands gently stroked the animals in the water. A museum employee was available to answer any questions and remind guests not to pick up any of the animals in the touch tanks. Throughout the museum were photographic cutouts for families to poke their head through and pretend to be a diver, an oceanographer, or a beach-goer. The Smiths spent the majority of their afternoon meandering through the aquarium and observing the animals.

One humid, August day the family piled into the van and headed to the Dallas Arboretum (sixth interaction). The Children's Discovery Garden, located inside the Arboretum, provided a late morning break from days spent hiding inside from the summer heat. The Discovery Garden was a very large space filled with all types of interactive spaces. The children could run over a skybridge designed to take you through the canopy of a forest. A treehouse had nets to climb up even higher and see the Dallas skyline in the distance. A winding staircase through the trunk of the tree brought patrons back down to ground level where touchscreens invited children to match the animal with its habitat of choice. Winding paths snaked through various areas of the park illustrating the various ecosystems and habitats of North Texas. In the very back of the children's area was a permanent exhibit where families played with water. Using solar energy, water cannons sent metallic flowers and pinwheels spinning. An Archimedes' screw brought water up to a bucket which would tip and ring a bell when full. The water rushing down past the bell would circle back around

to a slanted table where children could build locks and dams to lift a toy boat up. An educational building was near the exit of the Children's Discovery Garden. Walking through revolving doors revealed a large space on one side where a DNA demonstration was happening. Touch screens, digital microscopes, and display cases lined the opposite side of the building.

Michelle demonstrated many instances of exploration and discovery. She was always eager to try out an idea or activity. In every interaction, there was at least one instance of exploration or discovery. From mimicking a sheep to cleaning quarters with milk to attempting to catch a leaf on her head, Michelle explored and discovered. Questioning did not occur as frequently or at least verbal questioning others could hear. However, when Michelle did ask a question, it typically was a question that the adults were unable to answer as well. Michelle enjoyed reminding the researcher and Mrs. Smith of previous interactions and what was noticed or experienced during those events. This type of sustained interest occurred in every interaction except for two (attending the Estuarium and visiting the Children's Discovery Gardens). However, instances of sustained interest were apparent in all of the interactions.

## Across group

Across group analysis resulted in two large themes: anticipated and unforeseen. The anticipated themes present results in line with previous research studies on curiosity in children from prekindergarten to sixth grade. Unforeseen themes present results which have not been identified or presented in previous research. Each of the themes arose during the analysis of the written and photographic data.

**Anticipated themes**

As previous research demonstrates, children are curious about the natural world in which they live. Animals, dinosaurs, trains, and sounds comprise a few of the many topics most children become curious about at some point or another. When children become fascinated by topics such as these, observable behaviors such as exploration and discovery alert outsiders to the curiosity. Other observable behaviors, supported by previous research, which occurred within this research included expressing interest and questioning.

**Exploration/discovery.** Used interchangeably in literature, exploration and discovery were more apparent in some interactions than others. Less structured interactions tended to foster greater instances of discovery. More structured interactions, either by design or by adult influence, tended to have fewer instances of exploration or discovery.

One illustration of discovery happened during a walk through the Smith's neighborhood canal park (second interaction); Michelle and her two younger brothers experimented with different pitches in a tunnel underneath the main road. The tunnel was on the way to and from a fountain at the other end of the neighborhood. Traveling through the tunnel the first time, Michelle tried out different pitches with her voice and listened to the following echoes. First she pitched her voice very high and listened. Next she pitched her voice low. As she approached the end of the tunnel, Michelle created a sound that started off with her normal pitch, went high, and then dropped down low. Prior to stepping back out into the sunlight, she listened to the resounding echo (Michelle, I2). Michelle and her brothers spent a longer period of time in the tunnel on the return trip. This time started with trying different pitches as the children did during the first trip through the tunnel. Unlike the first trip, Michelle quickly switched to yelling "to the great beyond" with different volumes and

listened to the sound reverberate off the walls (Michelle, I2, 291-295). Noticing Austin and Cole copied her words, Michelle suggested everyone say “to the great beyond” on the count of three (Michelle, I2, 424). She counted off, everyone yelled, and she listened to the result.

A couple of weeks later, Michelle and Austin asked if they could do science in the kitchen. The mother agreed to the idea. Using a smartphone to search the internet, Michelle and her brother decided to make a kitchen lava lamp using vegetable oil, food coloring, and salt in a glass after viewing a website on at-home science activities for children. After a heated discussion between the siblings over the choice of food coloring to use, Michelle and Austin settled on red to be more realistic. Michelle poured the vegetable oil into the glass and then handed the red food coloring to her brother instructing him to add five drops. She added five drops of food coloring to the cup of oil after him. At the same time, the researcher carefully poured table salt from the original canister into a small dish for the children. Each child took a pinch of salt and sprinkled it on top of the oil. Michelle bent down to eye-level and watched as small beads of red food coloring dropped from the surface of the oil to the bottom of the glass. After a couple pinches of salt from both Michelle and Austin, Michelle asked if she could just pour all the salt into the glass at once. Receiving encouragement to try it out, Michelle picked up the dish and upended it into the glass. Bending down to eye-level once more, Michelle noticed the “salt [was] falling into the red jello” (Michelle, I4, 515). Once all the salt was upended into the glass, Michelle wanted to add other colors of food coloring to see what would happen. She added four drops of blue to the glass and observed that the food coloring looked neon blue (Michelle, I4, 584-590). There were eight choices of food coloring. Between Michelle and her brother, all eight colors eventually ended up in the vegetable oil just to see what happened (Michelle, I4, 650).

Later that same day, Michelle wanted to clean pennies with a mixture of distilled vinegar and salt like she had seen on the same internet site where she found the lava lamp idea. Austin ran upstairs and grabbed his wooden treasure box full of coins. Returning with the coins, Michelle and Austin sorted the coins into pennies and silver. During the sorting, Michelle and Austin decided they would also clean the silver coins but instead of cleaning them with vinegar and salt, they would use milk and food coloring. The milk and food coloring came from an earlier activity using dish soap and food coloring on the surface of the milk to make an "exploding painting". The researcher only facilitated pouring materials to prevent spills and observed the majority of the time. Michelle stated "what we're doing with the silver ones is we're going to dip them in milk thing…maybe [the milk] might make the same shape, but make the coin bigger" (Michelle, I4, 967-970). While the quarters and nickels sat in the milk, Michelle and Austin focused on using the vinegar and salt on the pennies (Figure 1). Both Mrs. Smith and the researcher inquired about the coins in the milk. Michelle responded "we'll let them sit for a while and let them change and we'll see what they look like" (Michelle, I4, 1002). After all the pennies were cleaned, Michelle and Austin fished out the silver coins from the milk, rinsed them off with water, and examined them. After her mother inquired, Michelle noted that there was no change in size or shape but the quarters did look a little cleaner than before.

*Figure 1.* Michelle takes quarters and nickels out of food-colored milk. Photograph taken by researcher.

Another example of discovery and exploration occurred on a particularly blustery day (eighth interaction). Michelle requested to go on a leaf hunt around the canal. Austin and Cole needed naps so Mrs. Smith asked the researcher to take Michelle. After the leaf hunt, Michelle and the researcher remained in the backyard. Michelle found a stick that had fallen from the tree in the backyard. Mr. Smith had built a retaining wall to help with the slope of the backyard the previous summer. The retaining wall consisted of landscaping cinderblocks. Armed with the newly acquired stick, Michelle began to tap the cinderblocks with the stick. She cocked her head to the side so her ear was parallel to ground. She tapped from one end of the retaining wall to the other end where it joined the back porch listening the entire time. Next she took the stick and stepped up to the porch's support post. She whacked the post with the stick and observed the sound noting the different tones between the wood and cinderblocks. Lastly, she went back to the tree where she had collected the stick and hit the tree trunk with the stick. She observed that the tree trunk, while wood, made a different sound than the porch post (Michelle, I7). Prior to heading inside to rub leaves, Michelle jumped onto one of the swings on the playset. Pumping her legs back and forth to gain

momentum, Michelle told the researcher "let's see if a leaf will fall on my head when I am swinging" (Michelle, I7, 122). She added that if a leaf fell on her head, she could place it in her zip lock bag and head inside. After fifteen minutes, Michelle was unable to experience a falling leaf so she grabbed her zip lock bag, entered the kitchen of the house, and begin leaf rubbing.

Avery also provided examples of discovery and exploration. While looking for rocks on the banks of the Brazos River (first interaction), Avery's brother discovered that rocks made sounds and splashes when hurtled towards the river. This observation prompted Avery to throw rocks into the water. Picking up a large rock, Avery threw it towards the river but when it came in contact with the surface of the water, the rock broke into two parts causing a different sound and sight than rocks that remained whole. Noticing the difference between the broken rock and all the previous instances, Avery attempted to recreate the phenomenon. Scanning the river bank, she tried to find another rock approximate to the one she just threw. Avery was unable to duplicate a rock breaking apart on the surface of the water but she tried on three separate occasions to replicate the event (Avery, I1, 233-237).

Continuing to walk up and down the river bank, Avery picked up a small, translucent, orange rock. Cupping the rock in her hands, she brought the rock up to her nose and took a whiff. Next she walked over to the researcher and her mom saying, "smell it momma. Smell it Momo [researcher]" (Avery, I1, 316). Both adults took turns smelling the rock in Avery's hands but admitted that could not smell anything. Eagerly, her brother took the rock, smelled it, and stated that the rock smelled weird. Avery responded that the reason the rock smelled weird was because it was in his hands. She then audibly gasped, proclaimed "sparkly!" and

picked up a reddish-pink rock with flecks of a substance resembling mica or feldspar (Avery, I1, 312).

A third example of discovery while at the Brazos River pertained to echoes. This instance started when Avery's mother handed her a flat, thin, large rock. As Avery asked her mother if the rock was to skip across the river, she took another rock that was in her hand and banged it on top of the rock she just received. An echo reverberated back from the other side of the river. Each time she banged the rocks together, she cocked her head to the side to listen to the echo bounce back. Avery took one rock and lightly tapped it on top of the larger rock. "I can't hear [the echoes]" replied the researcher when Avery looked for acknowledgement of the sound (Avery, I1, 367). This resulted in Avery clanging the two rocks together harder and faster. As soon as Avery received acknowledgement the researcher heard the sound that time, she began to try different methods to create echoes. First she rubbed the rocks together to make a scraping sound but there was no echo. She then banged the rocks together harder and faster. This time there was an echo. Avery continued to clang the rocks together and declared "I'm keeping these rocks. They make an echo" (Avery, I1, 376-377). Instead of pocketing the rocks, however, Avery pondered aloud, "I wonder what it sounds like with three rocks" (Avery, I1, 392-393). She picked up an additional rock, clanged the three together, and listened to the echo. She dropped one rock back on the ground after she banged the three together twice. Her exploration with the echoes continued for another two minutes (Avery, I1). The echo exploration halted abruptly when Avery hit the two rocks together and the larger one cleaved in two (Figure 2). Giggling, she exclaimed "I broke a rock!" as she showed the evidence to everyone (Avery, I1, 430).

*Figure 2.* Avery holding up one half of a rock cleaved during her discovery of echoes. Photograph taken by Mrs. Clark.

A couple of weeks after the trip to the river, the family decided to escape the heat by staying inside and using one of Avery's science kits she received for her birthday. The kit she opened on her birthday contained everything needed to make crystals. As with most science kits purchased in stores, the instructions left very little room for deviation if the end result was desired. Most instances of possible exploration were halted prior to beginning by Mrs. Clark following instructions and to ensure that Avery had a decent shot of actually growing crystals. Despite the very structured nature of this interaction, one instance of discovery occurred. Midway through the preparation of the crystal-generating solution, the instructions called for a seeding mixture. This seeding mixture consisted of a white, grainy powder. In addition to the seeding mixture, the kit also contained a stirring bowl and stirrer. Avery and her mother worked together to carefully measure out the correct portion of the seeding mixture and poured it into the mixing bowl. Looking at the researcher, Avery asked "can I stir it" (Avery, I3, 603). The researcher responded, more with the mindset of a friend and

adult authority than a qualitative researcher, with "there's no reason to right now. You don't have liquid but if you want to see what happens you can" (Avery, I3, 604-605). Focusing on the second half of the researcher's reply, Avery stirred the dry, white powder to see what might happen. She observed that stirring really did nothing to the dry powder other than moving it around the bowl.

A further case of discovery happened at another river later in the summer (seventh interaction). Much to the chagrin of Mrs. Clark, the interaction at Big Rock Park did not just entail climbing and playing around on the large rocks created millions of years ago. The Paluxy River appeared inviting on the hot July day. Naturally, Avery and David made their ways down to the banks of the river. Based out of concerns that her children might contract an infection from river water, the children were rarely allowed to wade in any non-chlorinated water. Excited to be allowed to wade in this water, Avery shucked her shoes as soon as she stepped onto the sandy beach but that was too soon. Moving quickly and hopping about to avoid burning her feet, Avery made her way to the water's edge. Quick as a wink, she bent both knees and jumped. No sooner than her feet touched the river's bottom did they slip on the algae growing on the rocks. Mrs. Clark and the researcher looked on with concern until Avery got her feet under her again. Her back soaked, Avery turned to face the adults and said "that was fun" (Avery, I7, 560). The researcher inquired why Avery chose to jump into the river to which Avery responded that it was because the river was muddy. For the remainder of her time wading through the river, Avery was more careful in spots where the rocks and river bottom resembled the muddy river's edge where she slipped.

Wading in the river, Avery noticed several schools of mosquito fish. Reaching down with both hands, she tried to scoop the fish out of the water. First she thrust her hands into

the water quickly but soon realized this action scared the fish away. Following a couple unsuccessful attempts, Avery switched tactics and tried to slip her hands in the water slowly while saying "fishy, fishy, fishy, fish" (Avery, I7, 583). She continued to try to catch a fish for several minutes. When her mother approached the river with David, Mrs. Clark asked what Avery was doing.

Avery: I'm trying to catch a fish. Dang it, oh, don't cuss. Dang it. I keep on missing.

Researcher: Why do you think you keep missing?

Avery: Because I'm not near the fish. Oh, there's more fish over there.

David: I was slipping on those rocks.

Avery: I need to get. I'm gonna get…

Researcher: If you just kind of just scoot your feet across the bottom, you won't slip as much.

Avery: Oh, like you're ice skating? (Avery, I7, 597-606).

Altering approaches, Avery began to glide her feet so she would not end back up in the water. She noticed that gliding her feet also produced less splash so she was able to get a little closer to the fish. Eventually Avery realized that she was not going to catch a fish though this realization did not stop her from trying to catch an egret later.

Before Avery stepped foot in the river, she wanted to know if the river was deep. Instead of waiting for a response though she took off for the river as soon as she was close enough and jumped. Her interest did not disappear once she waded in the water. When her curiosity became strong enough that she could not ignore it, Avery bent down and grabbed a handful of silt. Lifting the silt out of the water, Avery let it slide through her fingers and plop

back into the water. Realizing that letting small amounts of silt hit the water did not help her determine the depth, Avery grabbed another handful of silt and released it all (Figure 3). She informed the researcher that the water was not very deep. When asked how she arrived at that observation, Avery stated she could see under the water (Avery, I7, 693). She expressed a desire to go further down the river to the deeper portions since the area she was standing in was shallow.

*Figure 3.* Avery testing the depth of the water by dropping clumps of silt. Photograph taken by Mrs. Clark.

Instances of discovery and exploration were not limited to the home or rivers. One day Mr. Clark joined Avery and her mother during his lunch break. While Mr. Clark was talking to Mrs. Clark about the upcoming solar eclipse, the researcher listened while absent-mindedly playing with her straw in her water glass. “How do you do that?” Avery asked referring to how the researcher was lifting water with the straw and then letting it fall back into the glass (Avery, I9a, 36). Sensing Avery was interested, the researcher explained that it was pressure and demonstrated how to place her finger on top of the straw. From the time

Avery first expressed curiosity until lunch was brought to the table, she practiced and practiced. Her father noticed she was getting frustrated when she was unable to capture any water so he suggested the straw was probably the reason. This suggestion did not deter Avery. As the waitress stepped up to the table with the plates of food, Avery announced "Look! I'm keeping it in" (Avery, I9a, 42).

Out of all of the interactions with the Clark family, the day of doing activities with household items (ninth interaction) lent itself to the most discovery and exploration. Mrs. Clark suggested several activities using items such as glitter, vinegar, and baking soda. Avery quickly wanted to try different amounts of each item. At first, Mrs. Clark controlled the ratio of vinegar to baking soda but after the initial reaction stopped, Avery wanted to add more vinegar to see what would happen. When she did not get a response from her mother, Avery restated that she wanted to "put more vinegar in" and she wanted to add four tablespoons of baking soda to the current vinegar and baking soda solution (Avery, I9b, 97). Initially her mother resisted telling Avery the baking soda was just going to pile up on the bottom of the glass container. Eventually, she capitulated when Avery launched into chants of "put more in it and put more vinegar in it. Put more vinegar in" (Avery, I9b, 107). Avery and her mother continued to put varying ratios of vinegar and baking soda into the container until the last of the distilled white vinegar was used. The interaction began very structured but quickly because less so with the control shifting from Mrs. Clark to Avery.

Later that same day, Avery watched a video on the internet that demonstrated surface area with thumbtacks and a balloon. Expressing an interest to try the same activity, Avery grabbed a balloon to inflate. While she inflated the pink balloon, Mrs. Clark rummaged through the kitchen's junk drawer to find a plastic box of thumbtacks. Together Avery and

her mother created a square of sixty inverted thumb tacks following the video. Prior to placing the balloon on the bed of tacks, Mrs. Clark put her hand on top of the tacks as the man in the video had. No sooner than she lifted her hands off the tacks, then Avery followed suit. However, when it came time to use a balloon, Avery shied away from using her pink balloon. Instead she suggested using her mother's blue balloon. Slowly and with a little encouragement from Avery, Mrs. Clark lowered the blue balloon to sit on top of the bed of tacks (Figure 4). Realizing the balloon did not pop, Avery immediately suggested that her mother should put a brick on top of the balloon. A brick was not tested on the balloon but Avery did have the researcher push down on the top of the balloon. While she clamped her hands over her own ears, Avery expressed her doubt saying "[the balloon's] going to break" (Avery, I9b, 850). Yet the balloon did not pop. Seeing this, Avery removed half of the tacks underneath the balloon. Her mother tentatively lowered the balloon onto the decreased number of tacks but Avery had other ideas. Taking her hands, Avery pushed her mother's hand down. Mrs. Clark hesitated saying she did not want to pop the balloon but Avery said "you have to" (Avery, I9b, 855). With the added pressure and decreased number of tacks, the balloon popped and everyone in the room screamed in surprise.

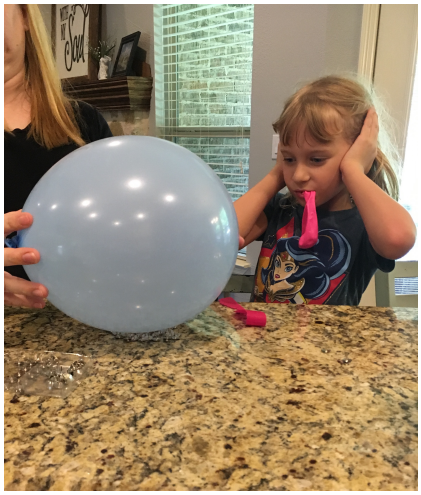

*Figure 4.* Avery covers her ears while her mother places a balloon on a bed of inverted thumb tacks. Photograph taken by researcher.

Despite fewer interactions with the Lovegood family, discovery and exploration were still observed. During the solar eclipse, which turned into a structured interaction because Mrs. Lovegood did not want her children to miss the phenomenon, Ezekiel found ways to explore and discover. Using the solar viewer, Ezekiel quickly noticed that the projected image of the eclipse would move around inside the box (Figure 5). He observed that the image moved up the inside of his box. When he titled the solar viewer, the image of the sun moved out of the box and then back into the box when Ezekiel tilted it the opposite direction. Once he realized that he was the one controlling how the image of the eclipse moved around on the inside of his shoebox, Ezekiel purposefully moved his box to change the places the image projected. He stated his discovery when he said “if I move the box, the moon moves around” (Ezekiel, I2, 596).

*Figure 5.* Ezekiel moves the image of the sun inside his solar viewer. Photograph taken by Mrs. Lovegood.

Hawaiian Falls waterpark provided an ideal yet surprising place to explore (third interaction). On a visit to the local water park, there was a splash area for little children. At one end of the kids' area there was a fountain that spilled into a rock pool below. The way the rocks were designed created an eddy. His mother brought a plastic dinosaur to play with in the water. Ezekiel placed the plastic dinosaur into the eddy and watched. When he realized that the water made his dinosaur spin in circles, Ezekiel began testing out other objects. He put some leaves in the eddy to see if they also swirled around. He then found a twig which he broke into small pieces and a plastic straw wrapper. He placed these items into the water to see if they moved the same way as the previous objects (Ezekiel, I3). The family moved to the wave pool shortly after Ezekiel completed his exploration with the eddy. While at the wave pool, Ezekiel stayed in the shallows with a pink, transparent inner tube. He spent nearly all his time in the wave pool trying to balance his dinosaur on the top of the inner tube. He managed to balance the dinosaur for very brief periods of time (Ezekiel, I3).

Several weeks after the water park, the researcher accompanied Mrs. Lovegood, Sara, and Ezekiel to see *The Nutcracker* (fourth interaction). Every time the audience clapped during the first act, Ezekiel tried out different ways to show his appreciation. First he clapped with both hands but the next time he only clapped with the tips of his fingers. The third time, Ezekiel attempted to whistle with his fingers but was unable to whistle. Therefore, he yelled "yeah" the next time the audience clapped (Ezekiel, I4a, 21). The final time the audience clapped before intermission, Ezekiel attempted to whistle but without his fingers. As with the first attempt, he was unable to make a sound. During intermission, Ezekiel found a green veggie straw on the ground. He glanced up at his mother and noticed she was not paying attention to what he was doing. He took the tip of his shoe and crunched a very small part of the discarded veggie straw. Smiling, he picked up his foot to observe the effects of his actions. He looked back up at his mother to make sure she was not looking at him. Satisfied that she was preoccupied, he stepped on the entire veggie straw. He then picked up his foot and examined all the tiny pieces closely (Ezekiel, I4a).

During another interaction, the entire family attended the Perot Museum of Nature and Science (sixth interaction). Most of the exhibits within the museum were designed in a way that limited the ability to experiment but did allow for discovery. One of the hands-on exhibits within the Expanding Universe area of the museum utilized nine bowling balls anchored to various weights to model the gravity experienced on each planet and the Earth's moon (Figure 6). Unlike previous visits to the museum, Ezekiel was tall enough to reach the bowling balls during this museum visit. Beginning with the bowling ball for Mercury, Ezekiel lifted up the ball. He moved down the line from Mercury to Venus to Earth. With each ball, he would grunt as he raised the ball and then say "hi ya" when the ball could not be

lifted anymore (Ezekiel, I6e, 2-6). Lifting the moon was the easiest for him. As he raised the moon, he expected the bowling ball to have more resistance than it actually did. The bowling ball shot up surprising Ezekiel and he let out an exuberant "yes!" (Ezekiel, I6e, 7). The outer planets required assistance from Mr. Lovegood although Ezekiel still wanted to try on his own. He told his father to let Jupiter go after his father lifted it up. Ezekiel placed his hands underneath to push the bowling ball up once his father released it. However, he could not hold the ball up for any length of time and let it go saying it was too heavy (Ezekiel, I6e, 13-17). Moving over to Neptune, Ezekiel worked with the researcher to lift the ball. As with Jupiter, as soon as the bowling ball was raised, Ezekiel told the researcher to let go so he could hold it on his own. Crouching with his hands pushing up against the ball, Ezekiel grunted and then panted when he released the ball. He turned to the researcher, wiped his brow with the backside of his arm and said "I was as strong as I could" (Ezekiel, I6e, 27). He walked to his left and returned to the ball for Mars, lifted it, spun it, and then dropped it. Before venturing onto another exhibit, he returned to the Moon and stated it was the perfect size. He stepped to his left and lifted the Earth up while he shared that the Earth bowling ball was even harder than the moon. Finally, he went to the right and tried to lift the ball for Neptune. He patted the ball on the top and said it was even harder than the previous two.

*Figure 6.* Bowling balls anchored to weights underneath the display represented the effects of gravity on each celestial body. Photograph taken by researcher.

Another exhibit located on a different floor of the Perot Museum of Nature and Science provided patrons a chance to view the veins in their hands with a strong beam of light. Mr. Lovegood placed his hand under the beam of light and called Ezekiel's attention to see the illuminated veins. He encouraged Ezekiel to put his hand under the light. Ezekiel placed his hand under the beam, turned his wrist over to each side and observed. Next he removed his hand, stood up on his tiptoes, and placed his head underneath the light. Laughing, his father told him to remove his head but reminded Ezekiel that he could view his wrist and even his forearm (Ezekiel, I6, 105-109).

**Sustained interest.** Defined as a persistent interest over an extended time period, sustained interest often occurred in conjunction with other behaviors of curiosity such as discovery and exploration. To avoid being repetitive, instances that were double coded for sustained interest and another observable behavior of curiosity will be mentioned, but only instances where interactions illustrating sustained interest that have not been discussed

anywhere else in this chapter will be highlighted in this section. To be considered sustained interest and not shared interest, the child needed to stay with the phenomenon for long spans or time, return to the phenomenon throughout the interaction, or revisit the phenomenon throughout several interactions.

At Fritz Family Petting Farm (first interaction), Michelle became attuned to the sounds of the animals from the rooster crowing to a sheep bleating. She stood at the peafowl enclosure for nearly eight minutes and sketched the peacock. Eyes intently focused on her drawing, Michelle heard the peacock make a low call. She copied the call (Michelle, I1, 19). There was an opportunity to pet and hold chicken further into the park. A rooster scratched in the dirt near the hen coop. While Michelle sat on the edge of the coop with a hen in her lap, the rooster crowed nearby. This sound caused her to laugh and then imitate the sound with her with version of "cock-a-doodle-do" (Michelle, I1, 49). Those two instances of discovery were short in comparison to Michelle's interaction with a sheep. Originally, the sound of a tom turkey drew Michelle and Austin, her brother, to the opposite side of the park. However, the sheep in the pen next to the turkey was very vocal. For over four minutes, Michelle stood at the fence. The sheep would bleat and Michelle would make the bleating sound back to the sheep. If the sheep did not bleat, Michelle would make the sound, wait for the sheep to bleat back, and then she would laugh (Michelle, I1, 142-195). She even made a video on the smartphone of the sheep bleating to show her grandmother later. When Mrs. Smith asked her children if there was anything else Michelle and Austin wanted to see prior to heading home, Michelle requested a return visit to the sheep. For another three minutes, Michelle and the sheep bleated (Michelle, I1, 346-361).

Several other illustrations of sustained interest occurred during the fourth interaction but two (lava lamps and cleaning pennies) are mentioned elsewhere in this chapter. Between making lava lamps with kitchen materials and cleaning pennies with salt and vinegar, Michelle and Austin created milk paintings. As with the other two activities in the fourth interaction, Michelle found the milk painting on the same children's website. For eleven minutes, the children added drops of food coloring onto the surface of milk in 8x8 baking dishes. Next they touched the food coloring with toothpicks dipped in dishwashing liquid soap the researcher squirted in a small saucer. The fats in the milk interacted with the soap and sent the food coloring radiating out away from the tip of the toothpick. Michelle used her toothpick to swirl the food coloring around to make a colorful milk surface. While her brother mixed until his milk turned an army green, Michelle was careful to keep the colors from blending too much. When she was finished with her creation and was ready to move onto something else, Michelle said she wanted to keep the milk forever. The researcher, without directly telling her no, guided Michelle through what would happen to milk as it warmed up and began to spoil. Michelle remembered the smartphone and settled for a photograph of her milk to remember what it looked like and then poured her milk down the sink (Michelle, I4, 715-890).

On the way to the Dallas Arboretum (sixth interaction), Michelle played with a RADAR mobile application. She also investigated objects in a tray with a digital microscope for approximately seven minutes and searched for the cause of a door chime in the café as discussed later. However, two other instances of sustained interest happened during this interaction. Prior to discovering the RADAR mobile application on the car ride to the arboretum, Michelle pulled a container of bubble mix out of a dental bag stashed in the

cubbyhole in the back seat. For seventeen minutes, she blew bubbles and watched where they popped in the van (Michelle, I6a). This activity was interrupted once Michelle became interested in the RADAR. The second example took place within the Children's Discovery Garden where there was a cross-section of a tree illustrating the types of information tree rings contain (Figure 7). Michelle pointed out which rings showed good sun, rain, and an old wound (Michelle, I6c, 407). Even though Michelle and her mother only spent three minutes discussing the tree rings, Michelle revisited what she learned during lunch in the café, on the ride home, and during future interactions with the researcher.


*Figure 7.* Michelle identifying the meaning of each tree ring identified by a colored dot. Photograph taken by Mrs. Smith.

The leaf walk (eighth interaction) where Michelle gathered various leaves on a windy day and the subsequent leaf rubbings occupied forty-five minutes. She gathered leaves for fourteen minutes. The remainder of the time was spent on creating rubbings. This interest lasted until she created rubbings of all the leaves in her bag (Michelle, I7).

The LASAR thermometer provided the means for another instance of sustained interest. What started out as Michelle using the thermometer to determine the mixture of the birdseed in a mixing bowl turned into a series of investigations with Austin. Prior to any series of investigations with the tool, there was a bout of sibling argument to determine equitable use of the thermometer. Once Austin and Michelle settled on a system to ensure fair usage, no object was safe. Between the two of the children, the counter top, mixing bowls, floors, and even body parts were measured to determine the temperature (Figure 8). Michelle had a better understanding of the purpose of the tool and recognized that it measured in degrees Fahrenheit. Austin continuously thought the thermometer measured height. When the bird seed mixture was placed in the refrigerator to solidify, Michelle opened up the freezer:

Mrs. Smith: Why are you all in the freezer?

Michelle: I'm just checking how cold it is.

Mrs. Smith: Close it.

Michelle: It's 24. (Michelle, I9, 464-467)

Besides simply recording the temperature of everyday objects, Michelle used the thermometer to record before and after temperatures. She observed the temperature of the birdseed mixture before it was placed in the refrigerator, immediately after it was removed, and periodically as the mixture sat out in room temperatures. In an hour, there were eleven instances where Michelle used the digital thermometer to observe the temperature of various objects.

*Figure 8.* Michelle used a LASAR thermometer on a variety of objects in and around the house. Photograph taken by researcher.

Interactions with Avery provided several examples of sustained interest as well. While banging rocks together on the banks of the Brazos River was the first instance of sustained interest for Avery, there was another instance after the river as the family was cooling off underneath the ceiling fan in Avery's bedroom. It began with a casual conversation between the researcher and Mrs. Clark about a mutual friend whose entire family had been diagnosed with strep throat. Mrs. Clark mentioned that anyone with strep who came within 100 feet would easily pass the bacteria on to her. The researcher inquired if Mrs. Clark considered getting her tonsils removed. This simple question led to Avery asking what tonsils were. Instead of providing the answer, Mrs. Clark encouraged Avery to look in her body book to see if she could find anything about tonsils. After flipping through her book, Avery asked where tonsils were located. Her mother opened her mouth and showed Avery where to find tonsils. Avery jumped up and ran off to the bathroom to look for her own tonsils. She then looked for her brother's tonsils and then the researcher's tonsils. She

then asked to see her mother's tonsils again. Moving from her mother, to herself, to her brother, to the researcher, Avery observed everyone's tonsils three times (Avery, I1, memo).

During the petting zoo portion of the trip to Fossil Rim, Avery noticed that the goats had horizontal pupils. This observation led to her asking "why do they have line eyes" (Avery, I4, 987). While no one could provide an answer to Avery's question, her observation became a part of the remainder of the trip through the park. When an animal would approach the window of the vehicle for treats, Avery would say if it had "straight eyes" or "lined eyes" referring to the horizontal pupils. She even asked for her mother to take a picture of one of the aoudad's eyes (Figure 9).

*Figure 9.* A photograph of the "lined eyes" of an aoudad as requested by Avery. Photograph taken by Mrs. Clark.

Returning to a previous area of interest, Avery found several sizes of loose rocks she could pick up while scrambling along the tops of the boulders at Big Rock park. Remembering the first interaction where she experimented with echoes by banging two rocks together, Avery picked up two rocks and hit them together (Avery, I7, 429). Avery clanked the rocks together and listened to the resulting sound four times before her mother told her to stop. Avery dropped the rocks and continued hopping along the tops of the boulders.

Even though Avery was unable to catch a mosquito fish in the Paluxy River (seventh interaction), she did not let that stop her from trying to catch an egret. An egret was hunting for its food just out of reach of people enjoying the waters. Avery tried repeatedly to sneak up on the egret by wadding through the waters. The egret would allow her to get about eight feet away before it would fly a short way down river. Over and over, Avery got close to the bird and then the egret flew away. Eventually, Avery returned to her mother on the river bank and said she was unable to catch the bird (Avery, I7).

The trip to the Fort Worth Museum of Science and History (eigth interaction) was full of instances of sustained interest. Avery insisted on completing every touch screen to power the model city. She spent twenty minutes uncovering dinosaur bones in the recreation of the paleontologist dig site. Avery returned to the two animated interactive dinosaur exhibits twice and spent a collective thirty minutes at both. The museum also had a wind tunnel with one inch sections of a cut foam pool noodle. These foam rings sat in a basket in the middle of a child-sized table. A stack of printed papers sat in front of the basket with scissors. Avery selected her piece of paper and then carefully cut out her paper helicopter. She selected her foam ring and slid it onto the bottom of the folded paper helicopter. She walked over to the wind tunnel, adjusted the wings, and released the paper into the stream of the wind tunnel. When the helicopter came out the top of the tube, Avery would run to catch it and return it to the stream. She added an additional foam ring to the bottom of the one she already had and released the helicopter. Avery alternated the bend of the paper wings and the amount of foam rings before each release. This interest lasted until Mrs. Clark stated it was late and time to leave the museum to head to lunch (Avery, I8a).

On a different day (ninth interaction), Avery and the researcher sat at the top of the stairs armed with left over balloons from a morning of kitchen science activities and raced them. Avery and the researcher each blew up a balloon and then released them on the count of three. Prior to releasing the balloons, Avery would set a goal to declare a winner such as first balloon to touch the ceiling or first balloon to land on the second step from the bottom. It felt like an eternity to the researcher and Mrs. Clark but in actuality, Avery and the researcher only raced the balloons for 15 minutes. Then it was time to pile into the car and pick up David from daycare. However, no sooner than the family walked in the door did Avery hand the researcher and her brother each a balloon. The three of them were at the top of the stairs sitting in a row, with Mrs. Clark at the bottom, blowing up balloons and releasing them all together (Avery, I9).

Unlike the two girls who typically demonstrated sustained interest within an interaciton, Ezekiel demonstrated sustained interest with his Legos. Not only would he focus on building his Legos for long durations of time during interactions, he also built Legos at some point within every single interaction (Figure 10). Sometimes he would build a Lego set using instructions (Ezekiel, predata). Other times he would disassemble a set in its entirety and then rebuild it exactly as the set was before he took it apart (Ezekiel, I1). At other times, Ezekiel built something he had in his mind using whatever Legos he had on hand (Ezekiel, I5).

*Figure 10.* Ezekiel deconstructed a previously built Lego set and laid out the pieces to rebuild. Photograph taken by researcher.

Another example of sustained interest accompanied the rarity of a solar eclipse. It came as no surprise that this phenomenon captivated Ezekiel. From making his solar viewer to stepping outside and manipulating the shadow inside his box, Ezekiel was fascinated. As soon as his solar viewer was built, Ezekiel was ready to go outside and view the sun. He even punctuated his command to go outside with two eager yells (Ezekiel, I2, 410-411). Stepping outside, Ezekiel proudly showed and used his solar viewer:

Ezekiel: Yeah, I made this.

Researcher: You did make it. Is there something in there?

Ezekiel: So look. You can see on your shadow that there's light flashing from the moon. That's cool!

Researcher: It is cool

Ezekiel: It's flashing from the sun and now you can't see it. (Ezekiel, I2, 477-482)

Each time Ezekiel noticed something with his solar viewer, such as squeezing the sides of the box to cause the image to flash, he would share his discovery with enthusiasm. At the end of the eclipse viewing, he stated he wanted to keep his box. Ezekiel still had his solar viewer on proud display in his room at the conclusion of the study.

Similar to Avery, when the Lovegood family attended a museum (sixth interaction), Ezekiel demonstrated sustained interest at several exhibits. What stood out with Ezekiel's visit was his attention to museum staff talks. Starting in the dinosaur section, Ezekiel listened to a museum staffer talk about the differences between mastodons and mammoths. During the talk, Ezekiel held a cast of a mammoth molar and a fossilized mastodon molar (Ezekiel, I6a). Next the family stopped by a podium with bird eggs on view. Just as he did in the dinosaur exhibit, Ezekiel listened intently while the museum employee talked about bird egg adaptations. He focused on the ostrich egg and continued wanting to touch it throughout the talk (Figure 11). His eyes widened when the employee brought out a blue emu egg for a size comparison to the ostrich egg (Ezekiel, I6c). The third and final talk the family listened to was in the mineral exhibit and was on rocks and minerals that fluoresce. Out of all three talks, this one was the most technical and abstract for a child. However, Ezekiel focused on the several minerals and rocks in white boxes. When he found one he wanted to see, he would pick it up and place it under the UV pen light (Ezekiel, I6d). He did not answer any questions asked of him at any of the three talks, but he maintained eye contact when talked to, stayed at the podium, did not wander off, and focused on the objects presented.

*Figure 11.* Ezekiel focused on an ostrich dummy egg during a talk on egg adaptations at the Perot Museum of Nature and Science. Photograph taken by Mrs. Lovegood.

**Questions.** Many questions were asked in all of the interactions. Some questions were fleeting. The purpose for these types of questions was to get an answer and move on to another topic or point of interest. Other questions led to further questions, sustained interest, or exploration. Since the second type of questions led to other behaviors indicating curiosity, those were the ones that were focused on in data analysis.

Ezekiel's questions were typically "why" questions. At the water park (second interaction), Ezekiel spent most of his time in the Lazy River which his mother and he described as a favorite place. Floating through the water, he asked why water parks did not make wave pools and lazy rivers together (Ezekiel, I3). As the family made a second loop through the Lazy river, Ezekiel asked why people can go through water. After spotting debris on top of the water's surface, he asked why can things float (Ezekiel, I3). When the questions were not "why" questions, Ezekiel would ask questions that were answered through exploration or discovery. One such instance occurred upstairs in the family room when Ezekiel was building with his Legos. He built a cannon and was about to attach it to the spaceship. He looked at the researcher and asked what would happen if he shot the Lego

cannon at his mouth. The researcher responded that he might swallow the tiny red Lego. However, Ezekiel clarified that his mouth would be closed. The researcher turned the question back on him and asked what Ezekiel thought would happen. Ezekiel responded "it might hit you and you will fall down but it won't hurt because it's a tiny Lego" (Ezekiel, I1, 249-250). Pressing the lever on the Lego cannon, Ezekiel then shot the cannon at his mouth to see what would happen. Another example of a question leading towards discovery happened during the construction of his solar viewer box. With the help of his mother, Ezekiel added the foil over the square hole to create an aperture. He had just finished taping the foil down and his mother was searching for a thumbtack, when he said "there you go. It's almost done. One more thing. Just a little hole. Where does the sun go? In this box" (Ezekiel, I2, 241-242). He picked up his box and started looking at all of the sides to try and figure out where the sun would shine through. Once the hole was made in the foil and he saw the light on the bottom of the box, he realized that the sun would shine through the hole.

Avery also posed many questions throughout the summer. When curiosity was sparked, Avery also used the strategy of asking questions regarding the "why". While driving through the animal park at Fossil Rim, Avery noticed the animals had tags in their ears. She asked her mom why the animals had tags. Her mother responded that the tags helped the employees know with which animals they were working with and keep track of how many of each animal were on the grounds of the park. Avery asked later on but referred to the tags as earrings (Avery, I4, 228-235). She also noticed a gemsbok missing one horn. This observation prompted Avery to ask why it had only one horn leading to a conversation between her and Mrs. Clark about the possibilities for the missing horn (Avery, I4, 288-295). During the same visit to the park, Avery inquired why they could not pet the deer that lived

in the neighborhood at home. Her mother informed her that the deer were wild animals and petting them would add scent to the deer. Not entirely satisfied, Avery asked why. Her mother responded by asking Avery if she smelled like deer. Avery responded:

> Avery: Human.
>
> Mrs. Clark: A human. So, if you touch a deer you're putting your human smell on them. And then they're not as protected in the wild. Momma knows some stuff about animals. (Avery, I4, 659-662).

Avery further asked why the deer were wild but was interrupted when an animal stuck its head into the window for food.

Not all Avery's questions arose at the animal park although that was where the lengthiest conversations resulting from a question took place. Every interaction the family had, Avery had questions. At the Fort Worth Museum of Science and History, Avery asked if the water shooting out of the fountain children were playing in was hot which developed into a conversation on using her observations to deduce information (Avery, I8, 2-7). When her family made crystals, Avery asked why the four smallest plastic cups were not filled up to the top with the crystal-generating solution (Avery, I3, 862). These were just a few of the myriad of questions posed.

Like Avery and Ezekiel, the majority of Michelle's questions consisted of "what is that," "why," or "how does this work." However, some of Michelle's other questions caused the adults to ponder the same question. One such question involved the insides of blueberries and why some have "green goo" on the inside while others have "purple goo" (Michelle, I5, 727-728). Adding to her question, Michelle stated she rarely finds purple and normally finds green. Expanding her question further, Michelle asked why the blueberries taste different on

the inside when they taste the same on the outside even when the inside color is the same. When asked to clarify, Michelle stated "the inside is the same color and the outside is the same color, blue and green, but the inside of the blueberries are all different. They taste different" (Michelle, I5, 738-739). Another instance arose from looking at photographs taken at the aquarium. Michelle asked what all the green was in the water. Her mother thought for a moment and responded that she did not know but that it might have been the aquarists mimicking how light moved through underwater (Michelle, I3). A further instance of questions transpired during the visit to the petting zoo. Michelle ran off to see the turkey and then ran back to ask her mother why the turkey was shaking. Her mother, unable to answer but curious, suggested that it was possibly because that was how the turkey breathed but did admit she did not know and wanted to know as well (Michelle, I1, 337-340).

**Unforeseen themes**

Observable characteristics of curiosity were anticipated because of the presence of these behaviors in previous literature and studies. As the data collection progressed, several unanticipated themes affecting curiosity quickly became apparent. Technology's impact on curiosity was unforeseen when the study was developed with the idea of using photographs as a data source. Interruptions and diversions were also unforeseen factors on curiosity. The curiosity of other, adults and siblings, was unexpected as well but did have an effect on the child participant's own curiosity. Fear of natural phenomenon was also unforeseen.

**Technology.** While technology has a broad definition, presented here it refers to devices that have screens and require some form of a power source. The main types of technology present throughout this study included smartphones, digital displays (both interactive and informative), and televisions. The ever-versatile and ever-present smartphone

provided several uses from the built-in camera to the plethora of mobile applications available.

While smartphones were always available, digital displays were found in places with educational leanings such as the botanical gardens or science museums. Informative digital displays presented information about the artifact on display. Sometimes the display ran on a loop requiring no manipulation from the viewer, but other times the display was a touchscreen. By touching designated places on the screen, the information would change. These digital displays were located in the aquarium, botanical gardens, and both science museums. Interactive digital displays presented information in a game-like manner through the use of touchscreens. The interactive digital displays in the botanical gardens had the children drag images of animals to the appropriate habitats or locate camouflaged animals within an image.

Televisions were present in the three homes and were on more than they were off. While the televisions were on, they were streaming video content for the other members in the house. Ezekiel was the only participant to have a television in the family vehicle. As soon as he would buckle into his car seat, he would put his headphones on and watch the television for the duration of the car ride.

While smartphones, digital displays, and televisions were the most prominent forms of technology, they were not the only forms present in the study. Tablets loaded with digital books and educational games were in the Clark's living room and car. Digital microscopes, programmable robots, and scanners with projection screens were at several of the informal learning environments. Laptops with internet provided access to video-streaming websites as

well. These technological devices supported curiosity in the child but at times also diverted curiosity or distracted the child.

***Supporting curiosity.*** Technology has the capability of supporting curiosity by providing readily available access to the world's information. Mobile applications are one such way information can be readily accessed. Typically topic-specific, mobile applications are pre-downloaded onto smartphones or are selected through an application store.

During a car ride to the Arboretum (sixth interaction), it started to rain about twenty minutes into a forty-minute drive. Michelle, clearly disappointed, complained about the rain stating that she hoped it would stop by the time the family parked at the botanical gardens. Out of habit and without thinking, the researcher opened a mobile application on her smartphone to look at the RADAR for the area (Figure 12). Reassuring Michelle and Austin (her brother), the researcher mentioned that they would not be in the rain much longer. When Austin asked why, the researcher showed both children the mobile application and explained how to read the RADAR image. Seeing yellow on the image, Michelle asked "is the yellow the water?" (Michelle, I6a, 305). In order to keep the explanation age-appropriate, the researcher provided a simplified explanation: the brighter the color became meant that the precipitation was typically heavier. To further emphasize the point, the researcher moved the screen down to the southern Texas coast where Hurricane Harvey had made landfall earlier in the week and stated "you see this really bright area, this red? That means it's thunder storming or raining really, really hard. But we don't have that where we are. We have the lighter colors" (Michelle, I6a, 317-321).

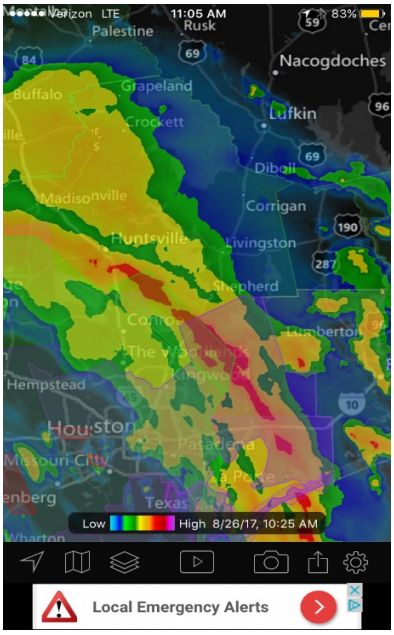


*Figure 12.* Screenshot of Hurricane Harvey on the RADAR mobile application Michelle explored on a drive to an interaction.

Further intrigued, Michelle began to ask about other cities in Texas that she knew. The researcher demonstrated how to move around in the application and handed the smartphone over to Michelle who then began to examine the scope of Hurricane Harvey on various places within Texas. At one point Michelle zoomed out to view the entire contiguous United States. Zooming out this far made the rains in the Metroplex difficult to view. This caused Michelle to ask the researcher to hold the smartphone while she put her hand out of the window to see if it was still raining as the car drove down the highway (Michelle, I6a, 421-423). Later in the car ride, Michelle noticed the red warning boxes outlining counties:

Michelle: But the red is darker than all of them.

Researcher: Yeah

Michelle: Why is it? Why is it raining hard? It should be when it's not that rainy.

Researcher: Well, red usually means warning, or watch out, or be careful. So that's why it's darker on the RADAR. (Michelle, I6a, 447-451)

Michelle then discovered that the mobile application also showed where reported earthquakes for the day occurred (Michelle, I6a, 529-537). This sustained interest concerning the various forms of information provided by the mobile application further demonstrated Michelle's curiosity with the RADAR. She had become comfortable enough with reading the colors used to show precipitation intensity. She had also associated the brighter colors with higher intensities. When Michelle noticed the blocks of red with only green precipitation, she questioned what she had learned and elicited information from the researcher to satisfy her curiosity. Michelle and Austin continued to take turns using the mobile application until the family arrived at the botanical gardens. At that point the smartphone was handed back to the researcher and the family piled out of the van. Whenever it began to sprinkle during the visit to the gardens, Michelle and her brother would refer to the rain in terms of colors from the RADAR. When it began to rain a little harder than sprinkling, Michelle expressed her distaste for the weather and stated "we only like it if it's light green" (Michelle, I6, 106). She then asserted that the rain was probably "yellow" but her brother disagreed with her and said the rain was only hard enough to be green (Michelle, I6, 105-115).

While Michelle was intrigued by the RADAR mobile application, Avery was curious about the compass mobile application. This discovery occurred while Avery was playing with the various applications already installed on the smartphone being used for children to collect their own photographs during interactions. In between recording and replaying videos, Avery stumbled upon the compass and called out "Momo [researcher], look what I found on your old phone" (Avery, 1a, 83). Once she found out what the mobile application was, she then wanted to know which way the car was traveling. By placing the smartphone in several different positions, she discovered that the needle on the compass would move. This

discovery led to her stating “you have to move it around” (Avery, 1a, 90) and asking “what way are we going? West, east, south? I don’t know” (Avery, 1a, 91). The researcher then instructed Avery and David on how to use and read the compass mobile application. For the remainder of the drive to lunch, Avery and her brother played with the compass.

For both Avery and Michelle, creating videos on smartphones with the built-in camera mobile application was a reoccurring occurrence. The creation of these videos was sometimes announced but was often made unannounced. It was not until the video was played that the adults were made aware of its creation in the first place. Michelle and Avery both had different purposes in the videos they created. Michelle created her video in a way that resembled a sports announcer while Avery’s videos were recorded to document what was happening much like a family video.

While baking cupcakes one evening at the Smiths’ home, Michelle and Austin wanted to help with the baking process as much as possible. Upstairs Mrs. Smith put Colin to bed for the night while Michelle and Austin remained in the kitchen with the researcher. Getting a start on the baking, Michelle, Austin and the researcher followed the instructions on the cake mix to prepare the batter. To maintain sibling harmony, the researcher provided the children with a measuring cup to dip into the batter and then pour into the muffin tins after the batter was thoroughly mixed. The children took turns dipping and pouring the batter. After Michelle took her turn and handed the measuring cup to her brother, she asked the researcher if she could take a video of her brother pouring the batter. Upon receiving an affirmative answer, Michelle picked up the smartphone, opened the camera application, pressed record, and narrated “Austin is making…we’re making cupcakes today with Miss

Morgan. Austin is pouring the batter into the cupcake holder and he finishes!" (Michelle, I5, 1146-1147). She then played the video back for her brother to watch with her.

Avery discovered the video-recording application very early in the research. On the way to lunch at a family-friendly fast-food restaurant after the visit to the river, Avery stumbled upon the video option in the camera application. She proceeded to record a video of the conversation in the car between the researcher and her mom which she replayed seven times (Avery, I1a). During the second interaction, Avery replayed the video of the conversation she recorded during the first interaction (Avery, I2). Several interactions later, Avery asked to watch the video from the first interaction during the drive to Big Rock Park but was told that it had been deleted after it was uploaded to free up memory on the smartphone. Instead of the first video, she watched a 17 second video taken during interaction seven where she created oobleck. After viewing the video, she laughed and stated that it was very short (Avery, I7a). Eventually, it got to the point where Avery watching videos she had created became a common occurrence. Her mother even said "I just thought my phone was ringing but she's watching that video" (Avery, 10, 338). Throughout several of the interactions, Avery's mother told her to stop making videos or to stop watching them. In all, Avery created and played videos in five of the ten interactions during the study.

Since smartphones were used for data collection, mobile applications were readily available. However, the smartphone was not selected as a data collection instrument for the mobile applications. Instead, the smartphone was chosen over a digital camera because of the assumption the children would be more familiar with operating a smartphone than a camera to take photographs. While photographs were originally intended for participants and the researcher to document instances of curiosity, they also became a way to support and show

curiosity. Out of all three participants, Avery was the most enthusiastic and intent on taking photographs of what she was interested in throughout the study's duration. She would excitedly share the photographs she took with statements like "look at all the pictures of rocks I've taken…I like to look at pictures" (Avery, I1, 455-457) (Figure 13).

*Figure 13.* Avery utilized technology to show her interest in fossils. Photograph taken by Avery.

At Big Rock Park, Avery wanted the adults to follow her and crawl into a crevice between two large rocks. The space was clearly too small for an adult to fit through. When Avery was finally convinced that an adult could not fit through the space with her, she took the smartphone to photograph the crevice. Upon emerging, she showed her mother and the researcher the space underneath the rocks.

In addition to the applications and camera on the smartphone, internet browsers also helped support curiosity. During two interactions (one with Michelle and one with Avery) internet websites fostered the curiosity happening at the time. In Michelle's case, the family

had just returned from a walk down the neighborhood canal where she had taken several photographs of plants in hopes that the adults could help her identify the names. Mrs. Smith and the researcher were able to identify only two of the plants in Michelle's photographs. For the remaining unidentified plants, Michelle asked to use the internet browser on the smartphone to look up the names. With the help of the researcher, Michelle identified all but one plant found on the walk (Michelle, I2d, 42-91). The second instance where internet websites supported curiosity occurred with Avery during the ninth interaction. On that day, it was too hot to go outside so Avery's mother was attempting to think of something to do inside the house. She went to her bedroom and returned with a laptop that she set up on the breakfast countertop. Avery hopped up on a barstool in front of the laptop and navigated to science videos on YouTube (Figure 14). These science videos illustrated various investigations which could be done with items found around the house. Several of the activities shown on the video website inspired both Avery and her mother to gather materials to recreate what the science videos had shown (Avery, I9b).

*Figure 14.* Avery demonstrated sustained interest while watching internet science videos. Photograph taken by researcher.

The smartphone was technology that was always present but was not the only technological tool used in the study. Informal learning environments utilized digital displays that invited patrons, especially children, to use. The majority of the digital displays could be categorized into two groups: informative only and interactive touchscreens. While the informative digital displays could still be touch screens, the sole purpose of these was to provide information. The touchscreen component functioned more like turning a page in a book. Interactive touch screens on the other hand, encouraged the person to learn the information through some sort of manipulation on the screen. Both of these displays appeared throughout the study in the interactions of all three participants.

During the sixth interaction, Ezekiel and his family attended the Perot Museum of Nature and History. This museum contained a variety of hands-on and informational-only exhibits. The museum level devoted to energy had several informational digital displays. One digital display on alternative cars provided a screen comparing the mechanics of different cars including diesel, hydrogen, hybrid, and conventional gasoline powered vehicles. While the cars could be changed in the side-by-side comparison by touching a down or up arrow, there was no other interactive element to the digital displays. Yet, Ezekiel stood by his mother until they went through each type of vehicle and compared the inner workings of each selection.

Another exhibit, this one on energy sources, located on the same level as the alternative cars also captivated Ezekiel. Six screens illustrating the more common forms of energy (biomass, nuclear, renewable, solar, electrical, and hydrocarbons) were mounted on the wall. When “start” was touched on the screen, the selected animated energy source would begin to talk about the pros and cons of that type of power. The animation would not stop

until it had run through its entirety. Ezekiel walked over to each display and turned them all on but did not watch. At first he did not appear to be interested in the presented information so his mother asked him if he would like to go join his sisters and father in the weather area of the museum (Ezekiel, I6f, 39-41). Instead of responding to his mother's question, Ezekiel went to the first video, started the animation, stepped back and sat on the floor (Figure 15). He repeated this process with each of the six videos until he had watched all of them. Once all six animations were finished, Mrs. Lovegood encouraged Ezekiel to follow her to the next exhibit to which he complied with her request (Ezekiel, I6f, 43-46).


*Figure 15.* Ezekiel watching an informational digital display on biomass. Photography taken by Mrs. Lovegood.

Avery and Michelle played with interactive touchscreens when they encountered them during family excursions. The Smiths encountered these types of touchscreens throughout the Estuarium as well as the Children's Discovery Gardens in the Dallas. These touchscreens reinforced the focus of each area. For instance, a touchscreen at the base of a two-story treehouse had children match an animal with an appropriate habitat. Michelle

spotted the touchscreens from above and ran down the spiral staircase circling the outside of the treehouse's trunk to the ground (Figure 16). Once there, she immediately began to play the game on the screen (Michelle, I6c). Her mother attempted to move her along through the park saying "okay, last one baby and then we're going to keep going" (Michelle, I6c, 382). But it was not until Michelle had matched every animal successfully that she moved. Further through the exhibit, Michelle was drawn to another touchscreen illustrating three types of energy (wind power, biomass, and geothermal). This touchscreen was a matching activity where the children would drag the picture to the correct label. Michelle stayed at this digital display until she had correctly matched all three types of energy to their names (Michelle, I6c, 602-607).

*Figure 16.* Avery using an interactive touchscreen at the Arboretum. Photograph taken by Mrs. Smith.

Whereas the digital displays that Michelle experienced were contained within the screen, Avery experienced digital displays that were linked to elements outside of the touchscreens. During her family's trip to the Fort Worth Museum of Science and History,

Avery and David went to the energy section of the museum. A 3D-model of a city that used both renewable and nonrenewable energy sources to power various portions of the model was located within this section of the museum. Eight touchscreens powered eight different sections of the model city and required the person to use critical thinking skills to determine the best amount of energy to turn on that section by touching the screen in several places. Avery and her brother went to each screen and completed the requirements to turn on that section of the city (Avery, I8). If another museum patron was at the screen Avery wanted to go to next, she waited patiently until it was her turn. In this section of the museum, the touchscreen served as a supporting technology with the main focus was the model city.

Other forms of technology supported the children's curiosities as well. Within the educational building at the Arboretum, there was a digital microscope connected to a computer screen. Next to the digital microscope was a compartmentalized box with a plexi-glass lid firmly screwed into place. In each of the compartments was an object from nature such as a butterfly wing, crystal, or a dried flower petal to examine with the digital microscope. As soon as Michelle and her family entered the educational building, the children headed towards the computer. Michelle referred to the digital microscope as a video (Michelle, I6d, 165). Both Michelle and David took turns looking at the items in the box with the microscope. Even though the microscope was never in focus, both Smith children sat in front of the computer until their mother ended the activity with a firm "okay, let's go" (Michelle, I6d, 191).

Avery and her brother enjoyed the technology they experienced in the dinosaur area of the Fort Worth Museum of Science and History. A giant projection screen greeted patrons of the museum as they entered the dinosaur exhibit. On the floor in front in of the screen

were four sets of dinosaur foot prints that had text instructing people to “stand here”. Once the computer recognized someone was standing on the footprints, digital velociraptors would appear and mimic the actions of the person standing in front of the screen. If Avery raised her hands in the air, the velociraptor would raise its arms. When Avery jumped, the velociraptor jumped as well (Avery, I8, 258-271). The Clarks visited this attraction twice during their visit to the museum.

Located on the other side of the wall containing the digital projection of velociraptors was another screen. This screen projected an origami-esque landscape (Figure 17) where dinosaurs walked across the paper-looking grasses and flew through the sky. These dinosaurs started out as a piece of 8x11 white paper with a printed outline. After picking out a dinosaur, Avery colored it while she explained to the researcher how the area worked:

Avery: You don’t have to color in the lines. It will just show up there [on the screen].

Researcher: Oh, wait. So you scan it and it goes up there?

Avery: I’ll show you. I’ll show you.

Researcher: Yeah, show me. That’s cool.

Avery: You can scribble scrabble. You can do it whatever you want. You can even get out of the lines and it just is that. (Avery, I8, 286-291)

Once the dinosaur was colored, Avery took it over to a scanner and scanned it into the computer. She returned to the table and eagerly awaited the arrival of her dinosaur on the screen. A “whoosh” sound announced the arrival of a newly scanned dinosaur into the virtual world. The appearance of her brachiosaurus was punctuated with a “I found mine!” (Avery,

I8, 318). The computer program animated the legs or wings, and head of the scanned image so the dinosaur appeared to move across the screen.

*Figure 17*. Animated display projected dinosaurs colored and scanned by Avery and her brother during a museum visit. Photograph taken by researcher.

There were six options of dinosaurs to color and Avery insisted on coloring each one. Between each scan, she would ask her mother if she could do another (Avery, I8, 390). After twenty-three minutes, David was ready to move on; yet, his sister was not ready to leave:

David: Let's go!

Mrs. Clark: Let her finish.

David: I can go put that up [scan the dinosaur].

Avery: Wait. Wait. Wait! Look! I saw mine!

Researcher: I see it. It moves very quickly. There it is. And there it goes. (Avery, I8, 394-398)

Once her dinosaur exited the screen, it was still difficult to leave because the dinosaurs returned periodically. This meant Avery wanted to stay and await the return of all her dinosaurs she colored.

***Diverting curiosity.*** Although not as prominent as supporting curiosity, technology was also capable of diverting curiosity. In both the Clark and the Lovegood families, technology was present in the vehicles. The Clark children always had their tablets in the car with them. When Avery and David were not taking photographs or videos with the smartphones, they were both playing games on their tablets. This could be interpreted as curiosity but it was not scientific curiosity as previously defined. Instead of conversing about what the family had just experienced or was about to experience, the two children were immersed in a digital world. The Lovegood family did not have a tablet at the time (it had met its demise just prior to the study) but there was a DVD player in the van. In place of a tablet taking precedence over conversations, a movie played on the drop-down television. Equipped with a personal pair of noise-cancelling headphones, Ezekiel's routine when he hopped in the car included buckling up and donning his headphones. In every interaction (totaling four of the six) where the family had to drive somewhere, Ezekiel was isolated from the rest of the family by the movie and headphones.

However, the car was not the only place where curiosity was diverted. One evening at the Smith's house, Michelle was sharing her polished rock collection with the researcher. She had lined up the collection of eight rocks on top of the granite countertop and was explaining the names she had given each rock. While she was naming each rock, she was fiddling with an iridium magnet in her hand that had originally accompanied magnetic silly putty. She accidentally dropped the magnet and observed it attract the hematite. This observation lead to

her touching each rock with the magnet to see which ones were attracted to the iridium and which were not. After she had gone through all eight rocks, she began to show the researcher which ones were magnetic. However, in the middle of talking to the researcher, the television show her youngest brother Colin was watching caught her attention. Without finishing her explanation, she went and sat down in front of the screen (Michelle, I5, 318-335) (Figure 18).

*Figure 18.* Michelle watching youngest brother's television show. Photograph taken by researcher.

**Interruptions and diversions.** Involving more than one person invariably introduced possibilities of interruptions. These interruptions were on purpose for safety reasons or parenting choices or accidental by the nature of conversations when siblings were present. Curiosity was also diverted through these interruptions. When this happened, the child's focus shifted from what he or she was initially curious in to another focus.

***Adult interruptions.*** Safety was one of the reasons adults interrupted instances of curiosity. Mrs. Clark, fearful of bacteria in the water did not allow Avery's interest in swimming in the Brazos River to come to fruition (first interaction). Even though the day

was hot, Mrs. Clark quickly responded "No! We are not getting in that thing" to Avery's suggestion that everyone go into the water (Avery, I1, 100-102). Another time Avery's curiosity was halted was due to the use of boiling water and plastic cups. One step required in the making of crystals required a solution with boiling water. Avery wanted to read the measuring cup to make sure the right proportion of water was used. However, Mrs. Clark desired Avery to take a step back while she poured the water. Recognizing the danger associated with boiling liquids, Avery took a step back and said "I will let you [pour]. I don't want hot water on me" (Avery, I3, 232). A third instance illustrating the impact of safety on curiosity occurred at Fossil Rim in the petting zoo. Goats roamed within the petting zoo with brushes located in various stations to brush them. Not raised around livestock, Avery was excited to brush one of the goats near her. Grabbing a brush, she walked around behind the goat to the side she wanted. When her mother observed this, she quickly commanded Avery's attention:

Mrs. Clark: Never walk behind a goat! Other way. Go the other way. There you go. See how it's easier. If you're going to, you want to walk a big circle behind it.

Avery: Why?

Mrs. Clark: So it doesn't kick you. You can pet him on that side. (Avery, I4, 975-981)

After that conversation, Avery was more hesitant and less eager to brush a goat. Instead she went to the pens to see what other animals were in the petting zoo. Eventually she did brush a couple other goats prior to leaving the petting zoo.

Mrs. Smith also interrupted instances of curiosity with concerns of safety. On the walk around the neighborhood, Michelle wanted to go much further than her mother. Expressing concerns for the lack of sunscreen and Cole's ability to keep up during a long walk, Mrs. Smith informed Michelle it was time to head back. Michelle, disappointed, ask why the family would not walk past the bridge. Mrs. Smith responded that the farther the family walked, the longer it would take to get back home and everyone would end up sunburned (Michelle, I2, 201-206). Once Michelle accepted the reason, the family turned around and headed home.

Another time safety took priority over curiosity was the evening the Smith family baked cupcakes. When it was time to take the cupcakes out of the oven, Michelle wanted to be right next to her mom. However, her mother told Michelle to back up since the oven was hot. Michelle asked for clarification. Mrs. Smith clarified that the inside of the door was hot and could leave a burn if touched. Once again, Michelle followed the instructions of her mother as soon as she had been given a reason (Michelle, I5, 1621-1623). Mrs. Smith set the cupcakes on the top of the stove range to cool. To pass the time while the cupcakes cooled, Austin inquired if he and his sister could go outside to look at an ant pile. Instead of providing permission, Mrs. Smith told her children no because it was "mosquito o'clock" and she did not want to deal with West Nile Virus (Michelle, I5, 2303). Switching tactics, Michelle told her mother she really wanted to go outside and see the sunset. Not missing a beat, her mother informed Michelle that the sunset could easily be viewed from the kitchen windows. Unhappy but acquiescing, Michelle turned her chair to face the window and muttered "I can't feel it" (Michelle, I5, 2323).

In addition to safety, adults also interrupted curiosity as the result of a parenting choice. An example of a parenting choice happened with the Lovegoods after the Nutcracker ballet. The family ran late getting to the theater so no one ate dinner. Instead, the family went to dinner at a restaurant after the play. Midway through the meal, Ezekiel took a straw wrapper and jammed it into the lid of the peppermill sitting on the table. After, he dipped his straw paper into his water to watch the water wick up the paper. His mother stopped him and told him he could not drink that water anymore because he had put germs in it. Towards the end of the meal, Ezekiel began to explore with his food. He dipped French fries in his milkshake, ground salt on his ketchup, and put pepper on his fries. If it had not been 10:30 at night, his mother may not have halted Ezekiel's exploration but because it was so late and the family still had to drive home, Mrs. Lovegood decided to end his explorations. His mother told Ezekiel "I want you to eat and not experiment" (Ezekiel, I4, 28).

Several instances of adults interrupting curiosity happened during the crystal making kit with Avery. When all the crystal-generating solutions were poured into the containers but still needed to cool before the seeding mixture was added, Mrs. Clark directed her children to their bedrooms to clean. Avery wanted to stay and watch the water in the cups. Her mother informed Avery that nothing exciting was going to happen and that the solutions were just cooling off. She then reminded Avery that she needed to clean her room (Avery, I3, 304-308). Later when all six crystal cups contained solution and seeding mixture, it was time to find a dry, warm place to store them undisturbed. Avery announced that her room was pretty warm but her mother informed Avery that her "room is pretty messy and [the crystals have] to be a place where they can't be moved around" (Avery, I3, 124-125).

For the Smiths, a day at the Dallas Arboretum needed to have a definite ending so that Michelle could make it back home in time for her violin lessons. Shortly after noon, the family headed towards the exit of the Children's Discovery Gardens. This required walking past the educational Discovery Center. Michelle asked if it was possible to go into the building. Mrs. Smith replied that it was lunch time so they would just have to come back to the gardens another day and see more. However, Austin supported Michelle's request to go into the Discovery Center. Mrs. Smith acquiesced on the condition that the family only stayed inside the center for five minutes (Michelle, I6d, 88-100). After a quick lunch in the café, it was time for the family to walk to the other side of the botanical gardens towards the exit. Upon leaving the café, Mrs. Smith crouched down to be eye level with her children. "We're going to be focused on walking so we can get back, okay. We can still look at stuff with our eyes, but let's not stop and go down rabbit trails, okay?" stated Mrs. Smith (Michelle, I6d, 413). No sooner than the family began walking did Michelle point to a trail that led to a waterfall. Mrs. Smith emphasized that they needed to get home and Michelle was not going to be able to walk through the water because Mrs. Smith did not want her children to be "soaking wet the whole way home" (Michelle, I6d, 419).

***Sibling disruptions.*** Similar to the adults interrupting or diverting curiosity, siblings had the same effect. Not as frequent as adult interruptions, siblings also diverted curiosity through behaviors such as asking to go to a different place, vocalizing an opinion, or interrupting the conversation of the child participant.

David, Avery's brother, tended to interrupt curiosity when he would ask to go to a different place. During the walk through the neighborhood (second interaction), David wanted to go home. Midway through the walk, David began to say that his legs were tired

(Avery, I2, 172). As he became more and more vocal about his legs, he frequently cut off his sister:

Mrs. Clark: Look. A mushroom.

Avery: I want it.

Mrs. Clark: Yo, it's not the eating kind. That would make you sick.

Researcher: It's the decomposing kind.

Avery: What's a decomposing kind?

David: Mommy, my legs are tired! (Avery, I2, 166-172)

Avery never did receive an answer to her question. Instead, attention shifted away from her question on the type of mushroom to Mrs. Clark calming David down enough to finish the walk back home.

Another instance occurred at the Fort Worth Museum of Science and History in the dinosaur dig area (eigth interaction). Using a brush, Avery swept sand to the side and asked "is there anything under here" (Avery, I8a, 99). David interrupted Avery's question when he pointed to a different area in the exhibit and said he wanted to go over there. Instead of finishing her exploration of the area she was in, Avery stood up and followed her younger brother to the new location.

Austin tended to interrupt Michelle's curiosity when he voiced his own opinion on what Michelle was doing. When the two siblings worked together to create a density jar (tenth interaction), Michelle wanted to see if the food coloring would mix on its own without stirring. She was content to sit back and watch what could happen if the glass was left alone. Austin, on the other hand, was very impatient and told Michelle to hurry up and stir the liquid. He became very adamant that instead of waiting to see if the food coloring mixed,

Michelle stirred the liquid (Michelle, I10, 308). Later, Michelle had rubbing alcohol she dyed yellow which she was adding to the density jar. As the liquid filled the volume of the glass, Austin began to notice the liquids nearing the rim of the glass. Possibly panicked, Austin began telling Michelle that there was "too much water" and that she needed to stop (Michelle, I10, 376). Once again, Michelle listened to her brother and stopped trying to see how much of the liquid she could add to the glass before it spilled.

The final type of disruption came in the form of conversational interruptions and stemmed from the natural flow of conversations involving three or more people. Austin tended to be more vocal that the other participants' siblings. Frequently he interrupted Michelle. When Michelle and Austin made lava lamps, Michelle started to ask "Can I do…" but was interrupted by Austin describing how many drops of food coloring he placed in his cup of oil (Michelle, I4, 611). Possibly Michelle was asking permission to explore or discover. Maybe Michelle was going to ask a question about the phenomenon occurring. Whatever the reason, Michelle's question was halted in Austin's enthusiasm. Another instance with Michelle and Austin happened on the day they were making bird seed ornaments (ninth interaction). The birdseed mixture was in the refrigerator. Michelle asked the researcher if they could do a test. The researcher encouraged Michelle. However, right before Michelle began to detail what exploration she wanted to test out during the period of waiting, Austin handed Michelle the LASAR thermometer (Michelle, I10, 446-451). This diverted Michelle's curiosity from the test she wanted to do and further investigation with technology.

**Initiation of others.** At times during the study, the curiosity of the children did not arise within but was piqued by outsiders. These outsiders, typically parents or siblings,

observed or interacted with the immediate surroundings in ways that elicited behaviors of curiosity from the child participant.

***Adult initiation of curiosity.*** At times, behaviors of curiosity were initiated by adults. These adults could be parents, the researcher, or employees of the place the family was visiting. Invitations to the child, questions posed, observations made by the adult, or actions taken by the adult were all ways the child's curiosity was piqued during interactions.

Inviting the child participant into an activity was a behavior only seen by employees. The employee at the Fritz Park Petting Farm encouraged Michelle to touch the feet of a chicken sitting in Michelle's lap. The employee also invited Michelle to touch the belly of the chicken as well (Michelle, I1, 83-86). The employees at the Perot Museum of Nature and Science also provoked Ezekiel's curiosity during the talks at the podiums located throughout the museum. One such instance happened at the bird egg museum talk. In discussing bird eggs while Ezekiel touched an ostrich egg, the museum employee mentioned her personal favorite was a Kiwi which lays the largest egg in proportion to its body size. Using her computer, the employee showed a picture of a kiwi bird and outlined the area similar in size to the kiwi's egg. Ezekiel smiled and gasps. He then listened intently as the museum employee shared more about various bird eggs (Ezekiel, I6c).

As the child participants used questions to share their curiosity, so did the adults. Often times these adult questions primed the children's curiosities. Making crystals with the Clark family entailed using dye. Since Mrs. Clark was the one who opened the individual packages, her thumb and forefinger eventually became discolored. She held her thumb up and asked Avery if the fingerprint was visible. Immediately Avery wanted to see her own fingerprints but was unable to due to the lack of discoloration her own fingers (Avery, I3,

836-841). Later in the summer, Avery wanted to recreate the coke and Mentos trick she had seen on the internet. After the reaction in both the diet and regular soda, Mrs. Clark asked Avery to notice the difference between the two beverages. Avery noticed the diet soda had less liquid remaining in the bottle than the regular soda. The question posed by Mrs. Clark and the observation by Avery led to Avery exploring what would happen if she dropped other candies into the two bottles (Avery, I9b, 565-566). In another example, Mrs. Smith asked if Michelle had seen the turkey gobbling at the Fritz Park Petting Farm. This question prompted Michelle and Austin to run off in search for the turkey. When they both returned, Michelle excitedly explained what they saw and insisted that her mother and the researcher follow her back to see the turkey as well (Michelle, I1, 137-140). A final example of the influence of adult questions happened on the walk around the canal with the Smith family. Michelle was examining the pistols of a flower on the bank. The researcher asked Michelle if the flower smelled good but Michelle had not smelled the flower. Surprised, since Michelle was so close to the flower examining it, the researcher asked "you're not sure they smell" (Michelle, I4, 85)? The second question induced Michelle to smell the flower and every subsequent flower on the walk to examine the smells (Michelle, I4).

Simply making an observation prompted the child's curiosity in some cases. At the Perot Museum of Nature and Science, Mr. Lovegood lifted Ezekiel up to view a casting of various dinosaur tracks which lit up to show different movements recorded in fossil beds. When he lifted Ezekiel up, Mr. Lovegood directed Ezekiel's attention to the lit footprints saying "they light up. Isn't that cool" (Ezekiel, I6, 14). Ezekiel began to ask about each of the colors of tracks illuminated. In the same exhibit hall Mr. Lovegood pointed to a skeleton of a moose:

Mr. Lovegood: Look at that dinosaur.

Ezekiel: That's not a dinosaur.

Mr. Lovegood: Then why is it in an exhibit about dinosaurs? (Ezekiel, I6, 9-10)

What ensued was a short conversation about dinosaurs leading to Ezekiel ask why the moose was in the dinosaur hall. Mrs. Smith also used observation to elicit Michelle's curiosity in the Children's Discovery Gardens. A replica of a log with doors to lift sat on a path leading to the water portion of the park. Michelle walked right by the log but Mrs. Smith stopped and beckoned Michelle over. "Look at this. It's got little hidden things," stated Mrs. Smith (Michelle, I6c, 458). Michelle stated she wanted to find some of the hidden objects and began lifted each flap searching for the camouflaged animal models. She continued lifted the flaps and searching until she found every animal in the log. Just as Mr. Lovegood and Mrs. Smith sparked curiosity with their observations, so did Mrs. Clark. When Avery and Mrs. Clark created a lava lamp in the kitchen, Mrs. Clark noticed the beads of food coloring descending. She prompted Avery to watch what happened as Avery added salt to the mixture (Figure 19). This observation statement caused Avery to view the lava lamp intently and for over ten minutes.

*Figure 19.* Curiosity piqued by an observation made by her mother, Avery looks intently at a glass filled with vegetable oil as food coloring and salt are added. Photograph taken by researcher.

The researcher also inspired curiosity through observations similar to the parents. While hiking in the Acton Nature Center (tenth interaction), the Clark family walked into an established oak tree grove. The researcher casually pointed out how one tree was growing horizontally and then vertically. This observation caused Mrs. Clark to remark on how fun the tree looked which in turn incited Avery's curiosity to the point where she ran off yelling "I want to go and slide on it" (Avery, I10, 436). She attempted to climb up on the trunk but was actually too short. After a couple failed attempts, Avery's attention was drawn to a lean-to constructed out of branches and twigs opposite of the twisted tree trunk.

Sometimes curiosity was triggered by the actions of the adult whether unintentionally or intentionally. The RADAR mobile application was one example of unintentionally triggering curiosity. Another instance of an unintentional triggering of curiosity followed a lunch at a restaurant with the Clark family (ninth interaction). As the Clark family was

leaving, movement in a very dirty fountain with low water caught the attention of the researcher. Unaware of Avery watching, the researcher crouched down to observe shrimp-looking larvae. Avery crouched down beside the researcher and peered into the water. The researcher found a twig to stir up the water and get a better look at the larvae. Avery asked what they were but the researcher had no idea. Eventually with the use of a smartphone, Avery and the researcher determined that the larval version of a damsel fly was what was in the fountain (Avery, I9a).

Mrs. Lovegood unintentionally triggered curiosity at the Perot Museum of Nature and Science as well. A wall with silhouettes of birds and the wings spans was located on the fourth floor. As the family walked through the bird exhibit, Mrs. Lovegood walked up to the bird wingspan wall, turned around, and placed her arms over the silhouette of a bird to see her arm span in comparison to a bird's wingspan. Ezekiel followed and tried out his arm span on several of the bird wingspan silhouettes (Figure 20).


*Figure 20.* Mrs. Lovegood's curiosity prompted Ezekiel's curiosity concerning the wingspan of different types of birds compared to his arm span. Photograph taken by researcher.

Intentional adult curiosity occurred most often in settings where the family paid an admission such as the Perot Museum of Nature and Science or the Children's Discovery Gardens at the Dallas Arboretum. In the water portion of the Children's Discovery Garden, Mrs. Smith cranked a lever to turn the Archimedes' screw raising water up to the top. When the water filled the bucket, the bucket would tip pouring water. Mrs. Smith wandered over to the lever first and turned it. This action drew the attention of Austin and Michelle. Michelle encouraged her mother to keep turning the lever to add more water. When the bucket tipped for the first time, Michelle started to turn the crank while her mother explained the historical purpose of the Archimedes' screw. As Michelle tired, Austin jumped at the chance to turn the lever and fill up the bucket (Michelle, I6c).

An additional instance of intentional adult curiosity took place at the Perot Museum of Nature and Science with the Lovegoods. Ezekiel stood in front of a thermal imaging screen with his father. He began to dance while watching. Mr. Lovegood rubbed his hands together and showed Ezekiel the heat from the palms of his hands. While Ezekiel watched, Mr. Lovegood shook his hands to show how the body parts cooled. Ezekiel copied. Taking a black screen from the display tray, Mr. Lovegood slapped it to show how heat transferred. Again, Ezekiel copied and slapped the black screen. Mr. Lovegood then explained what the different colors on the thermal image meant. Ezekiel stayed in front of the thermal imaging screen for ten more minutes dancing, slapping screens, and moving body parts (Ezekiel, I6, 1113-118).

After tending to the chickens at the neighbor's house (sixth interaction), Mrs. Clark, Avery, and David needed to water the garden. The tomatoes were planted in a raised bed garden in the shape of an "u". No tomatoes were ripe around the perimeter of the raised bed.

Casually, Mrs. Clark said that she thought there would probably be some tomatoes inside the "u" if only someone could fit in there. Avery, tending to another bed in a different part of the garden, ran over and said "I will go in there if you like tomatoes" (Avery, I6, 192). Once her mother replied in the affirmative, Avery ducked through the vines and went into the "u". She called out that there were green tomatoes but no red ones and exited the bed.

***Sibling initiation of curiosity.*** Even though all three participants had siblings, the younger brothers of Avery and Michelle were present during every interaction. Ezekiel's older sisters were rarely present. Therefore, instances of curiosity initiated by siblings were more prevalent in the cases of Avery and Michelle than in the case of Ezekiel. Sometimes curiosity was initiated or sustained when a sibling asked a question. Other times it was an observation or action which resulted in curiosity in the participant. And still other times curiosity was initiated by a command to come from the sibling.

Questions posed by a sibling would lead to the participant's interest in the source of the question. Austin was the only sibling across all three cases that posed questions during interactions. When the family walked the neighborhood canal during the second interaction, Austin asked where the water fountain was located (Michelle, I2, 86). The children had walked this same path with their father previously but not with their mother. The question was directed towards Mrs. Smith but since she had never walked that far down on the canal before, she was unable to provide an answer. Instead of generating a response from Austin's mother, the question caused Michelle to become interested in the possibility of seeing the fountain. This interest provided purpose for the walk. Twice the mother tried to stop the walk because it was the heat of the day and twice Michelle and her brother pleaded to go to the

fountain. Finally, the family reached the fountain (Figure 21) and Michelle took several photographs.

*Figure 21.* Water fountain located in neighborhood and accessed by sidewalks surrounding a canal. Photograph taken by Michelle.

While visiting the Dallas Arboretum, the stomach growling reached a point where the sound could no longer be ignored. Mrs. Smith led her children to the café for lunch. Every time a patron walked through one of the two entrances to the café a door chime sounded. The adults ignored this sound but eventually Austin asked "why is [the sound] the same thing over and over again" (Michelle, I6d, 326). This question brought Michelle's attention to the door chime. Announcements made by either her or her brother punctuated the air immediately following the sound of the chime. As Michelle noticed the frequency of the door chime, she then began to look around for the source. In very little time, Michelle connected the sound of the chime to an entrance door opening for customers. "[I] knew it! Because they're going out," pronounced Michelle as a family of four left the café (Michelle, I6d, 328). Desiring to find what created the sound now that she knew the cause, Michelle hurried

to finish her lunch. Pushing back her chair, she walked around the inside perimeter of the café waiting for another customer to enter or leave. Eventually a family walked in. Michelle ran back over to the table where her family was sitting to share that the sound was coming from a park bench placed near the door that had just opened (Michelle, I6d, 352). Once again, Michelle left, but this time she walked towards the bench and waited to hear the sound again. Immediately after Michelle pinpointed the source of the sound she ran back to the table:

> [The speakers] are over there, behind the bench. There's a white finger, like this… and it's just right there hidden. [The chime sound] popped my ear once I got close enough. It popped my ear. But I knew where it was coming from because it's mostly coming from over there. You can't hear it anywhere over here, or here, and then I tried over here. Ding-dong! Because it's bouncing off the window and stuff. And then once I looked for it over here. Ding-dong! Hits in my ear. And the best part is figuring out what it is. (Michelle, I6d, 357-362)

The question posed by her brother in annoyance during the beginning of lunch sparked Michelle's curiosity and led her to the discovery of the chime ("white finger") underneath the bench.

Observations from the siblings occurred more often and across all three participants than questions. The only interaction where Ezekiel's siblings were present was the solar eclipse (first interaction). During this entire interaction, his siblings were right next to him creating their own solar viewers. Once the family went outside to view the eclipse, the observations of his sisters sustained his own curiosity in the phenomenon:

Beth: The shadows are so weird.

Researcher: It's called ripple effect. I just heard about it on the news when I was driving up. So, the shadows look different when there's a partial eclipse and it's called a ripple effect. Scientists don't actually know what causes it.

Ezekiel: Yea, but how does look this way?

Researcher: They're studying it to try to figure out what causes that. (Ezekiel, I2, 431-437)

Prior to this observation, Ezekiel had taken his solar viewer over to the playset in the far corner of his backyard. He had climbed up the ladder to the platform above the ground. His sister then made the observation about the shadows. While the researcher was sharing information about the shadows that she had just learned, Ezekiel climbed back down the ladder, solar viewer still in hand, and came to stand next to his sister. Next he asked why the shadows looked the way they did. As the researcher responded, Ezekiel lifted his solar viewer back up to his eye and began trying to find the solar eclipse again. In this instance, his sister's observation had renewed Ezekiel's own interest in the solar eclipse.

At the petting zoo, the first interaction for the Smith family, Austin noticed a Texas spiny lizard basking on the ground in front of the steps. In his excitement of the observation, Austin called out "Guys. Guys. Look at the iguana on the steps" (Michelle, I1, 278). This shared observation intrigued his sister. Michelle, who had been coloring inside the barn, put her crayon down and walked out to the deck of the little barn. Her brother was sitting on the top step, starring at the lizard so Michelle sat down next to him. Both children sat very still and observed the lizard. They stayed this way for a little less than two minutes when the

researcher lost her footing, tripped, and scared the lizard away. With the lizard out of view, Michelle stated "I think he went under the barn" (Michelle, I1, 288). The resulting conversation led to Michelle sharing what she knew about iguanas while still keeping an eye out for the lizard. Soon after, both children got up from the steps and went back into the barn to color more. After ten minutes, Mrs. Smith called her children out of the barn. As Michelle stepped out, she started to scan the ground again looking for the lizard her brother had first observed.

One day (seventh interaction) while Cole was taking a nap upstairs, Michelle and Austin were playing the backyard. Austin noticed a hornet's nest attached to the underside of a swing on the playset. Michelle crouched down and twisted to the side from afar but was unable to see the nest. Frustrated, Michelle said "I can't see the hornet's nest" (Michelle, I2c, 58). Her mother provided a little more direction so that Michelle could locate the hornet's nest. This caused Michelle to walk up to the swing and stop about two feet away from it. She then bent down onto her hands and knees, twisting her head to the side. However, from this distance, she was still unable to see the nest. By this point the researcher had observed the hornet's nest as well which caused Michelle to ask if she could see it. She finally moved to a place where she could observe the hornet's nest attached to the underside of the swing.

Another instance of curiosity initiated by a sibling's observation occurred along the river banks of the Brazos during the first interaction with the Clark family. Many rocks of all shapes and colors covered the river bank. During the beginning of the family's walk up and down the river bank, Avery would only look at the rocks and take photos. As the walk progressed, she began to pick up rocks in addition to taking photographs of them. When her brother shared rocks he had found with her, she would look at them but not touch them.

Soon, David began to share the items he found with his mother and the researcher in addition to his sister. Once he began to do this, Avery started to take more interest in what her brother found. David bent down and picked up a rock. As he did this, he said "I found a shiny shell! Momo! Look" (Avery, I1, 194). This statement caused Avery to turn around and walk over to her brother. She took the shell from his hand and holding it in her own said "it's hot" (Avery, I1, 195). After this exchange, Avery shared an interest in the rocks and shells her brother found during the time at the river.

During another interaction where the Clark family was driving through the wild animal park (fourth interaction), David was looking at the map of the place. All of a sudden, he exclaims "there is horses we get to see!" and turns to his sister to show her the map while repeating his exclamation (Avery, I4,1271). Avery shared her own interest in seeing the horses in the park and leaned over the center counsel of the car to show the map to the researcher. Periodically throughout the remainder of the drive through the park, Avery would mention that she could not wait to see the horses. She wondered about the appearances of the horses, if they would come up to the car windows, and when she would be able to see them.

The actions of siblings, be it play, discovery, or exploration, would also spark instances of curiosity within the participant as well. During the interaction at the Brazos River with the Clark family, David began picking up rocks and throwing them in the river. First the rocks were more akin to pebbles in size and did not catch anyone's attention. Picking up a rock the size of his fist, David announced to everyone to watch what he was doing. When he knew he had everyone's attention, he hurled the rock towards the rushing river with a resounding plop. This caused his mother to pick up a rock and attempt to skip it across the river's surface while David continued to throw rocks. Avery joined in and

alternated between throwing rocks in the river to hear the plop and attempting to skip them across the river like her mother was doing (Avery, I1). Eventually David moved on to looking for fossils on the river bank with his mother but Avery continued throwing rocks into the river. At one point, Avery threw a rock in the river and then took a picture but by the time she pressed the capture button on the smartphone, the only evidence of the rock were ripples across the surface. Not satisfied with this, Avery picked up a larger rock and threw it. This time she successfully took a photograph of the rock with the splash that resulted. She then picked up three different sized rocks and threw them in the river to hear the different sounds each sized rock made as it plopped beneath the surface (Avery, I1, 146-151).

Another example of sibling actions provoking curiosity happened as the Smith family entered the education center at the Children's Discovery Gardens. Two choices to enter the building invited families inside. One entrance was a traditional glass door on hinges. The second choice was a rotating glass door. Mrs. Smith and the researcher headed for the traditional door. Austin headed for the rotating door to enter the building. Michelle remained indecisive for a moment and then opted to follow the adults. Once the family was ready to walk to the café for lunch, Austin ran straight for the rotating door yelling "Let's take the spinning door" (Michelle, I6d, 201). This time Michelle followed suit (Figure 22). Laughing, the children ran around the inside of the rotating door three times before finally stepping outside. Looking perplexed, Michelle inquired "how did you get out" when she noticed the two adults waiting patiently outside the glass doors (Michelle, I6d, 203).

*Figure 22.* Michelle and Austin run around the inside of a rotating door at the Children's Discovery Gardens. Photograph taken by Mrs. Smith.

An additional illustration where actions initiated behaviors of curiosity transpired during the evening cupcake baking session at the Smiths' home (fifth interaction). During the mixing of the batter, Austin was using a whisk to stir. This action caused Michelle to ask for her turn. When Michelle's brother ignored her and continued to stir, Michelle became very insistent in her request: "Austin can I have a turn? Can I have a turn? Austin, can I have a turn" (Michelle, I5, 992). Austin appeared to enjoy the mixing process because he was smiling and laughing while he stirred. Michelle, sensing she would not get a turn to stir if she did not do something, quickly suggested they use the whisk together. Each with a hand on the handle of the whisk and no hands holding the bowl, Michelle and Austin worked together to stir the batter as Michelle gleefully exclaimed "Austin, look. We're doing it together. Turn, turn, turn! We're spinning our whisk together" (Michelle, I5, 1002). This action lasted until the bowl almost came crashing to the floor. Austin cautiously suggested that they did not whisk together in order to prevent a cupcake batter mess.

Another significant aspect of sibling initiation was commands especially when issued from a younger sibling. While at the Brazos River, Avery wondered what color the rocks would be if the dirt was washed off of them. Instead of dipping the rocks in the river herself, Avery appealed to the researcher. However, instead of the researcher dipping the rock in the river to wash away the dirt and reveal the color, Avery's brother grabbed the rock, said "let me try" and dipped it in the river (Avery, I1, 215). The color of the rock tuned out to be a brilliant orange and the rock was slightly translucent. Upon seeing the newly washed rock, Avery stated that she liked the way the rocks looked when wet. After that, Avery no longer hesitated to see the change of color in a rock. If she found a rock that she liked the look of dry, she would also wash it in the river to see what it looked like wet before deciding to keep the rock for her collection.

When the Clark family was at the Fort Worth Museum of Science and History, David took the lead and chose the exhibit. Declaring he was going to the dinosaur dig, David walked off in the direction of the exhibit. Intrigued, Avery asked her mother where the family was going. Her mother informed her of the next location as decided on by Avery's brother. Once the family arrived, both Avery and David picked up brushes and magnifying glasses. Independently they worked together to excavate models of fossils. However, Avery's brother called for Avery to come work next to him. Together, Avery and her brother uncovered a large femur cast of a dinosaur that was once native to Texas (Figure 23).

David: Momma, I think we found a dinosaur bone.

Avery: This is the part we missed. That's the part we missed. It's all over the place. Momma, look what we found the rest of. (Avery, I8a, 179-182)

The demands of her younger brother led the family to the dinosaur excavation exhibit where David and Avery worked together to uncover a large dinosaur bone.

*Figure 23*. David and Avery unbury a dinosaur femur at the museum. Photograph taken by Mrs. Clark.

It was also the commands of Avery's brother that led to the sustained interaction with the animated projection of the velociraptors in the Fort Worth Museum of Science and History. Avery walked right past the digital projection when the family entered the dinosaur portion of the museum. She was headed towards the other side of the wall where patrons colored and scanned images of dinosaurs to animate. Her brother beckoned her over with a simple command: "Avery, come here" (Avery, I8, 258). This command redirected Avery's attention and she walked over to the digital velociraptors. She stood on a set of dinosaur footprints next to her brother and solicited the attention of the researcher as she began to interact with the display.

Austin, like David, also used commands to obtain his sister's attention. One of the first attractions that greeted guests at the Children's Discovery Garden is a skywalk. The

skywalk enables patrons to gain a bird's eye view of the canopy layer of a forest. Upon entering the gardens, there is a fork in the path. The skywalk is to the left and a downward slope veers off to the right. Michelle could not decide which path she wanted to take but her brother wanted to go to the skywalk first. Signs pointed out key features of the forest which the family viewed as they meandered through the skywalk at tree level. Approximately at the midpoint of the skywalk Austin pointed to a sign and said "Michelle, look at the sign" (Michelle, I6c, 316). This command drew Michelle's attention to a sign that described the levels of a forest from the top to the bottom. With both children peering over the railing, Michelle asked what was underneath the canopy. This question led to a discussion about the layers of the forest and how each layer had different animals that live there (Michelle, I6c).

The end of the skywalk led to a two-story tree house. Surrounding the crown of the tree were climbing nets and a view of downtown Dallas across from the lake. A spiral staircase curled around the outer trunk of the tree and led to the ground. Another spiral staircase wound through the inside of the tree trunk to the ground. Austin spied the tree trunk staircase first and encouraged his sister to join him. Looking back at her mother, Michelle asked if they could go inside the tree and down to the bottom. As soon as the children were granted permission, they raced down the stairs out of site. Once they reached the bottom, Michelle exclaimed "it's six miles down here" (Michelle, I6c, 338). When Austin and Michelle raced back up to the top of the stairs, Michelle shared with her mom about how they had gone all the way to the bottom and it was very interesting.

**Fear of nature.** Out of the three participants, Avery experienced fear in several interactions. One of the predominate fears, poison ivy, Avery held appeared in three interactions. Whenever Avery encountered a plant with pointy, green leaves and a visible

stem, she immediately asked if the plant was poison ivy (Avery, I6, I7, I10). Her mother reported that Avery had never experienced poison ivy prior. Another of Avery's fears were bees. When eating snow cones one afternoon, a bee flew too close to Avery. She screamed, threw her snow cone cup, and started sobbing uncontrollably while saying "there is a bee. I hate bees" (Avery, I7, 1292). Her mother drew her close and tried to calm her down by explaining the bees were drawn to the sugar in the flavored ice. However, another bee flew too close causing Avery to squeal and run away. Her mother suggested everyone pack up and start walking back to the car. On the walk back, the researcher asked Avery why she did not like bees. Avery responded that she just did not like them. Mrs. Clark added that Avery had never been stung by a bee either (Avery, I7, 1413-1418). Spider webs and snakes also caused Avery to change her mind about investigating an area further. She summed up her feelings best during the last interaction on the nature walk, "sometimes I don't like nature when it scares me" (Avery, I10, 200-201).

**Conclusion**

This chapter provided a description of each interaction for each participant (case). Following the establishment of each case, the themes identified during data analysis were described. Many instances of the behaviors of curiosity occurred throughout all of the observations during the summer and autumn to comprise support for each theme: anticipated or unforeseen. As the themes were developed, photographic data provided by the researcher, child, or parent were embedded. Anticipated themes included instances of exploration and discovery, sustained interest, and questions. However, many influences to the child's curiosity were unforeseen. These unanticipated traits included the influence of technology, interruptions and diversions, initiation of curiosity by others, and fear of nature.

# Chapter V: Discussion

Since existing literature on young children's curiosity is limited, this study was in response to this research gap. The main purpose was an investigation into the scientific curiosity of young learners. This chapter provides a discussion of the research questions guiding the study. This is followed by an analysis of the limitations and implications of the study. The chapter ends with outlining possible areas for future research.

## Research Question 1: Natural phenomena and curiosity

*What are young learners curious about that may possibly influence future science learning and education?*

Across group analysis highlighted several natural phenomena that elicited behaviors of curiosity. The phenomena which captivated the participants included observing animals, experimenting with sound, discovering what happens when mixing items, and using water. Young learners experience curiosity and enjoyment when they are provided opportunities to encounter natural phenomena (Eshach, 2006).

In every case, the children were curious about animals, as was apparent in across group analysis. Ezekiel demonstrated sustained interest at the science museum when the museum employees talked with him about bird eggs and mammoths. Avery showed sustained interest taking care of chickens, and trying to catch fish and egrets, as well as with all the exotic animals at Fossil Rim. Michelle also demonstrated sustained interest several times throughout the interactions when she was fascinated with a bleating sheep and a peacock, observed a fence lizard, and tried to catch a bird at the Arboretum. This curiosity with animals adds to research indicating children are naturally curious with their immediate surroundings (Drive, 1985; Howes, 2008).

The young children were fascinated with the phenomena of sound across the group as well. Animal sounds, sounds created by tapping, throwing rocks on the ground and in the water, and echoes fascinated the attention of the children. All of these instances of curiosity might be mistaken for play to an outside observer (Leibham et al., 2005) but provided avenues for the phenomenon of sound to be explored. Behaviors such as experimenting with the size and shapes of rocks (Avery) or changing the pitch and volume of an echo (Michelle) provided opportunities for the children to learn more about the phenomenon of sound and further develop an understanding of scientific processes. Piekny et al. (2014) found similar results with four-year-old children.

Additionally, the children were interested in any experience that allowed for mixing items. Building representations of objects found in life with various parts of toys fascinated Ezekiel. Being part of a family that embraced engineering, Ezekiel's construction behavior demonstrated his observation of the world as well as his sustained interest. Similar to the findings of Chak (2007), interactions involving mixing substances, solid or liquid, provided opportunities for exploration and discovery. Corn starch, oil, food coloring, water, candy, milk, dish soap, vinegar, and other household items were the mediums of both semi-structured and unstructured discovery for Michelle and Avery. These findings support and extend Johnson et al. (1980).

The children were also engrossed by water being a readily available resource (Siry & Max, 2013). Playing in the water at a waterpark or river provided a medium for exploration for Ezekiel and Avery. In places of informal learning, such as the water garden in the Arboretum or the eddies in the water park, the children were captivated by water as well. Furthermore, water was easily accessible in a kitchen and fairly easy to clean up, which

enabled the children to freely use water with minimal restrictions from parents. Utilizing water during kitchen science interactions provided a framework for the children to discovery and explore (Ramey-Gassert, 1997).

These natural phenomena illustrated in this research could provide avenues for future science learning in more formalized science education. Furthermore, the accessibility of these phenomena ensure that any child, when given the opportunities and encouragement, can have the possibility to develop scientific curiosity.

**Research Question 2: Emerging actions**

*When a natural phenomenon captivates a young learner's scientific curiosity, what actions follow?*

Prior studies on curiosity used participants in prekindergarten, or four years of age (Gerde et al., 2013), or older than third grade or eight years of age (Morais, 2014). Unlike previous research, this study included participants typically neglected in curiosity research. Furthermore, curiosity research prior to the 1990s focused on more structured, quantitative approaches, while research after the 1990s focused on curiosity in schools. This study made a conscious effort to observe instances of scientific curiosity in less structured environments in which the children were able to have more freedom. As such, time was not as large of a constraint as it would be in a classroom environment, nor were the settings of the interactions. Despite those differences, the actions following a young learner's curiosity have also been observed in prior studies in structured environments (Siry, 2013)

Depending on the natural phenomenon that captivated a participant's curiosity, several different actions followed. These actions included exploration and discovery (Reeve & Nix, 1997), sustained interest (Silvia, 2005), and sharing interest with other people through

conversations and questions (Thoman, Sansone, Pasupathi, 2007). Exploration and discovery tended to be most prevalent during unstructured experiences where the child was provided with opportunities to explore. The more structured an interaction, the fewer instances of exploration and discovery appeared. Sustained interest indicated the child was engrossed in the natural phenomenon because he or she stayed engaged with the phenomenon for an extended period of time or returned for further interactions. When a natural phenomenon interested a child, the child either posed a question or shared observations of knowledge. When people experience something interesting, sharing it with other people who are good listeners can transform memories of the event and make it more salient.

**Research Question 3: Experience characteristics**

*RQ3: What are characteristics of experiences young learners bring with them from outside of their schooling that may influence scientific curiosity?*

Since most experiences prior to formal education occur within families, young learners bring pre-formed understandings of what is allowable when curiosity is sparked (Crowley & Jacobs, 2002). Depending on the values of the family, these characteristics may include the incorporation of technology and familial dynamics.

Technology, relatively new since the main body of research on curiosity was conducted prior to the 1990s and in the early 2000s, supported and diverted curiosity in the children of this study. Across group analysis showed several instances where technology diverted curiosity. Ezekiel would get in the vehicle and put his headphones on to watch a movie. There he would stay absorbed, withdrawn from family conversations and sights that passed by in the car window. In this extreme case, he remained isolated from the rest of the family. However, he was not the only one for whom technology withdrew him from family

conversations. Avery and her brother David also had access to technology in the vehicle. The absence of headphones enabled Avery to at least hear the conversations. When she heard a portion of conversation that caught her attention, she would place whatever technology she was using aside and enter into the discussion. Michelle had virtually no access to technology during car rides and even with her seat in the far back of the van, she participated in conversations and observed what was outside the windows.

The three participants encountered technology outside the vehicles as well. In places where technology existed, it could serve to encourage learning. Similar to the findings of Arnone, Small, Chauncey, and McKenna (2011), informal places of education, such as museums, capitalized on the use of technology to engage patrons, stimulate curiosity, and support interest. Given the choice, Avery would probably have stayed at the dinosaur exhibit all day to color and animate her creations. Most of the time Michelle used technology to support her own curiosity by looking up plants with the internet or examining objects under a digital microscope. Ezekiel also utilized technology in a museum to support his own curiosity on types of energy. Technology was present in one way or another throughout most of the interactions. Therefore, it was a characteristic of those experiences and it is important to understand that technology has the potential to support scientific curiosity (Arnone et al., 2011).

Familial influences provided an additional characteristic of the experiences. Supporting the research of Liebham et al. (2005), the relationships within families impacted instances of curiosity. Sometimes parents halted or encouraged curiosity due to parenting choices. This finding supports literature on parenting (Moore & Bulbulian, 1976) which states that parents “tend to reinforce curiosity and exploratory behavior” (p. 171) as well as

the influence of other adults (Engel, 2011). Exploration had the potential to be dangerous or sometimes have an associated element of fear. Bacteria, infections, and sanitation are not normally considered by a child but are in the minds of adults such as Mrs. Clark. Sibling influences also had the capacity to initiate curiosity through questions, commands, or exploration (Chak, 2007). While the younger brothers encouraged curiosity, at times they also halted it due to attention-seeking behavior such as whining, exhaustion, or hunger. However, across group analysis also revealed that parents initiated instances of curiosity through conversations, questioning, and even the parent's own curiosity behaviors. This finding supports previous research (Crowley & Jacobs, 2002) which suggested that the behaviors of parents, especially explanations to questions, help children resolve cognitive conflicts and create extending questions. Educators need to understand how the dynamics of the family have laid the framework for the scientific curiosity of children in class. Adults who foster instances of curiosity tend to encourage children to be more willing to express and act on curiosity; whereas, adults who tend to limit expressions of curiosity tend to influence children to express fewer instances of curiosity (Engel. 2009).

## Limitations of study

Even though the results of this study are not intended to be generalizable, several limitations influenced the research. These limitations included sample size, recruitment, relationships with the researcher, and technology as a data collection tool.

Sample size was a limitation to this study. Originally the researcher intended to recruit one female and one male child in each age of interest, resulting in six participants. However, recruiting participants proved to be a difficult task. Initially there was a large interest from families desiring to participate. However, when the researcher informed the

potential participants of the requirements of the study, specifically that a parent needed to be present, interest declined. This resulted in only three young children participating in the study. With only three participants, it was impossible to have a girl and boy of each age.

Participant recruitment presented a limitation to the research. The nature of using a purposive sample limits the variability of the sample. All of the participants in the study had previous relationships with the researcher. This carried the implication that the families came from similar circles as the researcher due to how they were recruited. The decision to utilize purposive sampling, while enabling the researcher to grow and develop, carried an additional consequence of limiting the knowledge on scientific curiosity as it emerged. Since a lack of diversity existed within the sample, the three participating families valued similar characteristics and behaviors of curiosity as the researcher. The observed characteristics of scientific curiosity in this study may not be a complete representation, thereby unintentionally limiting the researcher's understanding of this subcategory of curiosity. Furthermore, this lack of diversity aided in the data collection since instances of scientific curiosity were permitted to happen more often than they were halted. However, the lack of diversity also means that this study cannot speak to what happens to scientific curiosity in families that do not actively support questioning or exploration and discovery.

Furthermore, all three participants and their parents had pre-existing relationships with the researcher; therefore, the participants may have been influenced by those relationships. Since the families had personal connections to the researcher, particular interactions may have been selected by the families to provide the greatest opportunities for natural phenomena to emerge. These personal relationships resulted in a conscious and ever-present effort of the researcher to record and analyze data with an objective lens, and to be

careful not to include other aspects of the families not observed during the duration of the study.

The decision to use an older smartphone over a digital camera was made due to the assumption that children would be more familiar with the former than the latter. Yet, this decision introduced a piece of technology that provided opportunities for diversion or interruption of curiosity. While the camera mobile application was familiar to the children, the use of a smartphone for data collection also provided access to all the other capabilities of a smartphone, including the mobile applications. This meant that during interactions, a child, such as Avery, could open up other mobile applications like the video application or the RADAR application. Some of the mobile applications enhanced the curiosity or presented opportunities to foster curiosity that would be unavailable without a smartphone. However, others interrupted curiosity or took the child out of the interaction as the child became absorbed in a mobile application. Even though the use of a smartphone for data collection introduced an unintended variable, since there was no ability to limit the child participants to only using the camera application, it was still the best choice in terms of what all three children were familiar with to take photographs.

## Implications

The researcher made a conscious decision during the planning of this research to conduct the study away from school environments. However, there are several implications for education resulting from this study. One implication focuses on how educators, specifically early childhood and elementary, teach. Other implications include learning environments, and designing lessons.

Often times educators have strict scope and sequences that have to be followed even in the early elementary grade levels. However, there is a delicate balance between adults fostering curiosity and interrupting it. All too easily, educators run into the potential danger of disrupting a child's curiosity in order to move the instruction forward. Questioning often tends to be interrupted by a teacher in order to move the conversation and discussion. In the same way that parenting styles suspended curiosity in this research, so do teaching styles have the potential to interrupt scientific curiosity. If a teacher loathes messes, exploration may be interrupted. If time is a constraint to a lesson or subject, discovery and sustained interest may be diverted.

Similar to educator behavior, learning environments need to include informal science experiences which support behaviors of scientific curiosity. In early elementary learning environments, educators should have several open-ended areas such as sand and water tables. To work best, these types of learning environments should allow for a myriad of possible combinations or solutions. Several variables (e.g. objects with varying densities in a water table) also increase the multitude of solutions. Given that young children are intrigued by sound, animals, and mixing as indicated by this study, opportunities to explore those natural phenomena can be incorporated into classrooms and educational settings. In addition to tangible items to explore, these informal experiences need to have time built in for unstructured discovery. Pairing children with more or less knowledgeable others in informal science experiences provides a companion to explore, discovery, and experiment with natural phenomena.

The findings of this study reiterate the importance of providing lessons that include curiosity behaviors: questioning, exploration, and discovery. Designing lessons that provide

avenues for these behaviors enables students to have opportunities to develop scientific curiosity. Lessons with these attributes may lead to sustained interest which persists over time. Currently curiosity decreases as children move into consecutively higher grades. However, implementing lessons where experimentation, discovery, questioning, and sustained interest are allowed—even expected—to arise, may reverse this trend. As educators, we want curiosity to remain in education for as long as possible because many businesses and post-graduate opportunities look for employees who are innovative, creative, and pioneering. In order to have those characteristics, a person needs to be curious. Walt Disney described children as "sensitive, humorous, open-minded, eager to learn, [with] a strong sense of excitement, energy and healthy curiosity about the world in which [they live]. Lucky indeed is the grown-up who manages to carry these same characteristics over into adult life" (Watts, 1997, p. 359). Deliberately planning lessons to foster scientific curiosity throughout a child's education is one way to increase the chance for producing a curious adult.

## Future Research

Since curiosity research is beginning to enjoy a revival and there is a limited body of research on young children older than four but younger than eight, there are several recommendations for future studies. These areas include conducting research with a larger sample, examining the influence of technology on curiosity, studying the impact of the type of formal education on curiosity, and investigating the influence of siblings on curiosity.

This research used a very small sample with only three young children participating. Expanding the study's sample size while following the same procedure would increase the trustworthiness. The participants in this current research were from similar socio-economic

statuses with parents of similar educational backgrounds. Two of the three participants were from Caucasian households, and one participant was from a multi-racial household. The backgrounds of the participants limited the diversity of the sample. Increasing the sample size in future research to not only include more children in each age group but also to increase diversity would possibly shed an informative light on scientific curiosity.

Originally intended for data collections only, technology became an unforeseen theme as its influence on curiosity emerged. Further studies could look at the influence of technology on scientific curiosity. As seen throughout the cases comprising this research, technology had the capacity to foster or divert scientific curiosity. Technology consists of a large variety of types ranging from smartphones to televisions to touchscreens to animated displays in museums. The body of research on curiosity would benefit from a study considering how these various technologies influence or divert scientific curiosity, especially as technologies continue to permeate every aspect of our lives in the western world.

Research on the impact of the type of education a child receives would also expand on this study. Scientific curiosity may be influenced by the type of formal education a child receives. In the United States, parents and guardians have several choices for education: public, private, charter, homeschool, or on-line. What does the impact of the type of education have on the child, considering the fact that research has shown that instances of curiosity trend downward as a child progresses through the public education system? Does this same trend occur in other types of education?

A fourth area of future research would benefit from a study on the influence of siblings on the curiosity of the young child. In this study, all three participants had siblings. Two of the three participants' siblings were younger, whereas the third participant had older

siblings. Researching the effect of younger, older, or no siblings on the scientific curiosity of a young learner would be beneficial to the line of curiosity research.

# Chapter VI: Epilogue

Developing relationships during qualitative research over extended periods of time is difficult to avoid. Multiple case study methodology further complicates the ability of a researcher to avoid relationships with participants, since trust needs to be fostered between all involved parties. Working with young children presented a third factor which complicates the attempt to avoid developing relationships with participants. What follows is a brief account of how the relationships between the participants and the researcher have continued beyond the conclusion of the study.

## Lovegood family

The researcher has maintained contact with the Lovegood family since the conclusion of the study. This contact has predominantly happened through social media and texting since the drive is time-consuming. However, the researcher and the Lovegood family have reunited once in December. Ezekiel has started kindergarten and is homeschooled by his mother. He still enjoys constructing creations in his mind with Legos. According to his mother, Ezekiel is quickly learning his letters and sounds and is eager to start reading all types of books on his own. Once the current school year winds down, the Lovegoods and the researcher plan to reunite and go on a couple of excursions around the Dallas/Fort Worth area for fun.

## Clark family

The Clarks and the researcher have continued to spend time together since the conclusion of data collection. Because of the long drive, visits are not weekly as they were during the summer. Avery is now in second grade. Her parents made the decision during the end of the summer to enroll Avery in public school. She has turned into an avid reader of

chapter books, and her interest in non-insect animals has deepened as her reading skills have improved. Her parents gifted Avery and her brother a membership to Fossil Rim Animal Park for Christmas. Avery has reported to the researcher that she is still trying to sneak up on birds but has been unsuccessful so far.

**Smith family**

Similar to the Lovegood family, the researcher and the Smith family have seen each other only once since the conclusion of the research. However, the researcher and Mrs. Smith keep in touch with phone calls as well as texting and social media. Michelle is eagerly awaiting the conclusion of the next two months so she can greet her baby sister and no longer be the only girl in the house. Michelle is attending second grade this school year. She still loves anything art related and still enjoys sharing what she has learned at school with her family. Once the baby arrives and summer begins, the researcher and the Smith family have plans to revisit Fritz Park Petting Farm and take a few more walks through the neighborhood. As with all three families that participated in the study, the drive makes frequent visits an all-day endeavor.

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Appendices
Appendix A: IRB

# INSTITUTIONAL REVIEW BOARD

# STUDENT PROTOCOL REVIEW REQUEST

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The TCU Institutional Review Board (IRB) is responsible for protecting the welfare and rights of the individuals who are participants of any research conducted by faculty, staff, or students at TCU. Approval by the IRB must be obtained prior to initiation of a project, whether conducted on-campus or off-campus. While student research is encouraged at both the undergraduate and graduate level, only TCU faculty or staff may serve as Principal Investigator and submit a protocol for review.

Please submit this protocol to the appropriate Departmental Review Board for recommendation and submission to the IRB. DRBs will submit to the IRB electronically at IRB.StudentSubmit (pdf preferred). Include the Protocol Approval Form as a word document with highlighted sections filled in. Also submit a consent document, HIPAA form if applicable, Protecting Human Research Participants Training certificates, recruitment materials, and any questionnaires or other documents to be utilized in data collection. A template for the consent document and HIPAA form, instructions on how to complete the consent, and a web link for the Protecting Human Research Participants Training are available on the TCU IRB webpage at www.research.tcu.edu. Submission deadline for protocols is the 15th of the month prior to the IRB Committee meeting.

1. **Date:** 1.17.2017

2. **Study Title:** Scientific curiosity in young learners (DRB-1703-106)

3. **Principal Investigator (must be a TCU faculty or staff):** Dr. Molly Weinburgh

4. **Department:** Andrews Institute of Mathematics and Science Education

5. **Other Investigators: List all faculty, staff, and students conducting the study including those not affiliated with TCU.**
   Morgan Stewart (Education)

6. **Project Period:** 4.1.17-3.31.18

7. **If you *have* external funding for this project –**
   **Funding Agency:** NA **Project #:** **Date for Funding:**

8. **If you *intend to seek/are seeking* external funding for this project –**

   **Funding Agency:** NA **Amount Requested From Funding Agency:**

   **Due Date for Funding Proposal:**

9. Purpose: **Describe the objectives and hypotheses of the study and what you expect to learn or demonstrate:** This study seeks to add to the limited body of research on scientific curiosity in young learners by providing answers to the following research questions:
    a. What are young learners curious about that may influence future science learning and education?
    b. When a natural phenomenon captivates a young learner's scientific curiosity, what actions follow?
    c. What are characteristics of experiences young learners bring with them from outside their formal schooling that may influence scientific curiosity?

    Through this close investigation of participants, I anticipate to observe young learners engaged in familiar and unfamiliar environments within familial units. Because this is a qualitative study, no hypothesis can be predicted.

10. Background: **Describe the theory or data supporting the objectives of the study and include a bibliography of key references as applicable.**

    Existing literature on curiosity and interest within elementary science education reveals a dearth of studies on young learners and their personality traits that may indicate curiosity in science. Within this body of literature, a large quantity of research on upper elementary students in third to sixth grades as well as on pre-kindergarteners exists. Yet, early elementary students (kindergarten to second grade) remain a relatively unexplored population. Furthermore, as published studies have continued to illustrate a decline in positive attitudes towards science (Osborne, Simon, & Collins, 2003), research focused on science interest has overshadowed research on curiosity. It is at this intersection, where the lack of research on the curiosity of children from five to seven-years old, that this study is situated.

    Since curiosity is a personal and independent endeavor where a person constructs knowledge on an individual level, situated learning theory (Lave & Wenger, 1991) will provide the theoretical framework for this study. Situated learning theory is rooted in the work of John Dewey (1938) and Lev Vygotsky (1987). As with social constructivism (Vygotsky, 1987), situated learning theory consists of a process where meaning is constructed from real, daily activities in conjunction with social relationships. Unlike social constructivism, situated learning theory describes junctures where prior knowledge creates connections with informal or authentic experiences. Lave and Wenger (1990) explain that through the process of participation in a learning activity, children construct their own knowledge from the combination of prior and current experiences. Social interactions and collaborations are essential to this knowledge acquisition as are authentic contexts.

    Curiosity can be thought of as a desire (Kashdan et al., 2009) to know more information about something and is elicited by ambiguity, complexity, or novelty (Litman, Collins, & Spielberger, 2005). Scientific curiosity as defined by Harty and Beall (1984) is a desire for information only related to the domains of science. Children are born as little

scientists (Gopnik, 2004) and are naturally curious from birth (Piaget, 1952). By investigating the world around them, young children seek information to help them resolve cognitive disequilibrium resulting from novel experiences. When encountering information that does not fit within an existing theory of the world, a child will strive to find information that fills in a cognitive gap between the child's theory of the world and the new knowledge encountered (Jirout & Klahr, 2012). Behaviors such as problem solving, sustained interest, or discovery indicate that a child is curious and desires to resolve information gaps. Depending on the intensity of the curiosity, the process of encountering a new idea, seeking out information to fill the cognitive gap, and then resulting in knowing typically leads to more questions (Loewenstein, 1994) and the cycle of curiosity continues.

In young learners, a curiosity for the natural world exists (Chak, 2007). Through their propensity to explore, young learners are motivated to acquire new knowledge despite conceptual conflicts. Typical behaviors that may indicate curiosity include child-initiated experimentation or exploration and discovery (Chak, 2007). Exploration and discovery differ from child-initiated experimentation because as the child explores the environment, he or she investigates in a haphazard manner unlike the systematic manipulations in experimentation. To an outside observer, these behaviors may take on the appearance of play (Siry, 2013), but it is through these activities that children begin to develop their scientific processes (Piekny, Grube, & Maehler, 2014).

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Vygotsky, L. S. (1987). The genesis of higher mental functions. In R. Reiber (Ed.), *The history of the development of higher mental functions* (Vol. 4, pp. 97-120). New York, NY : Plennum.

11. **Subject Population: Describe the characteristics of the participant population including the inclusion and exclusion criteria and the number of participants you plan to recruit:**

Due to the young children being younger than seven years old, this study will use two populations of participants: young children and the parents/guardians. The primary participants and the main focus of the study will be the young children. The secondary pool of participants will be the parents/guardians of each of the young children. As such, there will be up to six young children and the parent/guardian for each young child.

Since the primary participants are young children, a rapport and trust will need to be established with both the legal guardians and the participants prior to any data collection. To foster this relationship, several face-to-face informal, conversational meetings will be conducted after selection for the study in a variety of environments including but not limited to living rooms and public parks.

Two populations will be included: child and parent/guardian. Permission (provided by the parent/guardian for child due to young age) and consent (for adult to participate in interviews) will be obtained from a legal parent or guardian who will also be considered participants of the study due to the researcher working with minors. Inclusion selection criteria requires no more than two children in each age group from five to seven years old for a total of up to six participants. Participants (child and adult) must be able to understand and communicate in English. Participants will need to be comfortable in a variety of settings around others. Furthermore, a legal guardian will need to be present at all interactions and maintain contact with the researcher between interactions.

Legal guardians will also be interviewed; therefore, they must be willing to participate in one semi-structured interview.

12. **Recruitment Procedure: Describe your recruitment strategies including how the potential participants will be approached and precautions that will be taken to minimize the possibility of undue influence or coercion. Include copies of the recruitment letters, leaflets, etc. in your submission.**

The recruitment will begin with a purposive sample. Participants will be recruited through a combination of selection criteria (noted above) and connections until fulfillment is attained. Since rapport will need to exist with the young learners prior to the beginning of the study, the researcher will begin recruiting through relationships with friends and church members. The researcher will gradually increase recruiting from personal relationships to referrals from close friends to acquaintances until the number of desired participants is obtained.

13. **Consenting Procedure: Describe the consenting procedure, whether participation is completely voluntary, whether the participants can withdraw at any time without penalty, the procedures for withdrawing, and whether an incentive (describe it) will be**

offered for participation. If students are used as participants, indicate an alternative in lieu of participation if course credit is provided for participation. If a vulnerable population is recruited, describe the measures that will be taken to obtain surrogate consent (e.g., cognitively impaired participants) or assent from minors and permission from parents of minors.

Prior to the first interaction, the researcher will meet with the parent/guardian and young learner to go over the study. Since assent (written or verbal) is not required from children younger than 8 years of age, only parent permission and a media recording release for the child and consent for the adult will be obtained. After granting permission, the participants and/or legal guardians may withdraw from the research at any time by informing either the researcher (Morgan Stewart at morgan.stewart@tcu.edu) or Dr. Molly Weinburgh (m.weinburgh@tcu.edu) by phone, email, or verbally. Since this is a qualitative study and data analysis begins as soon as data are collected, any data collected up to the point of the withdrawal of a participant, adult or child, will remain with the researcher. However, no other data pertaining to both participants related to the one requesting withdrawal will be collected. No incentives will be offered to participants or their legal guardians for participation in this study.

14. Study Procedures: Provide a chronological description of the procedures, tests, and interventions that will be implemented during the course of the study. Indicate the number of visits, length of each visit, and the time it would take to undergo the various tests, procedures, and interventions. If blood or tissue is to be collected, indicate exactly how much in simple terms. Flow diagrams may be used to clarify complex projects.

Once participants are recruited, parents/guardians will be provided with a packet. The packet will contain a cover letter (Appendix A) briefly describing the purpose of the study, a parent permission (Appendix B) pertaining to the child's participation, a parental consent form (Appendix C) pertaining to the parent's participation in the study, and a media release form (Appendix D) for photographs and audio files.

Next, a series of three to five hour-long interactive sessions will be conducted prior to any data collection. The purpose of these interactions will be to develop rapport between both the parent/guardian and the child participants. These sessions will be conducted in the home, parks, or other places the family feels comfortable interacting with the researcher. While the activities the researcher and child engage in are unique to each child participant, they may include completing puzzles, reading and discussing picture books, walking or playing outside, or coloring. The intent and importance of these interactions is to begin to create space for the child and parent to develop trust with the researcher.

Once all parties in the study feel comfortable with the developing relationship, an initial semi-structured interview with the child participant will commence. This interview will not exceed thirty minutes and will follow the initial interview protocol (Appendix E). These interviews will be digitally recorded and transcribed at a later time. Within a week following the interview with the child participant, a one hour, semi-structured interview with the parent/guardian participant. In addition to the question stems provided in the initial interview protocol (Appendix E), questions developed from the responses of the

child will also be included. Since these questions cannot be created until after the interview with the child, interviews with the parent/guardian cannot occur immediately following the conclusion of the child interview.

After the conclusion of the initial parent interview, the researcher and parent/guardian will work together to create an open line of communication to allow for invitations for the researcher to accompany family excursions to various places as well as participating in some daily family activities. Since curiosity stems from what interests the child at that time, these excursions and interactions will take a variety of forms. They may include visits to zoos or museums, walks to a park, or bug searches in a backyard. Just like the type of excursion will vary and is difficult to predict, the duration of each excursion or interaction will also be difficult to predict. However, to create the most complete picture of scientific curiosity in young learners, the duration of the observation will match the duration of the excursion to provide opportunities for descriptive data collection (Creswell, 2007). For example, the observation of a trip to the zoo will occur for the entire stay at the zoo.

During these interactions or excursions, field notes, observations, photographs taken by both the researcher and the child, and other artifacts such as drawings, library checkout lists, paintings, or writings will be collected as multiple data sources (Yin, 2008). Photographs taken by the researcher will focus on instances of the child demonstrating scientific curiosity while photographs taken by the child will most likely focus on what the child finds interesting during an excursion or interaction. With approval, conversations that may occur between the researcher and the child will be digitally recorded and transcribed at a later time. Since this study employs a case study methodology and needs to have definite end (Smith, 1978), the study will not exceed eight months or ten interactions/excursions but the time spent with the researcher and the participants will vary with each family (Stake, 2000).

Creswell, J. W. (2007). *Qualitative inquiry & research design* (2nd ed.). Thousand Oaks, CA: Sage.
Smith, L. M. (1978). An evolving logic of participant observation, educational ethnography and other case studies. In L. Shulman (Ed.), *Review of research in education* (pp. 316-377). Itasca, IL: Peacock.
Stake, R. E. (2000). Case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research (2nd ed.)* (pp. 435-454). Thousand Oaks, CA: Sage Publications, Inc.
Yin, R. K. (2008). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage.

15. <u>Data Analyses:</u> Describe how you will analyze your data to answer the study question.

For this study, written data will consist of interview transcripts, observations, and field notes. Since the cases in this study will have unique data sets for each participant/guardian dyad, the analyses of these types will concentrate on descriptive data not aimed at making generalizations but focusing on the information-rich complexities present in each case.

Prior to any analysis, interview transcripts, observations, and field notes will be formatted so that line numbers are included in the documents. Once each document is prepared in a similar manner, conceptual categories will be coded for as they arise *a priori* (Miles, Huberman, & Saldana, 2014). These conceptual categories will be created

by identifying similar words and phrases (in the case of interviews, field notes, or textual artifacts) within the data. The conceptual categories will be categorized into larger themes that describe the phenomenon of scientific curiosity.

Visual data (i.e. photographs, drawings) will use analysis similar to that of textual data where the images will first be examined for what is included to see what conceptual categories arise (Harper, 2000). The images will then be analyzed to see what is excluded from the photographs or drawings as well: what is absent from the image, cropped out, and left outside the shot (Wang, 1999). The photographs and drawings created by the child participants will provide insight on how he or she interprets curiosity (Frith, Riley, Archer, & Gleeson, 2005) as conceptual categories emerge. The visual data will be analyzed for each child in isolation to see what conceptual categories emerge and not used to make generalizations across all participants. As with the textual data, conceptual categories will be combined into larger themes as the study progresses and more visual data are collected. These themes will provide a visual description of scientific curiosity.

Frith, H., Riley, S., Archer, L., & Gleeson, K. (2005). Imag(in)ing visual methodologies [Editorial], *Qualitative Research in Psychology, 2*(3), 187-198. doi: 10.1191/1478088705qp037ed.

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Wang, C. C. (1999). Photovoice: A participatory action research strategy. *Journal of Women's Health, 8,* 185-192.

16. **Potential Risks and Precautions to Reduce Risk: Indicate any physical, psychological, social, or privacy risk which the subject may incur. Risk(s) must be specified. Also describe what measures have been or will be taken to prevent and minimize each of the risks identified. If any deception is to be used, describe it in detail and the plans for debriefing.**

Since all data will be collected with parents/guardians in attendance during family interactions and excursions, no part of this study has foreseeable risks greater than the minimum. If the child or parent/guardian indicates apprehension about being photographed or voice-recorded, at any time, photography and/or voice recording will be stopped and not resumed until participant indicates he/she is comfortable again.

17. **Procedures to Maintain Confidentiality: Describe how the data will be collected, de-identified, stored, used, and disposed to protect confidentiality. If protected health information is to be re-identified at a later date, describe the procedure for doing so. All signed consents and hard data must be stored for a minimum of 3 years in a locked filing cabinet (and locked room) in the principal investigator's office, lab, or storage closet at TCU. Your professional society may recommend keeping the materials for a longer period of time.**

Participants' names will be removed and given a pseudonym on all transcripts, field notes, and media captions. If a media release is signed in its entirety, photographs containing the faces of both the adult participants and young children participants will

remain visible while faces of passersby will be removed or covered from photographs. However, if portions of the media release are not signed (for example, the parent/guardian does not provide release for his or her likeness to be in photographs), the participants who do not have the release will not be included in photographs by the researcher. Should a young child participant take a photograph of his or her parent/guardian whom did not provide release, the face of the parent/guardian will be blurred or covered in the photographic image. All data analysis will be conducted with the pseudonym assigned and data will be saved as computer files on password-protected devices. The parent permission, child consent, and media releases will be stored in Dr. Weinburgh's office at TCU for 3 years following the conclusion of the study in a locked file cabinet. Data collected during the study will be destroyed after all analyses are completed.

18. **Potential Benefits: Describe the potential benefits of the research to the participants, to others with similar problems, and to society.**

    Potential benefits of this study to society include adding to the limited research on curiosity in young learners. This study may also inform educational curriculum by providing insight on what natural phenomena children are excited about. For the participants in this study, potential benefits include nurturing a love of science and fostering existing scientific curiosity.

19. **Training for Protecting Human Research Participants: Submit training certificates for all the study investigators. The training link is available on the TCU IRB webpage at www.research.tcu.edu.**

    Training certificates for both Dr. Weinburgh and Morgan Stewart are found in Appendix G.

20. **Check List for the Items That Need to be Submitted: Please combine all the files into one pdf document before submitting the materials electronically to the IRB. To prevent any delay in the approval of your protocol, use the most recent template for the protocol, consent document, and HIPAA form by downloading them from www.research.tcu.edu each time you prepare your materials.**

    a. Protocol ☒
    b. Consent document ☒
    c. HIPAA form if applicable ☐
    d. Protecting Human Research Participants Training certificate for each investigator ☒
    e. Recruitment fliers, letters, ads, etc. ☒
    f. Questionnaires or other documents utilized in screening and data collection ☒

**Appendix B**

Cover letter attached to forms provided to parents

Dear Parent:

You and your child have the opportunity to participate in a research study exploring scientific curiosity in young learners.

Prior to the official commencement of this study, the researcher (Morgan Stewart) will begin to develop a comfortable working relationship with you and your child through a series of interactions in your home or another comfortable environment. The main purpose of these interactions where no data will be collected is to foster a trusting relationship with your child.

As part of the data collected for this study, the researcher will conduct initial interviews with you and your child. In addition to the interviews, you agree to include the researcher in at least ten family interactions or excursions over the course of eight months. During these interactions, the researcher will observe your child and may voice-record or photograph during this time. Your child will also be provided with a camera to take photographs of events or things that he/she finds interesting. Finally, drawings, samples of writing or other artifacts created by your child as a result of an excursion will also be collected as data for this research.

The TCU research team is interested in the natural phenomena that young learners (children between the ages of five and seven) demonstrate scientific curiosity in. With your permission, your child will be asked to interact with the researcher and share the phenomena he or she is most curious about throughout the duration of this study.

This packet contains three (3) documents: Parent Permission, Parent Consent, and Permission for Media Release. Please read it and decide if you want to give permission.

Thank you,

TCU research team
Dr. Weinburgh, Piper Professor and William & Betty Adams Chair of Education
Director, Andrews Institute of Mathematics & Science Education

**Appendix C**
Parental Permission

Texas Christian University

Fort Worth, Texas

## PARENT'S PERMISSION TO PARTICIPATE IN RESEARCH

**Title of Research:** Scientific curiosity in young learners

Funding Agency/Sponsor: N/A

Study Investigators: Dr. Weinburgh/Morgan Stewart

What is the purpose of the research? This study seeks to add to the limited body of research on scientific curiosity in young learners (children between the ages of five and seven).

How many children will take part in this study? For the full study, we anticipate 6 children ranging in ages from five to seven.

What is my and my child's involvement for taking part in this study? Your child will participate in one semi-structured interview not to exceed thirty minutes that asks your child about topics he or she is interested about at home and at school (if school age). After the completion of the initial interview, your child will participate in no more than ten excursions/interactions where the researcher is present. These excursions will vary in duration and depend on the schedule of your family. The excursions may include, but are not limited to, museums, parks, libraries, and/or your backyard. During the interactions/excursions, your child will be observed by the researcher for instances of scientific curiosity. These observations will include notes and photographs taken by the researcher. In addition, your child will be permitted and encouraged to take photographs of things the child finds interesting.

For how long is my child expected to be in this study, and how much of my child's time is required? Your child is expected to be in this study for at least ten interactions/excursions or eight months, whichever occurs first. Durations for each interaction/excursion will depend on the place of the

family outing. For example, an observation of a trip to the zoo may take three hours; whereas, a trip to the library may only take 30 minutes.

**What are the risks of taking part in this study and how will they be minimized?** Physical, psychological, and emotional risks are minimal in this study. The physical risks associated with this project are similar to those encountered in the course of daily activities and will be minimized through the adult supervision. There is a risk of confidentiality with interviews, artifacts (i.e. drawings, library-check out lists), and photographs. Names will not be associated with any of the interviews or artifacts and a pseudonym will be provided. If a media release is signed for photographs, the visual images containing your child will only be used in the ways specifically denoted on the media release. If all or portions of the media release are not signed, photographs of your child will be cropped or the face blurred so that your child's identity is protected. At any point during any interaction or excursion, you or your child may request photographs or audio recordings stop to also protect confidentiality.

**What are the benefits for taking part in the study?** A potential benefit resulting from participation in this study may include fostering an increased enjoyment of science.

**Will I be compensated for taking part in the study?** No compensation will be provided for participation in this study.

**What is an alternate procedure(s) that I can choose instead of having my child take part in this study?** Due to the nature of this study, there is no alternative procedure, but you may choose not to participate.

**How will my child's confidentiality be protected?** All transcriptions, artifacts (i.e. drawings, photographs taken by the child), and observations be coded and the names removed. Photographs showing faces will only be used if the media release is signed. If the media release is not signed, photographs of your child will not include the face or the face will be covered with a sticker or blurred out. The data will be saved as computer files on password-protected external drives and TCU shared drives. The parent permission, child consent, and teacher consents will be stored in Dr. Weinburgh's office at TCU for 3 years in a locked file cabinet.

**Is my child's participation voluntary?** Yes, your child does not have to participate in this study.

**Can my child stop taking part in this research?** Yes, your child may withdraw from the study at any point.

**What are the procedures for withdrawal?** At any point in the study, you or your child may verbally state a desire to be withdrawn from the study. You may also call or email either researcher to withdraw your child from the study.

**Will I be given a copy of the permission document to keep?** Yes, a copy of the permission document will be provided to you prior to the start of the study.

**Who should I contact if I have questions regarding the study?** Dr. Molly Weinburgh, 817.257.6115 or m.weinburgh@tcu.edu
Morgan Stewart, graduate student at TCU, 817.891.1052 or morgan.stewart@tcu.edu

**Who should I contact if I have concerns regarding my child's rights as a study participant?**

Dr. Tim Barth, Co-chair, TCU Institutional Review Board, Phone 817.257.6427
Dr. Bonnie Melhart, Co-chair, TCU Research Integrity Officer, Phone 817.257.7104

Your signature below indicates that you have read or been read the information provided above, you have received answers to all of your questions and have been told who to call if you have any more questions, you have freely allowed your child to participate in this research, and you understand that you are not giving up any of your legal rights.

**Child's Name (please print):** _____ **Date of birth:**_____

**Parent's Name (please print):** _____

**Parent's Signature:** _____ **Date:**_____

**Investigator's Signature:** _____ **Date:**_____

## Appendix D

Parental Consent

**Texas Christian University**
**Fort Worth, Texas**

# CONSENT TO PARTICIPATE IN RESEARCH

**Title of Research:** Scientific curiosity in young learners

Funding Agency/Sponsor: N/A

Study Investigators: Dr. Weinburgh/Morgan Stewart

What is the purpose of the research? This study seeks to add to the limited body of research on scientific curiosity in young learners (children between the ages of five and seven).

How many people will participate in this study? For the full study, we anticipate up to six parents/guardians.

What is my involvement for participating in this study?
You will participate in one, hour long, semi-structured within one week of your child's initial interview. Immediately following the conclusion of this interview, you and the researcher will work together to create a line of communication to inform the researcher of times when the family intends to go on an excursion or times when the researcher may observe your child engaged in something he or she is curious about. The excursions and interactions will not exceed ten times but will vary in duration and depend on the schedule of your family. The excursions may include, but are not limited to, museums, parks, libraries, and/or your backyard. In addition, you will be expected to be present at every excursion or interaction where the researcher is present.

How long am I expected to be in this study for and how much of my time is required?
You are expected to be in this study for at least ten interactions/excursions or eight months, whichever occurs first. Durations for each interaction/excursion will depend on the place of the family outing. For example, an observation of a trip to the zoo may take three hours; whereas, a trip to the library may only take 30 minutes.

What are the risks of participating in this study and how will they be minimized?

Physical, psychological, and emotional risks are minimal in this study. The physical risks associated with this project are similar to those encountered in the course of daily activities. There is a risk of confidentiality with interviews, artifacts (i.e. drawings, library-check out lists), and photographs. Names will not be associated with any of the interviews or artifacts and a pseudonym will be provided. If a media release is signed for photographs, the visual images containing your child will only be used in the ways specifically denoted on the media release. If all or portions of the media release are not signed, photographs of your child will be cropped or the face blurred so that your child's identity is protected. At any point during any interaction or excursion, you or your child may request photographs or audio recordings stop to also protect confidentiality.

**What are the benefits for taking part in the study?** A potential benefit resulting from participation in this study may include fostering an increased enjoyment of science.

**Will I be compensated for taking part in the study?** No compensation will be provided for participation in this study.

**What is an alternate procedure(s) that I can choose instead of having my child take part in this study?** Due to the nature of this study, there is no alternative procedure, but you may choose not to participate.

**How will my confidentiality be protected?** All transcriptions, artifacts (i.e. drawings, photographs taken by the child), and observations be coded and the names removed. Photographs showing faces will only be used if the media release is signed. If the media release is not signed, photographs of you will not include the face or the face will be covered with a sticker or blurred out. The data will be saved as computer files on password-protected external drives and TCU shared drives. The parent permission, child consent, and teacher consents will be stored in Dr. Weinburgh's office at TCU for 3 years in a locked file cabinet.

**Is my participation voluntary?** Yes, you do not have to participate in this study.

**Can I stop taking part in this research?** Yes, you may withdraw from the study at any point.

**What are the procedures for withdrawal?** At any point in the study, you or your child may verbally state a desire to be withdrawn from the study. You may also call or email either researcher to withdraw your child from the study.

**Will I be given a copy of the permission document to keep?** Yes, a copy of the permission document will be provided to you prior to the start of the study.

**Who should I contact if I have questions regarding the study?** Dr. Molly Weinburgh, 817.257.6115 or m.weinburgh@tcu.edu
Morgan Stewart, graduate student at TCU, 817.891.1052 or morgan.stewart@tcu.edu

Who should I contact if I have concerns regarding my child's rights as a study participant?

Dr. Tim Barth, Co-chair, TCU Institutional Review Board, Phone 817.257.6427
Dr. Bonnie Melhart, Co-chair, TCU Research Integrity Officer, Phone 817.257.7104

Your signature below indicates that you have read or been read the information provided above, you have received answers to all of your questions and have been told who to call if you have any more questions, you have freely decided to participate in this research, and you understand that you are not giving up any of your legal rights.

Participant Name (please print): _____

Participant Signature: _____ Date:_____

Investigator Name (please print):_____

Investigator Signature: _____ Date:_____

## Appendix E
## Media release

**TEXAS CHRISTIAN UNIVERSITY**
**Media Recording Release Form**
**Parent**

**Title of Research:** Scientific curiosity in young learners

**Study Investigators:** Molly Weinburgh/Morgan Stewart

**Record types.** As part of this study, the following types of media records will be made of you during your participation in the research:

- Audio Recording
- Photographs
- Video Recording

**Record uses.** Please indicate what uses of the media records listed above you are willing to permit by initialing below and signing the form at the end. We will only use the media records in ways that you agree to.

- The media record(s) can be studied by the research team for use in this research project.

  Parent/Guardian Please initial: _____

- The media records(s) and/or their transcriptions can be used for scientific or scholarly publications.
- The media records(s) and/or their transcriptions can be used at scholarly conferences, meeting, or workshops.

  Parent/Guardian Please initial: _____

- The media record(s) can be shown/played in public presentations.

  Parent/Guardian Please initial: _____

I have read the above descriptions and give my consent for the use of the media recordings as indicated by my initials above.

Child Name: _____

Parent/Guardian Name: _____

Parent/Guardian Signature: _____ Date: _____

*If you have concerns regarding your rights as a study participant, contact Dr. Tim Barth, Co-Chair, TCU Institutional Review Board, Phone 817-257-6427 or Dr. Bonnie Melhart, TCU Research Integrity Officer, Phone 817-257-7104.*

## Appendix F
**Initial Semi-structured Interview Protocols**

**Child Protocol**
Hello, I'm Morgan. I'd like to talk to you about what you are curious about. When you are curious about something, you want to know more about it.

Tell me a little about your home? What is it like?
Who lives at your home?

What do you like to do at home?
What do you like to do at school (if school age)?

Tell me about something that you are curious about.
What other things are you curious about?

Where are places you like to go?
Why do you like to go there?

**Adult Protocol**
Hello, I'm Morgan. I'd like to talk to you about what sparks your child's curiosity. Curiosity is defined as an intrinsic passion for increased knowledge on something.
Tell me a little about your home.
Who lives at your home?
What are some of your child's daily routines and activities?
Tell me about your child's day. What types of things happen on most mornings? Afternoons? Nights?
Are there any activities or places that you go (e.g. shopping, library, parks) that you go to on less than a daily basis (e.g. once a week, every few days?)?
Are there other events that occur fairly regularly or during the weekend?
Who are the important people who participate in your child's life? Who are helpful in your child and who may also have activities or routines for teaching and learning (e.g. grandparents, neighbors, friends)?
What activities does your child enjoy doing?
Why do you think these activities are enjoyable?
Is your child involved in any extracurricular activities?
How do you know when your child finds something interesting or is being curious?

# Appendix G
## Ethic Certification for all researchers

### Dr. Molly Weinburgh

**Printed on 08/09/2014**

| | |
|---|---|
| **LEARNER** | Molly Weinburgh (ID: 4270350) |
| **DEPARTMENT** | Education |
| **EMAIL** | m.weinburgh@tcu.edu |
| **INSTITUTION** | Texas Christian University |
| **EXPIRATION DATE** | 08/08/2019 |

**IRB MEMBERS** : This Basic Course is appropriate for IRB or Ethics Committee

| | |
|---|---|
| **COURSE/STAGE**: | Basic Course/1 |
| **PASSED ON**: | 08/09/2014 |
| **REFERENCE ID**: | 13596749 |

| REQUIRED MODULES | DATE COMPLETED | SCORE |
|---|---|---|
| Belmont Report and CITI Course Introduction | 07/29/14 | 3/3 (100%) |
| Students in Research | 07/30/14 | 8/10 (80%) |
| History and Ethics of Human Subjects Research | 08/09/14 | 7/7 (100%) |
| Defining Research with Human Subjects - SBE | 08/09/14 | 5/5 (100%) |
| The Regulations - SBE | 08/09/14 | 5/5 (100%) |
| Assessing Risk - SBE | 08/09/14 | 5/5 (100%) |
| Informed Consent | 08/09/14 | 4/4 (100%) |
| Privacy and Confidentiality - SBE | 08/09/14 | 5/5 (100%) |
| Records-Based Research | 08/09/14 | 2/2 (100%) |
| Research With Protected Populations - Vulnerable Subjects: An Overview | 08/09/14 | 4/4 (100%) |
| Vulnerable Subjects - Research Involving Prisoners | 08/09/14 | 4/4 (100%) |
| Vulnerable Subjects - Research Involving Children | 08/09/14 | 3/3 (100%) |
| Vulnerable Subjects - Research Involving Pregnant Women, Human Fetuses, and Neonates | 08/09/14 | 3/3 (100%) |
| The IRB Member Module - 'What Every New IRB Member Needs to Know' | 08/09/14 | 7/7 (100%) |
| Texas Christian University | 08/09/14 | No Quiz |

**For this Completion Report to be valid, the learner listed above must be affiliated with a CITI Program participating institution or be a paid Independent Learner. Falsified information and unauthorized use of the CITI Program course site is unethical, and may be considered research misconduct by your institution.**

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Program Course Coordinator



### Morgan Stewart

**Certificate of Completion**

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Morgan Stewart** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 01/20/2014

Certification Number: 1364306

VITA

| | |
|---|---|
| Personal Background | Morgan Alyis Stewart<br>Burleson, Texas |
| Education | Diploma, Mansfield High School, Mansfield, Texas, 2002<br>Bachelor of Arts, Child Study and Language Development, Southwestern University, Georgetown, Texas, 2006<br>Master of Education, Science Education, Texas Christian University, 2012<br>Doctor of Philosophy, Science Education, Texas Christian University, 2018 |
| Experience | Teacher, Northside Independent School District, San Antonio, Texas, 2006-2008<br>Teacher, Midlothian Independent School District, Midlothian, Texas, 2009-present |
| Professional Membership | Association of Science Teacher Educators, 2013-present<br>Southwest Association of Science Teacher Educators, 2013-present<br>National Science Teacher Association, 2013-present<br>National Association of Research in Science Teaching, 2013-present<br>School Science and Mathematics Association, 2015-present<br>Informal Science Educators Association, 2016-2017 |

ABSTRACT

INVESTIGATING SCIENTIFIC CURIOSITY IN YOUNG LEARNERS: A MULTIPLE CASE STUDY OF A FIVE-YEAR-OLD, A SIX-YEAR-OLD, AND A SEVEN-YEAR-OLD

by Morgan Alyis Stewart, 2018
College of Education
Texas Christian University

Dissertation Advisor: Molly Weinburgh, Piper Professor and William L. & Betty F. Adams Chair of Education, and Director of the Andrews Institute of Mathematics and Science Education

The purpose of this qualitative, multiple case study research was to understand scientific curiosity in young learners (children between the ages of five and seven years) which is a population often neglected in qualitative curiosity research. Situated learning theory provided the theoretical framework since curiosity is viewed as an independent and personal endeavor in which knowledge is constructed on an individual level. This study focused on three research questions: (1) what are young learners curious about that may possibly influence future science learning and education, (2) when a natural phenomenon captivates a young learner's scientific curiosity, what actions follow, and (3) what are characteristics of experiences young learners bring with them from outside of their schooling that may influence scientific curiosity. Three young children and their parents participated in the study for a maximum of ten interactions. Data collection methods included initial semi-structured interviews of both the children and the parents, field notes, observations, and photographs taken by the researcher, adult participant, and/or child participant. The findings showed that several observable behaviors of curiosity in previous studies with younger and older participants were also apparent in this study's participants: exploration/discovery, questioning, and sustained interest. In addition to the anticipated findings, several unforeseen

findings appeared during the data analysis process. These unforeseen factors affecting curiosity included technology, interruptions and diversions, curiosity of other family members, and fear of natural phenomenon. The findings have implications for early childhood and elementary teaching practices, learning environments, and designing lessons in elementary classrooms.