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How Children in a Science-centered Preschool Use Science Process Skills While Engaged in Play Activities

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How Children in a Science-centered Preschool Use Science Process Skills While Engaged in Play Activities

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Dedication

I would like to dedicate this dissertation to my family and friends who supported me throughout this degree.

In particular my father and mother, Keith and Nancy McFarlin, who were my biggest cheerleaders and willing to offer up practical advice along with prayer to guide my journey.

My friends, Meredith Stivers, Yi Jeng Chen, Kathleen Walker, Pam Morris and Desiree Pallais who were always ready to read a draft, talk me down, or bolster me up.

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How Children in a Science-centered Preschool Use Science Process Skills While Engaged in Play Activities

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The University of Texas at Austin, 2011

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Self-motivated activities, or play, that children choose to engage in are manifestations of a variety of science process skills being used to construct knowledge about their environment. While many people agree that science skills should be fostered at an early age, due to the possible positive influence of a wider base of experiential knowledge and the development of a love of science, there is a lack of research available to support the development of early childhood science curriculum (Bredekamp & Copple, 1997, Brenneman, Stevenson-Boyd & Frede, 2009). This study follows the daily activities of four- and five-year-old children attending a science-based preschool in the southwestern United States. The play activities of the children were observed for their use of the science process skills of observing, comparing, classifying, measuring, communicating, inferring, predicting and experimenting. A wide range of play activities centered around the foundational skills of observing, comparing, measuring, communicating and inferring. The teachers and students combine to create a unique environment promoting excitement and exploration.

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Introduction

Every day, young children engage in various aspects of the scientific inquiry process as they play (Ashbrook, 2006). Children wonder about their world, ask questions, try different techniques to solve or answer questions, integrate new knowledge into their worldview, and share discoveries with friends (Ashbrook, 2006). With this intrinsic motivation to explore, young children are predisposed to engage in the content of science (Eshach & Fried, 2005). These self-motivated activities, or play, that children choose to engage in are manifestations of a variety of science process skills being used to construct knowledge about their environment. While many people agree that science skills should be fostered at an early age, due to the possible positive influence of a wider base of experiential knowledge and the development of a love of science, there is a lack of research available to support the development of early childhood science curriculum (Bredekamp & Copple, 1997, Brenneman, Stevenson-Boyd & Frede, 2009).

At one preschool in Texas, children are immersed in both life and earth sciences. All aspects of this preschool converge to provide students with a strong science learning experience. Parents bring their children dressed and ready for school with the expectation of returning just four hours later to find their children's clothes and bare feet smeared with dirt from playing outdoors. While encouraging students to make observations and explore on their own, teachers talk about science, from naming flowers to describing a chemical reaction. The school campus itself is designed to encourage science, from its play yard with rocks for turning over to its physical location on the grounds of a nature and science center.

As a result, children are engaged in science at this preschool and take steps to pursue their own interests. As they engage in science play, the students often participate in what could be interpreted as scientific inquiry. It turns out that this play is fulfilling parent, teacher and school goals because students are actively engaging with the natural environment as scientists. These behaviors tend to veer children away from the main group of learners in order to follow up on their own independent questions and explorations. Through their play, children are pursuing their own interests by experiencing science concepts, performing scientific processes, and having a sustained engagement in science. Having such young children engage in science may develop the children's future positive attitudes towards science bringing about the next generation of scientifically-minded adults. (Eshach & Fried, 2005).

This qualitative case study, is focused on a particular context, a science-based Texas preschool, to describe how a group of young children interact with each other, their teachers and the environment during moments when they engage in free choice activities (Merriam & Associates, 2002). The research question guiding this inquiry is: How do children in a science-centered preschool use science process skills while engaged in play activities? Play being defined as children's free-choice activities in the school's outdoor environment. Observations/field notes were the primary data source for this study, supplemented by narrative descriptions and still photos. Data were collected on-site, observing the children as they went about their school day in the classroom, play yard and nature center grounds.

Review of the Literature

Nature Education: Then and Now

Investigating how children interact with nature is nothing new in American education. Nature study began to gain popularity in the early 20th century as the best way for boys and girls in the first eight grades of school to learn science (Tolley, 2003). The urbanization of America led to the first generation of children growing up without a strong connection to the land, living in cities void of rural commonplaces such as fields of wheat, forests or wildlife (Tolley, 2003). Americans were beginning to realize that nature was not infinite in its abundance and the U.S. government started taking steps toward conservation through the establishment of wildlife refuges and national parks (Tolley, 2003). As the government was preserving wilderness, educators were beginning to take city children out into it (Tolley, 2003). Children were encouraged to closely observe the natural world and take notes, make sketches, and ask questions while teachers worked diligently to extend student knowledge into all areas of the curriculum (Tolley, 2003). Science education has undergone many incarnations since the nature study movement. However, nature study still remains relevant in our modern world, most notably in the field of early childhood education.

Today many states have suggested areas of science learning in their preschool standards. Texas, for instance, has PreKindergarden Guidelines to assist teachers in providing a strong educational "foundation" for later school success (TEA, 2008). The problem is that little to no research has been done on early childhood science learning that can point the way in a modern preschool science curriculum (Brenneman, Stevenson-

Boyd & Frede, 2009). Research has shown that children are inquisitive and motivated to engage in science activities but there is no definitive answer to what science should be taught in preschool (Brenneman, Stevenson-Boyd & Frede, 2009).

The content area of science is appropriate for young children due to its applicability to daily life and its ease of incorporation into play. The employment of fun, not as a hook to draw in learners, but as a real product of scientific activity can be found in modern childhood organizations such as the Cub Scouts (Jarman, 2005). While realizing the necessity of providing science instruction, Cub Scout leaders point out that without the intrinsic motivation of play the children would not participate (Jarman, 2005). Experiences that are fun can develop motivation to participate in future activities and can lead to the re-evaluation of prior experience (Jarman, 2005).

What is Play?

Play is intrinsically motivated, acted out for its own sake, is free, and provides a positive outcome. Play for its own sake is motivated by the satisfaction provided in the activity and is not controlled by basic needs. Play occurs with familiar objects or follows the exploration of unfamiliar objects. Children control their play activity and supply their own meaning for the activity (Saracho & Spodek, 1998). Play "is a set of cultural practices of which we are fully conscious" and in a science-based preschool it is reasonable to conclude that play activities would reflect the culture of the school (Frost, Wortham & Reifel, 2008, p.5). In this proposed study, play is defined as children's free-choice activities in the school's outdoor environment.

At the age of four children often engage in egocentric thought, which is the assumption that everyone feels and thinks the same as the child (Frost, Wortham & Reifel, 2008). This affects play in that the child may believe that everyone shares her ideas about the correct next step in a scenario or that she may have difficulty relating to another's emotions if they are different from her own (Frost, Wortham & Reifel, 2008).

Play can occur in different contexts and at a variety of levels. Parten's six categories of play behavior, unoccupied behavior, onlooker behavior, solitary play, parallel play, associative play, cooperative play, can be used to describe characteristics of a child's play (Frost, Wortham, & Reifel, 2008). Unoccupied behavior occurs when the child is watching anything of interest and randomly engaging with the environment. Onlooker behavior takes place when a child is observing or watching others play. The onlooker is physically close to the other children and may converse with them but not attempt to enter the play. Solitary play is when the child plays alone and uses different toys than the other children. A solitary player does not alter their activity to reference what others are doing. Parallel play occurs when the children are using the same toys but do not attempt to influence each other's activities. Associative players also use the same materials and make mild attempt to influence other's activities. In this kind of play there is no organization to the activity. The final category of play is cooperative. In cooperative play children are organized for a mutual goal (Frost, Wortham & Reifel, 2008). Although these play categories were created as a continuum of play development it has been shown in later studies that presumably lower levels, like solitary play, can produce high level cognition just as cooperative play can (Frost, Wortham & Reifel, 2008). These levels do however provide additional information for how the child is engaging in an activity and as such have descriptive value.

Benefits of Nature Play

Outdoor environments are beneficial in science learning because "children have a unique, direct and experiential way of knowing the natural world" and nature allows for a wider range of play experiences (Malone & Tranter, 2003, p.300; Tranter & Malone, 2004). The rich and varied materials afforded in a natural environment can also engage children in higher-level cognitive activities (Frost, Wortham & Reifel, 2008). A study by Tranter and Malone about children's use of school grounds cites that playing in nature has a positive impact on physical, social and concentration ability (2004). Malone and Tranter found that, "cognitive play allows children to act on the environment and discover and understand relationships through their own behavior. This type of play usually has as its goal problem solving, choosing, constructing, exploring and discovery and is unstructured informal learning" (2003, p.285). Dynamic play areas improve both the intensity of the child's play experience and their range of activities. The play space provided on school grounds therefore provides a set of affordances that can expand or limit children's play (Malone & Tranter, 2003). Natural environments often afford a high degree of malleability, allowing children to transform and engage the space according to their interest and developmental level (Malone & Tranter, 2003). According to Dyment & Bell (2009), educators at schools who recently included green space into their grounds found a wider range of students' interests being employed, such as students diversifying their play activities and engaging in nature exploration. Lindhold (1995), found that the greatest variety of activities in green school yards take place in wooded or natural areas. Pretend play is most commonly enacted in green areas, from schools with no more than a lawn to schools adjacent to a woodland (Lindhold, 1995). The woodland play environment stands for “richness, life and changeability” (Lindhold, 1995, p. 283).

According to Worth and Grollman (2003), three- to five-year-old children are uniquely suited to engaging in a life science program because of their “fascination” with the living things they encounter around them. Science process skill learning is also more successful when the children can physically manipulate objects (Ashbrook, 2006). These two aspects—young children learning life science and physical manipulation of the environment—combine to create an outdoor nature environment ripe for scientific discovery.

Student-centered investigations are another aspect of learning promoted within a natural environment. Students are empowered to design and carry out informal experiments in order to answer their own questions (Kirch, 2007). Some questions and methods of data gathering emerge directly from instructional activity while others are perceived as worthwhile due to the classroom culture of inquiry (Kirch, 2007). By embracing their role as scientists, students can be not only consumers but creators of their curriculum. Learning opportunities emerge from students’ actions and talk in an informal environment rather than being imposed on them (Rahm, 2002).

Benefits of Nature Exposure

Exposing children to green spaces can have a long-term impact on their appreciation and use of green spaces. In a study by Aspinall and Montarzino (2008), adults visiting a woodland were surveyed about their visiting habits as children. A majority of them, 67%, visited the woodlands weekly as children (Aspinall & Montarzino, 2008). Aspinall and Montarzino (2008), found that frequency of childhood visits to green spaces was a strong predictor of how often adults visit similar green spaces. This predictor showed a stronger correlation than the demographic variables collected (Aspinall & Montarzino, 2008). “These results suggest that frequency of childhood visits is associated with aspects of healthy activity, emotional engagement with natural or green places, ease of access, and confidence to visit places alone” (p.126). (Aspinall & Montarzino, 2008).

The therapeutic properties of nature benefit both children and adults by decreasing inattention and impulsivity (Kuo & Faber Taylor, 2004). Not only can nature decrease unwanted behaviors, it has been shown to improve mental focus and self-perceived health (Kuo & Faber Taylor, 2004 & Maas, Verheij, Groenewegen, de Vries, Spreeuwenberg, 2006). Research has shown that healthy design should include green spaces, especially for vulnerable populations such as the elderly and youth in urban environments (Maas, Verheij, Groenewegen, de Vries, Spreeuwenberg, 2006).

Role of the teacher

Teachers of young children often attempt to link educational activities with a child’s prior knowledge in an attempt to build upon an existing foundation of experience (Vygotsky, 1978). Fleer (2009) investigated how children engaged in everyday learning experiences within a classroom environment build science concepts. When children are given access to the tools of science for free exploration without deliberate intervention to scaffold science concepts, they tend to only engage in horizontal ways of thinking (Fleer, 2009). "Horizontal thinking" meaning that the children formed concepts related to everyday concepts, such as what the equipment does, and not scientific concepts, such as materials and their properties (Fleer, 2009). However, when a teacher explicitly tells the children what aspects of science they are exploring and carefully frames their experiences to showcase an aspect of science, there is evidence of a broader range of thinking (Fleer, 2009). According to Fleer, children should continue to experience everyday learning concurrently with scientific learning (2009). "Overall, these playful events allowed children to probe in ways which ensured that concept formation was much more systematic and led to the children's development of scientific concepts" (Fleer, 2009, p. 302).

According to the National Science Education Standards, there are currently "no nationally accepted learning standards for early childhood science education" (NSES, 2006, p.31). However, as children enter kindergarten, state science education standards are in effect. In Texas these standards are described in a curriculum framework called the Texas Essential Knowledge and Skills (Texas Education Agency, 1998). The focus of kindergarten science, as outlined in the TEKS is to introduce "simple classroom and field investigations to help students develop the skills of asking questions, gathering information, communicating findings, and making informed decisions" (Texas Education Agency, 1998). Students entering into a kindergarten classroom where these investigations are being performed could be helped by a strong experiential knowledge of the natural world.

For this study the role of the teacher is taken into account due to how they can focus student activities during their play. The children's learning experiences can be categorized according to how the teachers structure the school day and respond to the students' interests. These three categories of learning experiences are naturalistic, informal and structured.

Naturalistic experiences are controlled by the child (Charlesworth and Lind, 1999). Naturalistic experiences are spontaneously initiated as children engage in the world around them. According to Charlesworth and Lind (1999), naturalistic experiences are a major mode of learning for young children and therefore are suitable as a means of defining the child-controlled science process skill experiences. The role of the adult in a naturalist experience is to provide a rich and varied learning environment along with responding to the child's explorations with encouragement (Charlesworth and Lind, 1999).

Informal experiences are when the child and adult share control of the learning activity (Charlesworth and Lind, 1999). These joint interactions are spontaneous and can occur when the child reaches out to the adult for input or when the adult observes an opportunity to scaffold or work in a relevant concept. The role of the adult in an informal experience is to watch the child's activity and decide when they should insert their influence to alter or enhance a learning experience (Charlesworth and Lind, 1999).

Structured experiences are planned learning experiences or lessons controlled by the adult (Charlesworth and Lind, 1999). The adult sets up the environment and activity and directs the children's experience to teach specific concepts and skills (Charlesworth and Lind, 1999).

Since this study is focused on how children in a science-centered preschool use process skills during play, with play being defined as a child controlled free-choice activities in the school's environment, structured experiences will not be included in the presented data.

Science process skills

Science process skills are the ways people approach and study problems while beginning their journey into scientific inquiry (Lind, 1999). Science process skills include observing, comparing, classifying, measuring, communicating, inferring, predicting and experimenting by hypothesizing and controlling variables (Lind, 1999).

Lind (1999) describes observing as the most fundamental science process skill. Young children use their senses of sight, touch, smell, taste, and sound to gather firsthand information through exploration. When children are gathering firsthand information they are observing, an example of this is of a child looking at a classroom fish tank (Lind, 1999). Chaille and Britain (2003) believe that the construction of physical knowledge derived from experience is more important than the transmission of labels defining the same objects.

Comparing and contrasting, or identifying similarities and differences, leads children to focus their observations by comparing one object/phenomena to another (Lind, 1999). This is a precursor skill to classifying (Lind, 1999). An example of comparing and contrasting can be when a child brings a leaf to class in order to see its characteristics in relation to the classroom leaf collection (Lind, 1999).

Classifying is the process whereby children group and sort concrete objects (Lind, 1999). To classify, children will make comparisons between objects and develop subsets, or groups of objects that have a common unique characteristic (Lind, 1999). An example of classifying would be sorting groups of animals by color, such as brown and white, then defining a subset of animals as brown with four legs and brown with two legs (Lind, 1999). According to Piagetian stages of development children, preschool children can only classify using one characteristic at a time (Frost, Wortham & Reifel, 2008).

Measuring is the quantification of a child's observations through standard or nonstandard units (Lind, 1999). Standard units can include inches, pounds, degrees, seconds, and gallons while nonstandard units can include jumps, rocks, day events, and juice cups (Lind, 1999). At the preschool level children often assign units of measure by guessing (Clements & Sarama, 2009).

Communicating as a science process skill for young children refers to the ability to describe a phenomenon (Lind, 1999). Communication can be verbal or nonverbal (Lind, 1999). Nonverbal communication can be through gestures, body positions, facial expressions and pictures while verbal communication can be with words or vocal sounds (Lind, 1999). Communication requires a child to gather information, process it and then present it so that others can understand their meaning (Lind, 1999). An example of communication is when a child keeps a log of their experiences, such as daily weather, and then is able to answer questions regarding their observations (Lind, 1999).

Communication for preschool children can be for an audience of for personal use. When the child communicates aloud for personal use this is called egocentric or private speech. The role of private speech for a young child is to assist the child in accomplishing practical tasks by providing a verbal scaffold to talk through the difficult actions (Vygotsky, 1978).

Inferring occurs when a child makes observations, then is able to draw conclusions from them indirectly (Lind, 1999). This differs from observations that are information that the child directly experiences (Lind, 1999). An example of an inference is when a child observes leaves moving on trees while looking through a window and infers the wind is blowing. Children cannot feel the wind, but based on observations and previous experience, they know that the wind is blowing (Lind, 1999).

A child makes a prediction when they make a statement about what they think will happen at a future time (Lind, 1999). These statements are not random, but are based on observations of data and are reasonable expectations (Lind, 1999). Predictions are useful for the developments of an awareness of cause and effect and patterns (Lind, 1999). An example of prediction in an early childhood setting is having the children listen to a story about growing seeds, then predicting how many seeds from their package of seeds will grow into plants (Lind, 1999). Children will often observe the phenomenon they have made a prediction about and observe the actual results (Lind, 1999).

Experimenting by hypothesizing and controlling variables, or investigation, occurs when a child makes a hypothesis, or a statement of a relationship between variables, and then controls variables to see if the hypothesis is correct (Lind, 1999).

Young children will not often use an if-then statement as their form of hypothesis, and more often conduct investigations focusing on a lead question. The "then" part of the experiment is then acted out, an example of such a question is: "What happens if the magnet drops?" (Lind, p.56, 1999).

This qualitative case study, is focused on a science-centered preschool, to describe how a group of young children engage in science process skills as they play (Merriam & Associates, 2002). The research question guiding this inquiry is: How do children in a science-centered preschool use science process skills while engaged in play activities? Play being defined as children's free-choice activities in the school's outdoor environment. The process skills used to categorize the data are: observing, comparing, classifying, measuring, communicating, inferring, predicting and experimenting (Lind, 1999). Observations/field notes were the primary data source for this study, supplemented by narrative descriptions and still photos. Data were collected on-site, observing the children as they went about their school day in the classroom, play yard and nature center grounds.

Research Methodology

This qualitative case study, is focused on a particular context, a science-based Texas preschool, to describe how a group of young children interact with each other, their teachers and the environment during moments when they engage in free choice activities (Merriam & Associates, 2002). The research question guiding this inquiry is: How do children in a science-centered preschool use science process skills while engaged in play activities? Observations/field notes were the primary data source for this study, supplemented by narrative descriptions and still photos. Data were collected on-site, observing the children as they went about their school day in the classroom, play yard and nature center grounds.

This study follows a previously published pilot study (McFarlin, 2008) at the same preschool. The research question in the pilot study was more open ended, examining preschool children's informal outdoor nature interactions (See Appendix A). This study refines that question, asking how children in the same preschool use science process skills while they play. The first question allowed me to cast a wide net and used grounded theory during the data collection process to refine what aspects of play to focus on (Yin, 2010). The current question solidifies what aspects of play will be examined and how from the outset.

Figure 1. Play yard at the preschool with natural and manmade materials.

Figure 2. Sand area at the preschool. Interlinking rectangular troughs shown center-right will be referred to as the water maze.

Setting and Participants

Purposeful sampling, the selection of setting and participants due to their relevance to the research question, was required in order to find a preschool program featuring nature study (Maxwell , 2005). The City Parks and Recreation Department recommended only one site, The Nature and Science Center, as a popular nature field-trip location used by local public schools. Upon contacting the Center, I learned that they also maintain an early childhood school on-site. The curriculum of the science-based preschool is designed to emphasize learning about nature, science, and the environment through "hands-on exploration, experiments, crafts, songs, field trips, live animals, hikes, and outdoor activities" (Austin Nature & Science Center, 2008). The goal of the preschool is to "…foster a life-long relationship with the natural world" through these experiences (ANSC, 2008). This preschool provides an environment where children are immersed in "doing science" and is ideal as a location to study how science process skills are integrated into play.

In 2008, data from a pilot qualitative study also collected at this school was presented at a national research conference. In the previous study, I observed the four- and five-year-old classes during playtime and occasionally participated by helping the teachers when they needed assistance (See Appendix A). I also informally conversed with parents as they dropped off their children in the morning. From these interactions, I learned the value all the participating adults placed in promoting science learning. When it was time to gather data for this study, I approached the two teachers who I had worked with before and found them to be open to having me return.

In order to build rapport with the new teachers and contribute to the school in some tangible fashion I volunteered to assist with setup at the preschool every morning for a total of 20 hours over the twenty-nine day data collection period. Every morning I set out the paint for the day, straightened up the play yard, emptied trash cans, assisted in preparation of materials for formal learning activities and generally attempted to be useful.

The science-based preschool is set in a small historic limestone house located on the City Park Greenbelt in a southwestern city. The home is divided into three small classrooms. Two of the classrooms are for mixed-aged classes of four- and five-year-old children and the third is set aside for a group of three-year-olds (See Figure 3). Each room has a 1:8 teacher-to-student ratio in order to maximize individual attention, while a fourth teacher floats between rooms assisting where needed (ANSC, 2008). For this study, I focused on the two, mixed-age classrooms because the older children tend to produce more dialogue. The speech of the participants facilitates the interpretation of the children's actions while playing. Rather than guessing intentions, speech gives an insight to meaning.

Figure 3. Teacher Lisa's classroom.

The school opens at 9 a.m. and closes around 1 p.m. with an additional hour of operation on Friday. The students therefore have a half-day program where they learn and play in a science-rich environment. This school program requires parents/guardians to drop off and pick up their children early in the day. The ethnicity of the students, as related by the school's teachers, is predominately European American, however the school does not keep demographic data on their students.

The teachers operate their classrooms with a focus on natural sciences, incorporating hikes through the science center's grounds in the city's greenbelt, a classroom garden, and a play yard featuring natural elements such as a dirt base, shrubbery, live oak trees, stones, sand, and a water feature (See Figures 1 & 2). Teachers coordinate their lesson plans based on themes and are well versed in the common names of local flora and fauna along with scientific terms that they routinely incorporate into their formal and informal interactions with the children.

The teachers are very knowledgeable in the natural sciences. Teacher Meredith, the head teacher at the preschool, received her Child Development Associate (CDA) certification in 1981 and has worked for ten years at an inclusive/mainstream school before coming to the science center. Teacher Rosalind is certified to teach elementary education with a focus on reading and mathematics. Teacher Lisa has a degree in education with a focus on environmental studies. All of the teachers are very enthusiastic about the process of science when they interact with the children and it creates a pro-science atmosphere in the school.

Pseudonyms were assigned to all participants, teachers and students, in order to provide anonymity (Yin, 2010).

Data Sources and Procedures

The pilot study had acquainted me with the teachers in 2008 and two of the original four are still teaching at the school. The pilot study followed the four and five year old classes around during their outside activities, particularly hikes (See Appendix A). During the data collection period I followed the novelty, or situations that arose that piqued my interest. I observed many interesting situations using this technique but realized that I was missing what made the bulk of a child’s day. Since my “follow the novelty” method flitted from child to child I was unable to identify impetus for many of the activities and had a less thorough understanding of why a child was responding the way they were.

In this study I am more systematic in the data collection in an attempt to reduce bias (Yin, 2010). Rather than attempting to observe everything at once I followed only one child each day, including observations of the child during formal lessons and free play, indoors and outside. This new method provides insight into how formal lessons translate into play activities and how a variety of children use science process skills, not just the children engaging in activities I find interesting.

Groups of students rotate through the school each week according to their enrollment schedule. A child can be enrolled for as little as one and up to as many as four days each week. Data collection units were twenty-five individual children whose guardians have given participation permission attending the science-based preschool (Yin, 2010). Data was collected surrounding an individual child for the entirety of their school day with the exception of meal times. Data includes indoor and outdoor time and activities initiated by teachers as well as students. The narrower level of data collection units were the activities the child participated in that fell under the definition of play, naturalistic and informal learning activities, where the child has partial or total control of their activity (Yin, 2010). I followed all available participants one day before duplicating my observations. Observations continued until no new manifestations of science process skills play was observed (data saturation) on October 27, 2010.

The data for this study came from field notes, narrative descriptions, and still photos of children. Total time for gathering data was 29 days within September and October of 2010.

Fieldnotes for this observational study were handwritten as I followed one specific child each day for the entirety of their school time. I socialized with the children during meal times and kept a neutral demeanor as much as possible during data collection, as suggested by Yin (2010). The children quickly learned that I was not able to participate in their play and would often just ignore my presence. The time was also recorded in the notes as often as possible to keep a record of how long each activity lasted. All activities were recorded in the fieldnotes but special attention was put forth to document all nuances of play while structured activities were recorded in more general terms. Still photographs were also taken to capture "visually important matter" during the course of the school day (Yin, 2010, p. 82). The photographs were used to assist in recalling details of context during the fieldnote transcription process and as a visual record of events. Fieldnotes were daily transcribed with any supporting details daily by the researcher (Emerson, Fretz & Shaw, 1995; Maxwell, 1996).

Informal interviews with the children were intended to occur infrequently and only when I was unable to discern what the child was doing. These interviews consisted of the question "What are you doing?" without any further imposition on the child's activity. This standardized question is nondirective and was only be used as clarification within the normal fieldnotes (Yin, 2010). These interviews only occurred a few times before a child indicated it was disrupting the flow of their play and were discontinued from the data gathering procedures.

Researcher's Position

I am a teacher certified in elementary life-earth science, art and general studies in grades 1-8 along with a specialization to teach in prekinder and kindergarten. I have taught in classrooms ranging from babies to a mixed age class for 5 through 12 year-old children. In public schools I have taught lessons in Kindergarten, first grade, second grade and fifth grade and have participated in technical assistance visits, to observe teachers then find areas of strength and provide possible ways to improve classroom instruction. During my eight years as the head teacher of a mixed-age summer camp I focused on informal science and art education, incorporating field trips to expose urban children to nature not commonly found in their urban environment. I believe that exposure to natural environments provides a setting where exploration, both free and guided, builds up children's experiential knowledge base allowing for personal pleasure in discovery and assisting in linking new knowledge to experienced observations.

My interest in this particular preschool arises from the value parents and teachers place on hands-on exploration, providing a varied environment and the freedom to get dirty and take risks getting to know it. The easy acceptance parents have of picking up a child covered in mud at the end of the day flies in the face of my previous teaching experiences where I was cautioned to return the child at the end of the day looking better than when they arrived. This difference initially caused tension between my training to keep the child pristine and the culture of the school, and influenced how I perceived the children's and teacher's actions as remarkable or other. After extensive interactions with the teachers, parents and children at this school I have grown accustomed to the expectation of dirt and risk, only rarely making a conscious effort to withhold my preconceived ideas about how children should be overprotected to the point of restricting any activity involving dirt.

Analysis

Triangulation of data occurs in the form of rich description in the fieldnotes and photographs. Still photographs were frequently taken to record the context, participants and tools used in the play activity. These photographs support the fieldnotes, providing another layer of documentation for recorded events (Yin, 2010). Photos did not appear to disrupt play, as the children never acknowledged the camera. The teachers also requested that I take additional photographs during structured activities to provide them with documentation of the school year. Originally informal interviews as a means of clarification were also gathered but were discontinued within the first week.

Reliability of the fieldnotes was established during the first week of data gathering by also making an audio recording on three days and then comparing a sampling of the straight transcriptions of audio with the fieldnotes. While the audio recording was able to provide more exact phrasing it was not as rich as the fieldnotes that captured nuances of action. This age group is very physically expressive and the audio recording could not account for this. Furthermore the audio recording was difficult to transcribe due to the extraneous city and natural noises that frequently overlay dialogue.

Sorted and categorized data was compiled into a document along with the category definitions and was presented to the head science teacher at the school to review for sorting accuracy. The document had an example of at least one scenario falling under each category and spanned 34 pages or approximately twenty percent of the total data. An independent review by this early childhood teacher confirmed the categories as coded. A fellow early childhood graduate student in the technology field performed a second coding validation. This early childhood researcher was given uncoded fieldnotes and category definitions and coded without any additional input. Her coding confirmed my interpretations of the more basic process skills of observation and communication but she found it difficult to interpret between inference, prediction and experimentation. These complex categories are interrelated and it is difficult to separate them out cleanly.

The pilot study used grounded theory to develop categories from the fieldnotes (McFarlin, 2008). This case study draws on an aspect of the previous research related to children engaging in science as they played (See Appendix A). The idea of science play translated into using science process skills as the preliminary coding categories in this study. Focusing on only play activities further refines the data selected from the fieldnotes for coding. Only data that could be categorized as naturalistic learning, where the child is in control of the activity, and informal learning, where the child and teacher share control of the activity, will be analyzed as belonging to the realm of play (Charlesworth and Lind, 1999).

The initial code used to sort all of the fieldnotes consisted of eight science process skill categories associated with young children: observing, comparing, classifying, measuring, communicating, inferring, predicting, and experimenting. The secondary code of naturalistic, informal and structured learning was then used to filter out all activities the children did not have primary or shared control over and therefore could not be interpreted as play (Charlesworth and Lind, 1999, Yin, 2010). All data that fell under structured learning was held back at this point. Tertiary codes emerged from the data as similar recurring themes within each process skill and are related to known patterns of play and development in young children. The constant comparative method was used to examine the developing themes for any nuances that may be of interest to the fields of early childhood play and science (Yin, 2010).

It should be noted that since the field notes centered around an individual child for each day of data collection, instances of naturalistic experience should outweigh the number of informal experiences due to the teacher dividing her time between the eight students in her class.

Findings

The findings for this study are presented under the categories of observing, comparing, measuring, communicating, inferring, predicting and experimenting. With the introduction of each category there will be a brief description of the process skill and how it presented during the data collection period. Each science process skill is then broken into either naturalistic or informal learning experiences (Charlesworth and Lind, 1999).

Observing

Lind (1999) describes observing as the most fundamental science process skill. Young children use their senses of sight, touch, smell, taste, and sound to gather firsthand information through exploration. When a child is gathering firsthand information they are observing (Lind, 1999). The development of cognitive structures, according to Piaget, is dependent on the opportunities children have to gather experiential information. As children are continuously examining their environment they can either integrate new information into existing knowledge or expand their schema, mental organizational structures, to accommodate information that doesn't quite fit (Frost, Wortham & Reifel, 2008). This disequilibrium between known and unknown, according to Piaget, drives learning (Frost, Wortham & Reifel, 2008).

The problem with coding observations of children's actions is the overwhelming occurrence of children using their senses to gather information. Observing is the most commonly enacted process skill at this preschool and is a crucial piece of all other process skills, acting as a foundation for children to build on to form more complex concepts (Lind, 1999). In order to narrow the scope of the observation field notes, I chose only instances of children focusing their attention and appearing to take specific notice of some thing or phenomena. Even with this narrowed scope, there were over 500 instances of observing over the data collection period. Narrowing the data further, I focused on examples of observing that occurred independently of comparing, measuring, inferring, predicting and experimenting. The category of communicating may intertwine in some instances as children verbalize their observations.

Naturalistic learning (observations)

Naturalistic learning under the category of observing can be divided into *observing others*, *observing objects*, *observing phenomena* and *child builds on structured learning*. The first three naturalistic observation categories are straightforward examples of how children use their senses to observe people, things and phenomena without any teacher prompting. According to Johnston (2009), although teacher prompting can lead to higher levels of cognition and skill use, young children make a large number of spontaneous observations during play on their own. The final category of *child builds on structured learning* also has the children using their senses to observe, but the observations are stimulated from a teacher-controlled lesson. In these teacher-initiated scenarios the child is more likely to vary his or her observations and skill use (Johnston, 2009).

Observing others

Observing others is one of the least frequent instances of naturalistic observation. The children may watch the group for a few minutes but will often then find an activity to participate in either alone or with their peers. Observing others occurred more frequently at the beginning of the school year when children were less familiar with their peers and teachers and were tentative to join a group. As the child gain an understanding of the new environment's culture they are more confident in their ability to engage successfully.

Within this category, the student pays close attention to an aspect of a peer or teacher. *Observing others* occurs outside of comparing, measuring, inferring, predicting and experimenting. In this category the child watches to see what people around him or her are doing, often with the goal of seeing what options are available to participate in. It can also be an observation born from curiosity without any obvious intent to participate in an activity. Both of these scenarios would fall under the definition of "onlooker behavior" as defined by Parten. When a child engages in onlooker behavior they are physically within talking distance to the observed person; they may verbally interact but do not overtly enter the observed person's activity (Frost, Wortham & Reifel, 2008). The following example demonstrates a child silently observing her teacher in the play yard. Heather is standing alone about ten feet away from teacher Rosalind who is standing near the classroom door and attending to various children who come up to her for assistance.

> She [Heather] balances herself as she steps on a stone in a ring of stepping rocks (See Figure 4). She watches Teacher Rosalind and when the teacher moves, Heather moves too keeping a constant distance while balancing on the rocks. (9-17-10, p.16)

Figure 4. Heather balances on stones

In this example, the child is nonverbally following the actions of her teacher, staying a constant distance from her while watching her movements. Heather was quietly walking around the play yard watching what her peers were doing, examining objects, such as a gate lock, and keeping to herself. When she sees the teacher talking to her peers nearby, her attention focuses intensely and she becomes a satellite to her instructor, moving her body to keep a fixed distance. The child's initial undirected observations fall under Parten's definition of "unoccupied behavior" where she watches anything of momentary interest, then transforms into "onlooker behavior" when she focuses on the teacher's activity. Heather demonstrated a keen interest in her surrounding environment with her sustained silent observations over a 17-minute period of time.

Observing objects: "I found something cool!"

Observing objects is one of the most frequent cases of naturalistic observation. In this category the students observe an aspect of an object and communicate it aloud to their teacher, peers or without a specified audience in a full-voiced declaration. Observing objects was a skill highly valued by the teachers and many of their informal lessons involved pointing out something interesting to the class. The children were eager to share their discoveries too , communicating these to both peers and teachers.

Communicating to a peer or teacher is a science process skill whereby the child transmits their understanding to another (Lind, 1999). When the child speaks their observation aloud without a specified audience the child is most likely engaging in egocentric or private speech (Vygotsky, 1978). Egocentric speech at this age arises spontaneously and can be a verbalization of what the child is doing or can play a role in the attainment of a goal. "Children solve practical tasks with the help of their speech, as well as their eyes and hands" (Vygotsky, 1978 p. 25). Talking about his or her observations is at least as important as using sensory data to gather information.

In this first example of *observing objects* the class is on a class hike to see an old hitching post. Along the way the teacher begins making observations of a lizard on the ground. The children soon follow suit calling out personal observations as they climb on a ring of stepping trunks (tree trunks sliced at varying heights arranged in a semi circle). The children are engaging in parallel play as they climb from one trunk to another and call out observations. They are using the same environment in similar ways but are not playing with each other (Frost, Wortham & Reifel, 2008). Standing next to a stepping trunk Dylan makes his own observation and communicates it to the teacher.

> Dylan calls to the teacher and says, “Look I found something cool!” and points out the shelf mushrooms growing on the side of one tree trunk. (9-15-10, p.6)

The teacher looks at his discovery and continues the fieldtrip without adding to the observation. The next example of observing objects occurs in the sand area where a group of three children are using tools to dig a trench to channel a trickle of water into a river. The children are calling out to each other and are working on the similar task of diverting water. The players are engaged in associative play with Ella attempting to control what tools can be used; she tries to remove a pipe a boy is burying, and all of the children are focused on individual goals (Frost, Wortham & Reifel, 2008). When the water stops flowing, Ella voices her observation to the group (See Figure 5).

> Ella: “We’re digging and there’s no water.” “We don’t have any water!” (9-16-10, p.12)

Figure 5. Ella digs in sand as water is absorbed

The final example of observing objects took place during a class hike through the nature center grounds. Ella is observing each sign in the area and voicing it without any specified audience, thereby using egocentric or private speech to scaffold what sounds like a typical peer discussion.

> Ella: "Let's see what's in here." She looks at the signs and says, "A tortoise and two kinds of birds, cool." (9-16-10, p.13)

In these examples, the children are communicating what they observe through simply pointing out the object as something different and exciting, describing an aspect of the object such as the sand area being dry, or stating specifically what they are seeing in the instance of Ella seeing a sign and describing the contents of an animal cage. The motivations behind each scenario may be different, such as Ella hoping someone will put more water in the maze versus Dylan's desire to contribute to the class, but each example is drawn from a child making a statement about what they are seeing.

Observing phenomena

Observing phenomena is a category that had fewer instances of occurrence outside of comparing, measuring, inferring, predicting and experimenting. The observance of phenomena appears to be slightly more complex than observing people and objects, in that describing a situation is more difficult for a young child than describing something concrete. The content of these observations is influenced by the child's prior knowledge and experiences that enable communication (Johnston, 2009).

Figure 6. Sand area, Child pouring water into tiered water maze

The first example of *observing phenomena* occurs in the sand area of the play yard. Just a few minutes prior, Teacher Meredith had turned on the garden hose in the water maze. This series of tiered water troughs drains out onto the sand (See Figure 6). Dylan enters the sand area when the water starts to flow and uses a metal rake to grade a patch of sand to receive the water. There are three children in the sand area. Dylan observes the water absorbing into the soil and describes the phenomenon to his peers.

Dylan: "Everyone dig up the soil, water's leaking." (9-15-10, p.7)

Dylan uses this statement in an attempt to organize his peers into a cooperative playgroup with the common goal of preserving the available water. Cooperative play is play organized to reach a common outcome desired by all of the participants (Frost, Wortham & Reifel, 2008). The attempt at organization fails as the water becomes more abundant. The next example occurs a short time later when Dylan is piloting two plastic toy boats in a puddle of water (See Figure 7). The children are engaged in associative play, crouching down around the pooling water and are manipulating the sand to channel where the water will go (Frost, Wortham & Reifel, 2008). When another child tosses wet sand on top of one boat, Dylan observes the effect, the action of the boat sinking under the weight of sand.

> Dylan has two tiny boats, another boy chucks a handful of wet sand onto one and it sinks. Dylan says, "It sunk." (9-15-10, p.8)

Figure 7. Dylan moving his toy boats to another section of sand area

The final example of observing phenomena also occurs in the sand area of the play yard. Ella has just joined a group of classmates digging in the sand. They are engaging in associative play where they communicate at times in an attempt to control others actions but otherwise follow their own ideas (Frost, Wortham & Reifel, 2008). Ella observes water gathering in just one spot on the sandy ground. She then moves into the category of inference, attributing a cause to the phenomenon.

> She [Ella] looks at where the water is pooling and says, "There's a huge plug up there." (9-16-10, p.12)

Ella observed the pooling water and rather than defining the phenomena as is done in the previous two examples she describes what is causing the event to occur. This whole scenario could be categorized as an inference but since Ella is stating the cause as an observed fact and not one she is indirectly drawing I kept it in this category to illustrate how a child can be observing a phenomenon without directly verbalizing it.

In *observing phenomena* the children attempt to describe a situation they are seeing. The first example is when Dylan imprecisely describes water absorbing into sand as "leaking." He can see the effect of the water disappearing and is misinterpreting the cause or does not know another word to describe the action. Later Dylan can precisely describe the action of his boat going under water as "sinking." Ella also observes a phenomenon but rather than describe the action she describes the cause. Observing and describing a phenomena requires the child to draw from their prior knowledge to communicate what they know, such as the case with Dylan describing his boat going under water as "sinking" or making an approximation to convey the phenomena, as when Dylan said the disappearing water was "leaking."

Child builds on structured learning

Child builds on structured learning is a unique situation found within the naturalistic observation category since it has the impetus of a structured learning experience. This phenomenon occurs when a child participates in a structured, teacher-directed lesson, then makes a spontaneous, unsolicited observation related to the activity. This category does not strictly fit within the types of experiences proposed by Charlesworth and Lind (1999) as they begin as structured but are modified by the children into naturalistic. These spontaneous observations fall within the definition of play as being child-controlled and occurring as a free choice.

The simplest example of an *observation built on a structured experience* is when the child communicates an observation about a specific object after the teacher has directed the children's attention to an aspect of the object during a lesson. The first example of a child building on a structured learning activity occurs when Teacher Rosalind takes her class outside for a lesson on observing what lives under rocks (See Figure 8). After her demonstration of rock turning and careful looking, Dylan chooses his own rock to look under.

> After Ms. Rosalind finds a worm under a rock Dylan looks under another little rock and says, "I found an earwig under there." He makes no motion to touch it. (9-15-10, p.3)

Teacher Rosalind had begun the structured lesson on rock turning with the plan that children would end the activity by looking under a self-selected rock. She did not state this plan to the children at the outset of the activity and Dylan took it upon himself to begin independent practice. When Dylan communicates his finding to the teacher she does not admonish him for acting without permission, instead she acknowledges his find and continues her lesson.

Figure 8. Teacher demonstrates turning over rocks

The next example of *children building on a structured experience* occurs during a hike. The teacher begins the activity by pointing out flower colors and asks the children to continue sharing the colors they see around them (See Figure 9). The children engage in associative play and share aloud everything that they find interesting, from insects, to feathers.

Teacher starts to point out flower colors and then asks the kids to point out colors too. They are pointing out anything interesting as they walk in a group. (9-15-10, p.3)

Figure 9. Child shows her color collection

The structured lesson begins when the teacher begins to call out flower colors and directs the children to continue the activity. The children begin with calling out flower colors, demonstrating their grasp of the task but then assert their own twist on the lesson and call out everything that catches their interest, not just flower colors. The children practice the both skills identified by the teacher, observing objects and identifying colors, then assert their own ideas about what is of value to share with the group.

The following example also occurs on a hike. The teacher directs the children to sit at a picnic table. She guides an observation activity, directing the children to use specific senses to observe objects and sounds. She asks them to listen to the traffic sounds from the nearby road and watch leaves moving in the wind. Heather modifies the directed observation by asking Teacher Rosalind to explain an unknown object to her.

> She [Teacher Rosalind] leads them to a picnic table and has the class sit. She shows the kids the expressway over the hedge and shows a tree moving in the wind. Heather stands on the picnic bench and interjects, "what's that?" Heather points to a plastic wind catcher dangling from a tree. (9-17-10, p.16)

Heather is actively engaged in the structured lesson and when the teacher has the group look at leaves moving in the wind she notices another object moving. Teacher Rosalind answers Heather's question about the wind catcher then redirects to the next structured activity. This is a relatively short instance of a child inserting her own agenda into a lesson and when her curiosity is satisfied the lesson can continue.

The final example of a *child building on a structured experience* also occurs during a directed observation. Teacher Lisa is leading her class on a hike through the science center grounds and stops the children to point out various native plant species along the trail. When Teacher Lisa points out a yucca plant Ella follows up with her own observation.

> Teacher Lisa: "See the twisted yucca." Ella: "I see a snail on it!" (9-16-10, p.13)

Teacher Lisa is leading the structured activity, deciding which plants should be pointed out and identified as the children follow along behind her. A student calling out an additional observation is very common during hiking activities and is easily accepted as another source of knowledge adding to the hike experience.

All of these examples occurred when the teacher pointed out an object, such as a twisted yucca plant, or phenomenon, such as wind movement. The children were actively engaged in the planned activity and were eager to share their own observations with the teacher. One child even going so far as to ask the teacher to give a name to her observed object by pointing and asking, "what's that?" The children and teachers at this preschool clearly value each other's contributions of knowledge and share power in activities with relative ease.

The most complex example of an *observation built on a structured experience* occurred when the students created a spontaneous activity from a structured lesson. In this scenario the children are inside the classroom and are engaging in parallel play with all of the available toys. Teacher Rosalind is focusing on snakes this week and has precut snake silhouettes on the table for coloring, two laminated snakeskins on the light table, and is looking through a snake picture book with a few children. Dylan and Sasha are sitting at the light table rifling through the available papers and transparent materials.

> Teacher directs kids [Dylan and Sasha] to look at the snakeskin on the light table. She turns off the overhead light and asks them to look closely and see if they can find the head. Dylan and Sasha show teacher that you can still see it through a piece of white paper on top. They keep putting pieces of white paper over the snakeskin on the light table until it becomes opaque. (9-15-10, p.6)

In this example the teacher directs the students to use the light table for the purpose of observing laminated snakeskin. She specifically directs the students' attention to the task of finding where the snake's head is on the skin. The children begin working according to her direction then spontaneously modify the activity by adding sheets of white paper on top of the skin and observing the new visual aspect created by light filtering through the skin and paper. The children continue to add sheets of white paper until the light no longer filters through, creating an opaque stack of objects. Had the teacher not asked the children to use the light table, would they have noticed how light can be observed differently through differing thicknesses of paper?

The naturalistic observations inspired by structured experiences have the dual effect of children reproducing teacher actions as she models, experiencing the natural environment through observing and communicating, and directing the children's attention to objects and phenomena taught in the curriculum. The respect the teacher shows for the knowledge the children are contributing to structured lessons empowers the children to practice observing and communicate their findings at any time.

Informal learning (observations)

Informal learning occurring outside of the categories of comparing, measuring, inferring, predicting and experimenting was quite a rare and it was even more exceptional for a teacher observation to follow up a student's. This is of interest because of the tension between two commonly held ideas of how teachers should respond while their students play. The first belief is that play should not be interfered with; a "hands-off" approach where teachers only interact with children minimally during free choice activities (Frost, Wortham & Reifel, 2008). The second belief is that if a teacher is mindful of the student's current level of development they can make suggestions, ask higher order questions and use elaborated language to enhance play and cognition (Frost, Wortham & Reifel, 2008). Since there was only one example of a teacher elaborating on a student's observation during the data collection period it can be assumed that the teachers at this preschool ascribed more to the "hands-off" play approach. There will be a few examples later in the findings when the teachers capitalized on teachable moments and did scaffold the children's play but these are not common.

The one instance of the teacher responding to a child's observation with one of her own occurred in the play yard. Dylan and Max are climbing a wooden structure and begin to notice spider webs clustered around the area. The boys are engaging in cooperative play where they are sharing power in their play experience and are enjoying each other's company (Frost, Wortham & Reifel, 2010). There are a few loose car tires lying against the fence near the structure and they see a web inside one tire.

> They [Dylan and Max] find a spider web in a tire. Dylan goes to get Teacher Rosalind to see the web. She directs them to another web. (9-15-10, p.4)

In this case, the two boys find a spider web and ask the teacher to view their discovery. The teacher admires the web and points out another close by. She acknowledges their discovery as something worthy of notice and demonstrates her interest by sharing her own discovery.

Observational informal learning was more likely to take place on hikes where the entire class was looking out for interesting things to share, engaging in associative play, when the teacher points out her discoveries to the children as a member of the playgroup. In the following example the class is on a hike and Dylan starts the observation activity by pointing out a large rock. Teacher Rosalind joins with the children in pointing out other interesting objects.

> Teacher points out a spider web in a bush and then holds a mushroom so they can see the "interesting pattern of the gills." (9-15-10, p.3)

Dylan initiated this informal observation when he pointed out the rock. The teacher joined in the activity as a participant and modeled other ways of looking by pointing out the underside of the mushroom cap. The teacher informs the class that she will show them a large hole and the hike continues as well as the observation play. Later in the afternoon on a separate hike the class is continuing with their observation play. When a lizard crosses the trail Teacher Rosalind pauses the group, finding a teachable moment to discuss how to approach animals in a nonthreatening manner.

> Teacher stops class outside so they can see a lizard. She says, "We are going to learn how to see those things by walking slowly and carefully."(9-15-10, p.6)

In the first example of informal observation the teacher points out interesting objects as a method of scaffolding the children's excitement in the act of looking at nature. She also scaffolds how to make a more detailed observation and describes the subtleties of form present in a wild mushroom. The next shows the teacher pointing out a lizard as a part of the group's observation play and then building on this observation with the promise of future structured learning to enable closer observation of wild animals.

The participation of the teacher in the students' observation play serves as a validation of the children's interest and in some instances as a scaffold for ways to obtain more comprehensive information regarding the observed object.

Comparing

Comparing and contrasting, or identifying similarities and differences, leads children to focus their observations by comparing one object/phenomena to another. This is a precursor skill to classifying (Lind, 1999). An example of comparing and contrasting can be when a child brings a leaf to class in order to see its characteristics in relation to the classroom leaf collection (Lind, 1999).

Naturalistic learning (comparing)

Naturalistic comparisons are very common and present in a variety of ways. The first three naturalistic subcategories of *silent comparison, comparing within possession*, and *comparing person and object* are focused in some way on the child. The children use the method of *silent comparison* in order to more efficiently perform a self-selected task. In *comparing objects within possession,* the child feels ownership of an object and compares it to an object identified as belonging to a peer. Comparing an object to his/her own body assists in communication, relating an aspect of an object to personal experience. The final subcategory of naturalistic comparison occurs when the child compares two objects outside of his/her possession.

Comparing objects silently:

Comparing objects silently is the only category of data that does not involve the science process skill of communication. It was difficult to determine when a child was silently comparing and I only placed a scenario in this category when the child was closely attending to multiple objects and was trading the objects frequently to accomplish one goal.

The first two examples of silent comparison are performed with the intent to efficiently complete a task, exploring the ways objects can be used and how the objects impact the media the child desires to manipulate. In the first scenario Mason is inside the classroom and the children are free to choose their activity. Mason has retrieved the modeling clay tub from the art shelf and has set it on the table. The tub has a variety of containers of clay and tools to manipulate it. Mason opens a container of clay and begins a solitary play activity. Solitary play being when a child plays independently with different toys than his peers without attempting to reference what they are doing (Frost, Wortham & Reifel, 2008).

> Mason removes the teal color dough, twists it into two parts with his hands, smooshes it onto the table then grabs a small wooden rolling pin and begins rolling out the dough. Mason isn't pressing hard and alternates between a fixed handle and moveable handle rolling pin. He begins to lean heavily into the table to roll more efficiently. He finally shows a preference for the fixed handle, as it is more efficient for him. (9-20-10, p.22)

Mason compares how each rolling pin effects the modeling clay as he varies techniques to flatten it out. Finally he observes that the fixed handle rolling pin combined with his leaning technique makes a more visible impact on the clay and he chooses to continue working with that tool.

In the following example of *comparing objects silently* Heather is experimenting with three different digging tools in order to dig a hole in the sand (See Figure 10). The children in the sand area are engaging in parallel play; Heather is aware of what children around her are doing but she does not modify her activity to reflect her observations (Frost, Wortham & Reifel, 2008). Heather tries different ways of holding the tools and methods of digging.

Figure 10. Heather silently compares digging tools

> Heather watches Lindsey dig a hole and pour water in it. She [Heather] is now tossing small scoops about three feet from her. She is digging hard to get the plastic shovel into the sand. When she tosses the sand behind herself she notices a metal shovel.
>
> She [Heather] picks up the metal shovel then sets it aside when she sees a metal rake. She rakes while sitting then stands to rake.
>
> Heather sets down the rake, drops to her knees and tries out a plastic hand shovel. She sets in upon the table and while still sitting tries the metal shovel. She is now digging a much deeper hole, gripping the handle's end and also trying a grip near the digging end. (9-17-10, p. 19)

Heather's tool comparisons are driven by her desire to dig a deep hole in the sand. As she casts her eyes around the area near her she sees three possible tools for digging. As each new tool is observed Heather discards the current tool in order to try out the new one. Just like Mason did with the modeling clay, Heather also varies her technique in order to use each tool in the most efficient way possible.

The final example of silent comparison is performed, not with the obvious goal of completing a task but rather with a desire to satisfy curiosity. It occurs in music area of the play yard. James has just sat down at the drums after Chloe leaves to play in another area. He begins his comparison activity while alone in the music area, engaging in solitary play (Frost, Wortham & Reifel, 2008).

> James returns to drums when Chloe leaves. He sits and plays using two plastic drumsticks. He discovers a different sound is produced when he absently rubs the end of one stick over the surface of the metal drum. He then intentionally tries this with the two other drums to hear the different sound produced by each. (9-27-10, p.57)

James stumbles upon an auditory observation when he rubs the drumstick across the metal drum and hears a different sound being produced. Using this observation James intentionally explores the sounds produced by each separate drum. After a few minutes of silent comparison two more boys come into the music area and join James in the cooperative play activity of being in a band (See Figure 11).

Figure 11. James playing drums

Comparing objects within possession

When the children compare objects within their possession or objects they identify at the moment as belonging to them, they might be attempting to find a way to relate to a peer or simply communicating relative aspects of their property. The idea that objects in the school and science center grounds can be identified as belonging to a child is not extraordinary for this age group. According to Piaget, children from the ages of two to four years are in the symbolic function substage of preoperational thought (Frost, Wortham & Reifel, 2008). During the symbolic function substage children commonly display egocentrism, or a belief that everyone shares their personal perspective and holding an object makes it theirs (Frost, Wortham & Reifel, 2008). Combine the last bits of egocentric thought with the child's desire for peer approval, in these cases the child wants to have a peer acknowledge they possess similar objects, and this category comes into being.

The first example of a child *comparing objects within their possession* takes place in the play yard. These two boys had previously been rolling the trucks down a ramp and Dylan had stopped the play when it became too rough for him. The boys are collecting acorns and holding them in their truck beds. Dylan and Max have both chosen and identified a truck as belonging to them and have just begun to collect acorns.

> They [Dylan and Max] take trucks behind the puppet screen and Dylan begins collecting acorns in his truck bed. He says "yum-my!" He looks at Max's collection and says, "You have more than I do." Dylan squats and picks up the acorns with one hand. (9-15-10, p.5)

Dylan compares his collected acorns with the ones collected by Max. He then communicates to Max that his collection is larger. Dylan continues to collect acorns to fill, and feed to, his truck.

The next example of a child *comparing objects within their possession* takes place in an outdoor area of the science center where reproductions of dinosaur skeletons are buried in sand for children to uncover. This area provides shovels and brushes to manipulate the sand and uncover the bones, like an archeological dig site (See Figure 12). The whole class is present at the dig site and is engaged in associative play, where everyone is using the same materials and communicating but without any type of organization to the play (Frost, Wortham & Reifel, 2008).

Kate and Mary are brushing on the tail of a dinosaur skeleton partially buried in sand. Kate: "It's getting bigger and bigger." "We have the same brushes huh?" (9-24-10, p.49)

Kate is sharing her observations with Mary as she works at uncovering the dinosaur bones. Kate compares her brush to Mary's and then asks for Mary to agree that they have the same brushes.

Figure 12. Boys compare their excavation brushes at the dig site

Both scenarios have one child leading the conversation prior to the comparison and then the comparison is commented on without any kind of value judgment added on. This passivity may be because the child's possessions are not being threatened. Since all of the children in both scenarios have similar toys there is no need to assert that one toy is superior to another or to attempt to trade. When Dylan comments that Max has more acorns he simply begins to collect more from the ground, the inequality observed is not hinted at as being negative or wrong but simply a statement of fact, an aspect of their play that can add to the spoken dialogue. When Kate comments on her and Mary's brushes she makes no further observations regarding the tools, simply continuing the play scenario to reveal the buried bones. Both Dylan and Kate are conversing in a friendly manner and are attempting to relate to a peer.

Comparing person and object

Comparing an object to his/her own body assists in communication, relating an aspect of an object to personal experience. The children are drawing upon very strong stores of prior knowledge accumulated about their own body and incorporate a bit of egocentrism, the belief that others share the same perspective in order to communicate their understandings (Slaughter & Heron, 2004). Aspects of egocentric speech are also present in how these utterances may be a mental scaffold to talk through new information in a manner that makes sense personally (Vygotsky, 1978, Frost, Wortham & Reifel, 2008). The children compare an object to themselves or they can compare a part of themselves to an object. The following examples illustrate both scenarios.

In the first example of *comparing person and object*, a class of children paused during their hike inside the science center. They are freely exploring a room filled with animal and earth artifacts. Kate is standing alone in a corner of the room looking at a preserved rattlesnake poised to strike. Kate turns to me and shares her thoughts on the snake.

Kate: “Hey you want to see this?” she points to a rattlesnake in a glass dome,

“He’s scary” “He’s got teeth like this” she pinches her canines. (9-24-10, p.49)

Kate is focused on the snake’s fangs and relates their position in the snake’s mouth to her canines. Kate communicates her understanding with the gesture of pinching her teeth with both hands to make her meaning clear.

The next example illustrates how a child compares a part of their body to an object/animal. This scenario occurs in front of the drum set in the play yard. Two boys are sharing drumsticks and playing the instrument together when Dylan pauses playing to talk to Oliver.

Dylan starts to show Oliver a scab on his leg that he says looks like a tick.

(10-11-10, p.111)

Dylan wanted to share something he found interesting on his body, a scab, with his peer. To assist with communicating relevant information about the scab Dylan compares it to a tick, implying that it holds the same general size, coloration or possibly shape.

Kate observes the mouth of the preserved rattlesnake and notices the fangs. She compares an aspect of the snake to her own body, interpreting which of her teeth are most like the snakes and pinches her incisors to communicate her understanding. Dylan observes a scab on his leg and compares his healing wound to an animal. He communicates to Oliver that his scab is similar in appearance to a tick. By making this comparison Dylan demonstrates his attention to the visual aspects of his body.

Comparing two objects outside of possession

The final subcategory of naturalistic comparison occurs when the child compares two objects outside of his/her possession. This category is focused completely outside of the child. The children in this category do not consider any of the related objects as a personal possession, nor do they relate the object to their body. They are focused on concrete observations to make their comparisons. This departure from egocentrism does not quite reach the next developmental stage described by Piaget as concrete operation thought, due to a focus on only one aspect of an object at a time but it is a step forward (Frost, Wortham & Reifel, 2008). Within this category the children either focused on the objects' color, length or shape. The most common comparison featured the visual aspect of coloration.

The first example of *comparing two objects outside of his/her possession* occurs during a hike. Teacher Rosalind has already pointed out a wasp and mushroom to the group and the children are freely calling out their observations and talking amongst themselves, engaging in associative play. Nathan is contributing to the discussion by stating that a hornet stung him before. When Luke shows him some wild mushrooms Nathan communicates an observation comparing them.

> Nathan: "There are two different types (of mushroom) because one is white and one is dirty." (9-21-10, p.29)

Nathan makes a color comparison between the mushrooms, attributing them to different species based on their varying pigmentations.

The next example occurs inside of the classroom during free play. Kate and Mary are playing together in the block area with an assortment of plastic animal figurines on a low table on the carpet. Kate and Mary are engaging in associative play since they are sharing the toys and talking to each other but are not playing the same game (Frost, Wortham & Reifel, 2008). Kate is comparing two of the dog figurines and does not verbally identify either toy as a personal possession.

> Kate: "That is the mommy because it is the same color." (She holds up the Doberman and Dachshund toys). (9-24-10, p.47)

Kate considers the two toy dogs to belong to the same species due to the similarity in their coloring. She attributes the size difference to age, according the larger toy the role of "mommy."

The final example of a *child comparing objects outside of his/her possession* occurs on the play yard. Chris had found a pocket-sized reptile field guide earlier in the day and had taken to carrying it around with him, at times pausing to look through it. When he first encountered the book he brought it to the teacher and asked if it was hers as it was not common for books to be outside. The teacher replied that the book belonged to the school and Chris could use it if he wanted to. Chris is engaging in solitary play, independently choosing activities to amuse himself in different areas of the yard (Frost, Wortham & Reifel, 2008). After observing a reptile lawn ornament in the play yard

Chris remembers a picture he saw in the book and takes it out to make a comparison (See Figure 13).

Chris has the book open by the crocodile lawn ornament under the tree.

Chris: "This crocodile is blue and this crocodile is blue." He points first to the book then the ornament matching them together. (10-15-10, p.134)

Figure 13. Chris compares crocodile lawn ornament to field guide

Chris found the similar coloration of the picture and object to be interesting. The teacher had modeled many times how to use a field guide during structured lessons and Chris applied that knowledge independently.

In the first example the child describes the coloration of two mushrooms and uses this contrast to differentiate them as being of different types. In the other two examples, the children recognize the similarity of coloration and either consider the objects as a family unit, as with the brown dog figurines, or as a similar species, as with the crocodile lawn ornament.

The other instances of comparison focus on either the shape or length of the objects. In the following example, Tyler is in the play yard after lunch and is attempting to garner the attention of Ava who is still eating at the picnic table. He is the second child to finish his food and he is casting around for something to do while waiting for his friend to finish eating. He has taken a spot under a tall bush and absently picks a leaf and examines it, then compares the shape of the leaf to another object.

> Tyler holds up a serrated edge leaf, “This is like a sword.” “These ones make you itchy.” (10-12-10, p.124)

Tyler makes a casual comparison of the concrete object (leaf) to an abstract object (sword) was made with the intention of engaging Ava in a conversation. Ava is distracted by her peers at the picnic table and does not respond, leaving Tyler relegated to onlooker behavior until she is finished and can play with him.

In the next example Chris compares the length of two objects in the play yard. Earlier in the day Teacher Rosalind presented a structured lesson using a chameleon and ladybug puppet. The teacher described the characteristics of the chameleon, including its long tongue. The teacher took the chameleon puppet outside to be used in the puppet area. While engaged in solitary play, wandering the play yard, Chris suddenly decides to go into the puppet area. Chris has chosen to play with two reptile puppets and turns the faces of both puppets towards his own face comparing their fabric tongues.

> Chris goes to the puppet area and puts on puppets. Chris: "Now I get it, this lizard (indicating an orange lizard) and this chameleon have very long tongues." (10-15-10, p.137)

Teacher Rosalind's structured activity and addition of the chameleon to the puppet area led Chris to notice the chameleon's tongue. Chris continues his observation to include another lizard puppet and how it is similar to the chameleon.

Tyler observes the shape of a leaf and compares it to a sword and Chris looks closely at the two puppets on his hands and compares the length of their tongues. When children *compare objects without the aspect of possession*, they focus more on aspects of the objects and less on egocentric thought.

Informal learning (Comparing)

There was only one instance of comparing as informal learning during the data collection period. It occurred during a hike when the children were shuffling their feet on the hiking trail. One child started to shuffle and soon everyone was doing it and listening to the sounds produced by shoes dragging against gravel. Teacher Rosalind began to join the game asking the children to stop and start as a group. She then added a layer of comparison to the students' observations by asking them to continue their shuffling game as they changed walking surfaces. She asked them to listen for differences as they transitioned to a stone surface and again when they entered the carpeted science center.

> Kids are shuffling on rock trail and teacher has a start/stop game and asks them how the sound changes as they transition to a concrete patio, wood planking and a rug. (10-1-10, p.82)

Teacher Rosalind saw a window of opportunity to model making comparisons. The children were engaged in a cooperative play activity and rather than asking them to quiet down or behave she honored their activity choice and made her own contribution to the group. All other comparing experiences recorded during the data collection period that involved the teacher were a part of structured lessons.

Classifying

Classifying is the process whereby children group and sort concrete objects (Lind, 1999). To classify children will make comparisons between objects and develop subsets, or groups of objects that have a common unique characteristic (Lind, 1999). An example of classifying would be sorting groups of animals by color, such as brown and white, then defining a subset of animals as brown with four legs and brown with two legs (Lind, 1999).

Naturalistic learning (classifying)

Examples of classifying found in this study are limited to simple sorting or grouping without defining a subset. In Piaget's intuitive thought substage (age 4-7) children are unable to organize objects consistently based on only one attribute. The child may start sorting by color then switch halfway through to shape. Children in this substage are also unable to develop subsets within their groups (Frost, Wortham &

Reifel, 2008). The tendency to identify one characteristic at a time is supported in the comparing category when children focused on a single aspect of objects to compare.

In the first example of classifying, Ella is able to focus on only one attribute in a pile of natural objects. She does not change her sorting criteria or become distracted by another characteristic. The activity occurs in the play yard, as Ella is engaging in solitary play. Ella has been collecting acorns all morning and when Ella sees an abandoned metal pail that had been filled with acorns, hay and leaves, inverted onto a table she patiently begins to separate the objects (See Figure 14).

Figure 14. Ella sorts acorns

> Ella comes across a girl's pail that is inverted on the table. She sets her buckets by it and picks (sorts) the acorns from the pile to fill her buckets. (9-16-10, p.11)

The next example of categorizing also occurs in the play yard. The yard frequently is visited by grackles as they search for food. Tyler and Ava are trailing after the birds, playing cooperatively, and are able to identify the gender of the birds by their coloration, just as their teacher has done for them before.

> Owen joins (follows after) Tyler and Ava who are stalking grackles. Tyler and Ava are identifying grackles as either boys or girls. (10-26-10, p.168)

The children in this scenario are independently practicing classification just as their teacher has modeled on hikes. They remembered the coloration of the female and male grackles and used this information to inform their sorting criteria.

The first example of classifying occurs when Ella sees a pile of acorns, sand and hay and she picks through the pile to remove the acorns to add to her bucket. Ella is sorting the pile using the criteria of acorn or not an acorn focusing on only one attribute "acorn-ness" to categorize. The second example is when a group of children are following grackles around the play yard identifying each bird's gender based on their coloring, also only focused on one characteristic. Both classifying scenarios have the children identifying only two groups without any outliers. The object is either an acorn or not and the grackles is either male or female. A more complex group of objects may have revealed different kinds of sorting.

Informal learning (classifying)

Only one example of an informal classifying experience was recorded during the data collection period. It occurred when the students were standing inside of the nature center waiting for their classmates to finish with the water fountain. Next to the water fountain was a display table filled with natural objects (either bones or animal skins). The children were engaged in associative play as they passed back and forth the objects and held them up to ask the teacher to identify them. The teacher sees an opportunity in the students' interest and asks them to bring the objects over to her and sort them on the carpet into two piles using the criteria of bone or fur (See Figure 15).

> Kids keep asking teacher questions regarding the display. She then has the children collect all of the bones and put them in one spot on the carpet. She then directs them to pick up all the pieces of the fur that covers bones and assemble them into a pile by the bones. (10-4-10, p.91)

Figure 15. Bone and fur groups

The teacher scaffolds sorting into two groups, just as the children sorted in the scenarios that occurred prior to and after this demonstration. The students are able to complete the task without assistance and without imposing any additional subsets to the categories.

Measuring

Measuring is the quantification of a child's observations through standard or nonstandard units (Lind, 1999). Standard units can include inches, pounds, degrees, seconds, and gallons while nonstandard units can include jumps, rocks, fingers, day events, and pudding cups (Lind, 1999). At the age of four, children should be presented with everyday situations where they can compare heights and other lengths directly in order to identify objects as similar/different or more/less based on measurable attributes. The use of units at this age is often assigned by guessing (Clements & Sarama, 2009).

Naturalistic learning (measuring)

There are multiple examples of children measuring during play. The most common ways they measure are to either quantify an object/event or to make a comparison between an object/event and another object. Quantifying of an object or event was recorded with the child only using standard units such as minutes, feet and pennies. However, children measuring using comparisons tended to use nonstandard units such as ants, cheetahs and celestial bodies.

Quantifying measurements

The children quantified many of their activities, often wildly overestimating the amount they are attempting to convey to a peer or teacher. The students varied widely in their use of standard units, using the correct attribute of measurement for an object or activity if not precisely the correct subset of the unit. For example, a child wishes to describe the time it takes for a ball to roll up a ramp. He correctly uses a unit of time, minutes, but the event would be more efficiently measured in seconds.

The first example of a child quantifying an event occurred when Max is engaged in solitary play in the play yard. A couple minutes before this event Max and two other boys were engaged in associative play, rolling balls down the ramp. When Max decides to start launching balls up at the other boys they leave to play elsewhere. Max takes up a position standing at the base of the wooden ramp and begins to launch golf balls up the ramp, over the platform and out onto the rope bridge area (See Figure 16). As Max launches each ball he yells out how long it takes for the ball to travel to the platform. These utterances are considered as private speech since Max no longer has an audience. He may be practicing using his knowledge of time measurement, simply stating his actions aloud or attempting to garner back the attention of his peers with his announcements.

> Max tries rolling his ball up the ramp and the boys dissipate. Max announces random time intervals each time he releases the ball (every five seconds), “Thirty minutes again!” (10-13-10, p.125)

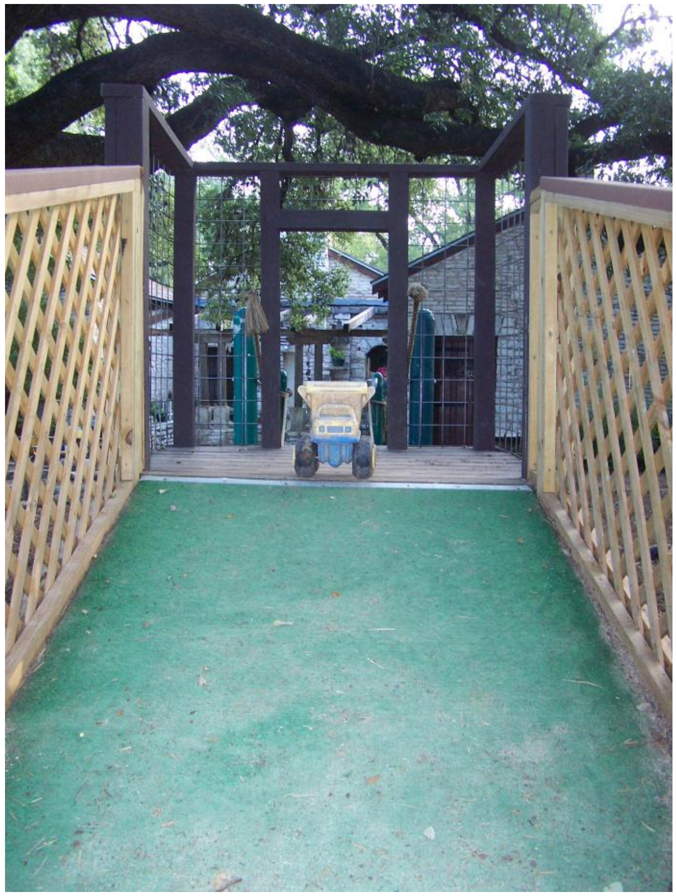

Figure 16. Photo taken from base of ramp

The next example of quantifying occurs in the play yard as two boys are collecting acorns to feed their toy trucks (See Figure 17). The boys are playing cooperatively to feed their toys (Frost, Wortham & Reifel, 2008). When Tyler says that they need more acorns Owen quantifies exactly how many they need.

> Tyler sets a plate in front of each truck and dumps his acorns on his plate. Both take trucks to the yard to collect more acorns then drive them back and dump out on plates. Tyler: "We need some more." Owen: "We need a million (acorns)." (10-12-10, p.121)

Figure 17. Tyler and Owen feeding acorns to their trucks

The following example happened on the play yard just after Dylan's class returned from a hike. On the hike Teacher Rosalind inserted a yardstick into the hole on a live oak tree to show its depth. The hole was approximately 25 inches deep. Teacher Rosalind often carried a wooden yardstick on hikes and would model how to take measurements. When Dylan arrived back in the play yard he wanted to communicate to Teacher Lisa what he had just seen.

> Dylan stops to tell her [Teacher Lisa] that he saw a hole in a tree "500 feet long." (9-15-10, p.4)

The final example of a child measuring an amount using a standard unit of measurement occurs in the play yard's sand area. Sarah and Rose are standing in front of a wooden table and Rose decides to pay Sarah for a bowl of sand. Rose wants to represent the quantity of money needed to make the purchase and uses the unit of pennies making a one-to-one correspondence as she counts them out.

> Sarah and Rose do commerce over bowls of sand. Rose is paying with invisible pennies and Sarah picks up three acorns, dropping them in an empty plastic cube saying, "Now I have three pennies." Rose: "Three pennies?" and taps the table three times setting down invisible money. (10-14-10, p.131)

In the first three examples the boys overestimate the quantity they wished to report. Max calls out that it is taking thirty minutes for a ball he throws to roll up a ramp, Owen wants to collect a million acorns in the front scoop of his toy truck and Dylan tells his teacher that the hole he just saw being measured with a yard stick is 500 feet deep. The last example shows two girls trading acorns for play pennies, which is the most realistic approximation of actual value out of all these scenarios and used one-to-one correspondence for an accurate tally.

Comparing measurements

When the children compare objects or events to another object they tend to use nonstandard units. They continue with the theme of ascribing the appropriate attributes to each object while exaggerating relative quantities. In the following examples size is compared to the Earth, sun, wind and an ant while speed is compared to a cheetah.

In the first example Natalie and Sophia are drawing outside on a table in the art area of the play yard. Both girls are engaged in associative play, communicating what they are drawing and copying each other's designs (Frost, Wortham & Reifel, 2008).

Natalie and Sophia are drawing similar pictures featuring hearts, hands and stylized hair (See Figure 18). Another child is present but is playing alone.

> Natalie to Sophia: "My heart (indicating her picture) is bigger than the Earth."
>
> Natalie: "Just kidding, the Earth is bigger." Sarah: "The sun is bigger."
>
> Sophia: "No, the wind is bigger 'cause it's everywhere, even in outer space."
>
> Sarah: "Yeah, the wind." (9-30-10, p.80)

Figure 18. Sophia's heart and hand drawing

The verbal exchange stops when Sarah is unable to think of an object larger than the wind and she agrees with Sophia. The exaggerations begin in a teasing manner then both girls make an effort to win the "what is bigger" contest. It is worth pointing out that in the scenario both girls knew that the sun was larger than the earth, demonstrating the science facts they have as a part of their prior knowledge.

In the next example of *comparing measurement* Dylan's class is on a hike. The teacher has just finished a structured learning activity where she modeled turning over large rocks to see the animals living underneath.

> He [Dylan] kicks over a 4-inch rock and finds an animal "longer than an ant." He kicks around, squats and looks at the ground intently. (9-15-10, p.3)

Dylan doesn't know what type of insect he found so rather than calling out its name he describes its size. He uses an ant as a comparison due to one of an ant's more obvious characteristics being a tiny length, or he may have thought this animal in some way resembled an ant. With either reason it is evident that he was comparing the unknown insect length with a fairly well known insect, communicating effectively an approximate size to his peers.

The final example of a child using a *comparing measurement* occurred on the play yard. Andrew's class has just finished observing an animal visitor, a ferret, running freely around in the classroom and he wishes to demonstrate his speed to the teacher. He uses one of the most common attributes ascribed to a cheetah, speed, to compare his running to.

> Andrew demonstrates that he is "as fast as a cheetah" for Teacher Rosalind. (9-29-10, p.73)

While Andrew most likely was not as "fast as a cheetah" he did run as quickly as he could to show his skill to the teacher. It should be mentioned that for the mammal unit

Teacher Rosalind had an orange felt silhouette of a cheetah in the classroom that children could attach black felt spots onto, so it is possible that cheetah were mentioned during that week as fast animals.

The first scenario starts off as an intended exaggeration, as Natalie compares a drawing to the size of the Earth. Natalie quickly explains this exaggeration as a joke but Sarah carries on the topic stating that the sun is bigger than the Earth. Natalie seizes upon this line of reasoning stating that wind is bigger than the sun and Sarah agrees. Andrew continues the exaggeration theme when he boasts of his personal running speed comparing it to the quickness of a cheetah. The only example of a child using a realistic comparison occurs when Dylan sees an unknown insect and he compares its size to that of an ant, using a commonly known insect as a recognizable nonstandard unit.

Standard and nonstandard units in measuring are used to communicate information about an object or event to another person. In some instances that information is concrete and accurate, such as when Dylan sees an insect "longer than an ant," while in others it is exaggerated to an extent to be unusable, such as Max declaring the ball he is throwing will fall in half of an hour. The use of standard or nonstandard units is no guarantee of accuracy.

Informal learning (measuring)

During informal learning experiences the teacher uses both standard and nonstandard units to communicate information. For measuring activities the teachers embrace more of the scaffolding approach to play, creating situations that require the child to think/act beyond their current level of development (Frost, Wortham & Reifel, 2008).

In the first example Teacher Lisa is discussing snakes with Max in the play yard. Snakes are the topic of this week's curriculum and the children have just listened to a snake book and cut a coiled snake shape from a paper plate in an in-class structured lesson. While outside, Teacher Lisa comes up with the idea of showing Max how long the longest known snake is.

> Teacher [Lisa] tells Max that the largest snake is 27 feet long. She gets a measuring tape (from inside the classroom) to see how long that is. Max: "Let's see how long this is" and holds up a spiral paper plate snake. Teacher measures the snake and tells him it is two and a half feet. Max holds the snake and Teacher holds up the tape measure. Max says, "Oh my gosh! Guys look at this!" "Sasha! This is how long the biggest snake is." "Isn't that cool!" Teacher had him walk back with the end of the tape and stops him at 27 feet. (10-13-10, p.128)

Max and Teacher Lisa are engaged in a cooperative play activity without any other children participating. When Max sees how far apart they are standing to demonstrate the snake's length he is so excited he wants to communicate his knowledge to another peer.

The second example of informal measuring comes about when the class is at the dinosaur bone excavation area. The children are all engaged in associative play as they choose shovels and brushes to clear off the bones (Frost, Wortham & Reifel, 2008).

Teacher Lisa then asks the children to use their bodies as nonstandard units to measure the skeleton (See Figure 19).

> Then teacher instructs class to lay down end to end to see if they are longer than the dinosaur bones they uncovered. (9-20-10, p.25)

Figure 19. Measuring a monosaur with nonstandard units

Teacher Lisa scaffolds how units should be laid "end to end" for an accurate measurement and she compares the total length of the children to the monosaur.

The teacher in the first scenario produces a measuring tape to give Max a concrete example of how long the longest snake is. Max is excited to see the actual length and also desires to have his paper snake measured. The second scenario is when the teacher attempts to give a comparative measurement to the partially submerged skeleton by asking the class to lie down on it to see which is longer. The children comply but quickly move on with their play activity of unearthing the dinosaur.

Standardized measuring tools were available inside of the classrooms but were never brought outside for the children to use. Even though measuring length was modeled various times by the teachers there were not any examples in the data to support any play measurement of length, either with a standard or nonstandard tool.

Communicating

Communicating as a science process skill for young children refers to the ability to describe a phenomenon (Lind, 1999). Communication can be verbal or nonverbal (Lind, 1999). Nonverbal communication can be through gestures, body positions, facial expressions and pictures while verbal communication can be with words or vocal sounds (Lind, 1999). Communication requires a child to gather information, process it, and then present it to another so that they can understand their meaning (Lind, 1999). An example of communication is when a child keeps a log of their experiences, such as daily weather, and then is able to answer questions regarding their observations (Lind, 1999).

Figure 20. Children communicate to solve a problem

The difficulty of coding instances of communicating is how intertwined communication is with each process skill category. The vast majority of the examples for each process skill involve the child communicating their thoughts (See Figure 20). Without communication I would not have been able to discern what the children were doing and their motivations behind their actions.

Naturalistic learning (communicating)

Examples of naturalistic communication can be found in each category but here are two samples of how children are communicating their ideas and observations to each other.

The first example is a conversation between two girls sitting outside at the block area building block structures. The girls are engaging in associative play where they are both using the blocks and making comments but are not working toward a common goal (Frost, Wortham & Reifel, 2008). A dragonfly darts past Mary's head and she jerks her head back giving a shout of surprise.

> Mary: "Ahhhhg!" Rachel: "What?" Mary: "A dragonfly almost bit me." Rachel: "Dragonflies don't bite." The girls both cite their friends telling them if dragonflies bite or not. Mary: "I believe my friends not you." (10-22-10, p.160)

The next example occurs between two boys conversing alone at a picnic table. They have just finished observing Teacher Rosalind reading with another boy and they are about to move on to another activity.

> Billy: "Did you know we used to have an alligator that was alive?" Billy takes Jason to show him the alligator lawn ornament. Billy: "It was cut up." Jason expresses his disbelief. (10-1-10, p.87)

In the first example the girls debate the characteristics of dragonflies, specifically their tendency or inability to bite, backing up their arguments by citing what they have been told in the past. The second example occurs when Billy explains to Jason how a resin lawn ornament used to be a live alligator. Both of these examples could be categorized as another process skill (inference) and showcase the importance of verbal communication in understanding the reasoning behind a child's actions.

Informal learning (communicating)

When teachers use expanded language with their students it results in higher language development (Frost, Wortham & Reifel, 2008). The externalizing of inner speech, verbalizing one's though processes, provides a model or scaffold for children to base their own thought processes on. With this scaffold talking through how to solve a problem or complete a task children can reach beyond their current developmental level (Vygotsky, 1978).

The teachers at this preschool were very verbal with the children during structured and informal activities and largely kept quiet during naturalistic learning. They often would wait for an invitation, such as a question, before entering play and then after providing information or assistance would transition out of the activity.

Inferring

Inferring occurs when a child makes observations and then is able to draw a conclusion from the knowledge attained during observations indirectly (Lind, 1999). This differs from observations where information is gathered from direct experiences (Lind, 1999). An example of inference is when a child observes leaves moving on a tree outside a window and infers the wind is blowing. The child cannot feel the wind but based on observations and previous experience they know that the wind is blowing (Lind, 1999). Categorizing inferences are difficult due to an incomplete understanding of each child's prior experience. It is not possible to know all of the observations a child has experienced before coming to school and what I may consider to be an inference may be the repetition of an event previously experienced and not a leap of logic.

Naturalistic learning (inferring)

Inferring within naturalistic learning occurred when the children either were trying to figure out a cause or reason for a current observation or when they were actively trying to solve a problem.

Inferring a cause

When children were *inferring a cause* to explain what they are observing, they either communicated their idea with or without support for the inference. The following scenarios are inferences the children supported with their reasoning. When children verbally support their reasoning it provides insight into the previous experiences and knowledge.

The first example of a child inferring and supporting their reasoning occurred on the nature center grounds where the replica dinosaur skeletons are available for excavation. Kate looks at the mosasaur skeleton and turns to tell me about it.

> Kate: "I know dinosaurs that have been extinct." "This one lived in the ocean because it doesn't have feet." (9-24-10, p.49)

Kate is familiar with the dig site and has most likely seen the sign describing the monosaur along with the picture depicting the animal swimming in the ocean. Her reasoning does not hint at these origins however when she points out that it has fins instead of feet.

The second example of a supported inference occurred while three boys are transitioning between activities in the play yard. Today Max has arrived at school wearing pieces of his Batman costume (cape, a thin cloth suit over his clothing, and a partial cloth face mask). Owen notices Max sneezing and draws the inference that Max is sick.

> Owen: "You got sick, you're sneezing a lot." Max: "I've got a Batman costume and I can't get sick." (9-28-10, p.63)

Both boys make inferences and support their position. Owen infers that sneezing people are sick and Max infers that people wearing Batman costumes can't get sick. Had Max not mentioned the costume we might have thought he just didn't feel sick, he never gets sick, or maybe that there was another cause attributable to his sneezes.

In the first example Kate is looking down at the dinosaur skeleton and infers that it once lived in the ocean. Her inference is supported when she says that the skeleton does not have feet. In the second example Owen infers that Max is sick and supports his inference by pointing out his sneezing. Max makes a supported counter inference indicating that he is immune to sickness because he is wearing a Batman costume. All three of these inferences are based on previously acquired information. Kate has knowledge of either aquatic animals or dinosaurs, Owen has knowledge linking continuous sneezing with sickness and Max has knowledge of Batman being invulnerable to illness. In these examples it is easier to categorize them as inferences because the children communicate some of their thought process behind their statements. In the following two unsupported inferences it is more difficult to trace the thoughts behind the statements.

In the first example Owen and Tyler are in the play yard collecting acorns to feed their toy trucks, engaging in cooperative play. Owen observes the color of the acorns and infers a cause.

Owen: "The ground makes nuts green right?" Tyler: "Right." (10-12-10, p.121)

Owen infers that the ground is responsible in some way for the acorn color but we do not know why he believes this. He asks Tyler to confirm his inference and Tyler agrees.

In the second example the class has gone on a hike to see a horseshoe embedded high in a tree trunk. The children have all reached out and touched the ends protruding from the bark (See Figure 21). Dylan offers up an unsolicited comment to explain why the horseshoe is located high on the tree.

> Dylan: "Maybe the horse was a good jumper" when he explains how the horseshoe ended up in the tree. (9-15-10, p.7)

Figure 21. Child touches horseshoe embedded in tree trunk

In the first example Owen infers that being on the ground makes the acorns green. Tyler confirms his inference, but neither boy indicates what knowledge they have to back up their statements. In the second example Dylan infers that a horseshoe stuck into the side of a tree was lodged there when a horse jumped high. Dylan leaves his justifications unstated and his peers have a choice of either accepting or rejecting the accuracy of his inference.

Inferring for a solution

While *inferring for a solution*, children encounter a problem, and after inferring how the problem was caused, try out a solution. This is similar to predicting and experimenting in that the solution may or may not work. I chose to keep this category separate due to the children making an inference at the outset and only attempting one solution without any other variables becoming a part of the scenario.

The first example of a child *inferring for a solution* occurred in the classroom after Teacher Rosalind has set out a variety of animal bones and pelts on the tables for children to explore. The children are engaging in parallel play and may occasionally switch over to associative play by commenting on a peers activity (Frost, Wortham & Reifel, 2008). Owen has a bobcat skull in hand and notices it is missing a jaw. He casts his gaze across the table and finds a large jaw sitting by itself.

> Owen manipulates bobcat skull, aligning the jaw, then he puts an orangutan skull on top of a javelina jaw (See Figure 22). (9-28-10, p.67)

Figure 22. Owen aligns bones from two different animals

Owen does not verbally communicate his inferences that the skull is missing a jaw and that the solitary jaw belongs to the skull, but he appears to be satisfied in how the two bones fit together.

The next example takes place on a table in the sand area of the play yard. Rose has already made and carried away a sand “cake” and was overcome with the weight of her load, dropping it all over the ground. When Rose returns to the table she sees Sarah making a sand cake too. When Sarah says that her cake is too heavy Rose infers why and finds a way to help, starting a cooperative play activity focused on reducing the weight of the cake (See Figure 23).

Sarah tries to pick up her cake and says it's too heavy. Rose picks up a small plastic hoe and carefully scrapes away sand from the sides, "to make it lighter." (10-14-10, p.130)

Figure 23. Rose scrapes sand off of Sarah's sand "cake"

Rose makes a few inferences in this scenario. First, that the reason she dropped her sand cake was due to it being too heavy. Second, that Sarah's sand cake will be too heavy to carry safely. Third, that scraping off sand will make it light enough to carry.

The final example also occurred in the sand area of the play yard. Dylan and James are playing with the water runoff from the maze. Dylan notices how the water flow slows. He infers what is causing the water to slow then clears a drainage hole in the water maze in an attempt to fix the problem.

Dylan: "James, something is blocking the waterway, not much water is coming down." Dylan goes to the next tier of the water maze and unblocks the drain hole with his fingers. (9-15-10, p.8)

In the first example Owen is manipulating an orangutan skull and observing the remaining bones scattered across the table. He infers that this skull is missing a jawbone and he locates a jawbone, setting the skull atop it. In the second example Rose has already attempted to carry a sand cake that was too heavy for her and she accidently dumped it on the ground. When Rose returns to the table and hears Sarah say that her cake is too heavy Rose infers that with less sand it will be lighter. To solve the problem Rose comes up with a way to scrape sand off the sides of the cake. In the last example Dylan observes that the water volume has decreased and infers that something is blocking the waterway. Dylan walks over to the water maze and looks for a blockage, clearing a drainage hole with his fingers.

While many examples of naturalistic inferring are started with the need to explain what is going on, some are voiced with the goal of fixing a problem. The thought processes that lead to these inferences may be spot on or completely inaccurate (as with the invulnerable Batman costume) based on the accuracy on the child's supporting knowledge and how well the child is able to generalize and synthesize what they already know.

Informal learning (inferring)

I was able to find only one example of informal inferring in the data. It occurred during a hike when the children observed a pile of bird feathers scattered across the ground under a tree. As the children begin collecting the feathers, engaging in associative play, Teacher Rosalind scaffolds an inference by asking them how the feathers might have gotten there.

> Kids find a pile of feathers and start picking them up. Teacher Rosalind asks them why the feathers are there. Dylan guesses that an animal ate it. (9-15-10, p.4)

When the teacher scaffolds the children to think about the cause behind the placement of the feathers the children pause in their collecting, look closely at the area and pull ideas from their prior knowledge. The teacher's open-ended question regarding the phenomenon of scattered feathers moves the play activity to a higher level (Frost, Wortham & Reifel, 2008). Dylan uses his prior knowledge to speculate that an animal ate the bird, leaving the feathers behind.

Predicting

A child makes a prediction when they make a statement about what they think will happen at a future time. These statements are not random, but are based on observations of data and are reasonable expectations (Lind, 1999). Predictions are useful for the developments of an awareness of cause and effect, and patterns. An example of prediction in an early childhood setting is having the children listen to a story about growing seeds then prediction how many seeds from their package of seeds will grow into plants. Children will often observe the phenomenon they have made a prediction about and observe the actual results (Lind, 1999).

Naturalistic learning (predicting)

Most naturalistic predicting presents in a similar manner to *inferring for a solution*, both categories occur when the children are problem solving and are based on previous observations. The difference in naturalistic predicting is that the children are speculating what will happen in the future if they try out a solution rather than inferring a cause for the problem first then basing their solution on observations that are immediate and similar to the activity.

The first example of a child predicting occurred in the play yard. Natalie has selected a small plastic aquarium to create a roly-poly habitat in. Sophia decides to help gather roly-polys and predicts where she will find them in the play yard. The girls then begin a cooperative play activity with the goal of roly-poly collection (Frost, Wortham & Reifel, 2008). From previous observations I know that Sophia has been exposed to looking for insects under rocks during structured lessons.

> Sophia looks at Natalie's aquarium, then scares off a grackle, before turning over the stepping stumps in music to look for roly-polys (See Figure 24).
> (10-19-10, p.147)

Figure 24. Sophia and Natalie search for roly-polys

The girls don't immediately voice their prediction, instead easily transferring knowledge about where to find insects to lifting up tree stumps.

The next example took place in the sand area of the play yard. Dylan and Ryan have set a piece of gutter under the water maze discharge hole in a cooperative play activity and are adding sand to the gutter to create temporary dams before releasing the flood. After a couple minutes of creating dams to force higher water pressure Dylan lays a piece of PVC pipe into the gutter to direct and force the water.

> Dylan: "You need to block it so it will go fast." "After I undo it, it will go fast."
>
> Dylan is watching, crouched down at the end of the gutter. He goes and plugs both ends of a pipe with sand and says it will make the water "blast."
>
> (10-20-10, p.150)

Dylan is sure that if he creates enough pressure by blocking the water flow he will create a surge of water when the sand is removed.

The final example also occurred in the sand area of the play yard. Nathan has just finished burying a long PVC pipe in the sand at the base of a river trench. Nathan was engaged in parallel play during the burying process. Another boy was also shoveling sand onto the pipe and Natalie was making her own river using the same water source. When the pipe is buried Nathan steps back to see the water flow into it.

> Nathan then notices the water is too low "The river's not reaching it." He looks at the river branch Natalie created and decides that the problem is her divergent trench so he grabs a large metal bowl and sets it upside down on the ground blocking water from her trench (See Figure 25). (9-21-10, p.32)

Figure 25. Nathan blocks Natalie's river branch with an inverted bowl

Nathan predicts that if the divergent trench went away his pipe will fill with water. This solution does raise the water level but as Nathan's pipe is still out of reach and Natalie is livid at his interference this solution is short-lived.

In the first example Sophia uses her background knowledge of roly-poly habitats to predict that she will find roly-polys under the stepping stumps. Next Dylan predicts that if he blocks the end of a pipe with sand when the water is released it will move fast. In the final example Nathan has buried a pipe in the sand to conduct water. When he realizes that the water is being split into two divergent branches, he predicts that blocking one of the branches will raise the water level enough to enter his pipe. In all three of these scenarios, the children are motivated to follow through with their prediction in order to achieve their goal.

Informal learning (predicting)

There is only one example of informal predicting in the data. It occurred when the teacher found a large insect that was missing a leg and set it aside to show the children. When she shows the insect to the students it begins to slowly crawl out of the play yard and towards the fence. The children are squatting all around the insect and are occasionally reaching out to touch it on its back, engaging in cooperative play as they regulate each other's actions to preserve the insect's life. One child asks what will happen to the insect since it is injured. The teacher gives her prediction for the insect's future.

> When some of the children question ask what will happen to the bug the teacher says he will probably get eaten by a bird and turned into energy. (9-27-10, p.54)

The teacher in this example uses the children's question scaffold her thought process, stating that she is unsure but it is likely that another animal will eat it. She continues on to add an additional layer of information regarding the cycle of life, giving the students even more information than what they may have been asking for.

Experimenting

Experimenting by hypothesizing and controlling variables, or investigation, occurs when a child makes a hypothesis, or a statement of a relationship between variables, and then control variables to see if the hypothesis is correct (Lind, 1999). Young children will often use an if-then statement as their form of hypothesis, such as "What happens if the magnet drops?" (Lind, p.56, 1999).

Naturalistic learning (experimenting)

There was only one example of naturalistic experimenting in the data. It occurred spontaneously and the cooperative play activity began with Owen scooping sand into a pipe. The other two boys join the activity to wash out the sand and then work as a group to attempt to figure out what is wrong with the pipe since they cannot see any water coming out the opposite end.

> Owen begins stuffing wet sand in the end of a six-inch flexible pipe. Nathan holds up the end of the pipe and orders Owen to pour water in it (See Figure 26). The pipe has slits all along it and the water drains before going to the other side (the boys don't notice this). Nathan: "Did it come out, did you see it? Let's try that again." Nathan now pours in water with the same result. Nathan: "Let's try this little pipe instead." Nathan stuffs sand in two- ¾ inch PVC pipes joined at a

90-degree angle. Tyler pours in water. This also didn't achieve exactly what Nathan wanted and he goes to rinse the pipe before trying again.

(10-26-10, p.171)

Figure 26. Owen pours water into the slotted pipe

The impetus for this experiment occurred when the boys began by using a slotted pipe. The confusion caused by the water not exiting the opposite end of the pipe leads them to an investigation by eliminating variables, first in the person pouring the water, then the type of pipe. The boys are forced to quit before they can arrive at their desired result but they are systematic in their investigation. The variety and open-endedness of the available materials makes this experiment possible. The flexible pipe can be compared to a PVC pipe as an instrument to transport water and sand.

Informal learning (experimenting)

There were no documented examples of informal experimenting. All recorded experimenting, that involved the teacher, took place as a part of a structured learning experience.

Summary

- Naturalistic and Informal learning may be insufficient categories to encompass the preschool play experience.
- Foundational process skills were the most commonly used during play.
- Physical environment influenced play, with a greater variety of activities centered around sand and water.
- Hikes enabled informal learning.
- Teacher modeling influenced student play activities.

Naturalistic and Informal Learning

The categories of naturalistic, informal and structured learning were selected as a secondary code in an effort to distinguish between play and teacher controlled activities. As these codes were applied to the data a new subcategory was discovered that did not align precisely with naturalistic, informal or structured learning.

Child builds on structured learning is a unique situation found within the naturalistic observation category. This phenomenon occurs when a child participates in a structured, teacher-directed lesson, then makes a spontaneous, unsolicited observation related to the activity. This category does not strictly fit within the types of experiences proposed by Charlesworth and Lind (1999) as they begin as structured but are modified by the children into naturalistic.

Foundational Process Skills

As described by Lind (1999), the foundational science process skill of observation was without a doubt the most engaged in and presented the widest variety of incarnations. Young children use their senses of sight, touch, smell, taste, and sound to gather firsthand information through exploration. When a child is gathering firsthand information they are observing (Lind, 1999).

Communication was also necessary at all stages of the data gathering process as it allowed the children to relate to their peers and teachers along with providing a mental scaffold for action (Vygotsky, 1978). Almost all of the play activities involved a child communicating information to their peers or even aloud as a scaffold for thought, egocentric or private speech, when they were alone (Vygotsky, 1978).

Intermediate process skills, that occurred less often but consistently are comparing, inferring and measuring. These skills can be considered intermediate due to their use of the base skills of observing and communicating and their usefulness in completing more complex tasks.

Classifying, predicting, and experimenting skills presented rarely during the data collection period. These skills could be considered as higher order due to need for the incorporation of foundational skills, such as such as comparing in order to classify (Lind, 1999). Experimenting could be considered the most complex skill, as the children need to control variables, make predictions and infer causes in order to solve a problem (Lind, 1999). While these skills are higher order they are not beyond the grasp of this age group, as evidenced by the play scenarios gathered at this preschool.

Influence of the Physical Environment

The physical environment of the play yard and science center grounds was an important factor influencing play. A majority of play scenarios revolved around movable or manipulatable elements. The moveable elements were natural and enhanced by a collection of manmade tools. Moveable elements primarily consisted of sand, water, acorns, leaves, and mulch. The supporting manmade tools most commonly used were digging implements, such as shovels, rakes, and hoes, carrying implements, such as pails and cups, and the physical structure of the water maze.

Hiking

Hikes took place daily at this preschool and consisted of the teacher leading her class of eight children out into the science center grounds. The grounds encompassed a wide variety of elements and terrains that were known to the children but still varied enough to keep an element of novelty. Over the course of the data collection period children went to the dinosaur excavation area, a manmade stream, a pond, an outlook tower on top of a hill, a meadow, to the rescued animal cages, dry creek beds full of large limestone boulders, and trails through wooded areas. The natural elements encountered changed with variables such as weather or mowing schedules and presented the children with a slightly different experience on each trip.

Any play activities enacted during hikes were inherently associative or cooperative, since the group stayed together, used the same materials and were guided by the teacher (Frost, Worham &Reifel, 2008). Furthermore the proximity of the teacher and her role as hike leader encouraged informal learning activities. These informal lessons had the teachers and students sharing power in the activity and often led to the children using higher order process skills.

Teacher Modeling

Teacher modeling was an important part of play at this preschool. Teachers constantly modeled a pro-science attitude, giving off excited exclamations at new discoveries and expressing eagerness to learn, verbally and physically.

Modeling science process skills occurred during structured and informal activities. The process skills most frequently modeled were observation, communication, comparing, inferring, and measuring. These skills were also the most commonly enacted by the students during play. Elements of children's play could be seen as deriving directly from teacher modeling, such as turning over rocks to find animals. Teacher modeling also was shown to scaffold higher order process skills through asking open-ended questions and talking through the teacher's thought processes aloud.

Discussion

Naturalistic and Informal learning categories

Child builds on structured learning is a unique situation found within the naturalistic observation category. This phenomenon occurs when a child participates in a structured, teacher-directed lesson, then makes a spontaneous, unsolicited observation related to the activity. This category does not strictly fit within the types of experiences proposed by Charlesworth and Lind (1999) as they begin as structured but are modified by the children into naturalistic.

This new category is important however due to its relevancy to constructivist learning theory. In the structured activities the adults are providing examples of how to engage in the environment using science process skills. These adults also have established the importance of each child's input into the classroom dynamic. So when the children interrupt, modify or extend a structured activity the teachers make space for their students to control their own learning. Constructivist theory values the more knowledgeable adult providing a scaffold or support for the children to build more complex understandings (Frost, Wortham & Reifel, 2008). In child builds on a structured activity the children may be practicing the skill addressed in the lesson or they may be using an element of the lesson as a springboard to begin a new activity, thus creating a wider variety of skill use (Johnston, 2009).

Informal learning

Informal learning activities were enacted at a much lower rate than naturalistic activities at this preschool. This may in part be due to the data collection method that focused on one child each day rather than on the teacher. As much of the school day was spent in free play in the play yard the teacher was not within speaking distance of all her students at the same time. The teacher could have been constantly engaged in informal instruction but as she would have needed to divide her time amongst eight children scattered about a play yard she would have a limited impact on a single student's free play activities.

There is also the possibility that the teachers felt a tension between the need to scaffold learning activities and the desire to allow children their own play decisions. (Frost, Wortham & Reifel, 2008). These two schools of thought regarding play, the "hands-off" and the scaffolding approach were enacted by the teachers according to student prompting and their environment.

The teachers at this preschool were very verbal with the children during structured and informal activities and largely kept quiet during naturalistic learning. They often would wait for an invitation, such as a question, before entering play and then after providing information or assistance would transition out of the activity.

Most informal learning occurred during hikes, when the teacher and class were in close proximity to each other and were engaged in some form of observation. The teacher would find an opening or teachable moment where students were actively engaged with their environment then impose a higher level of thought, or skill onto the children's activity which has been shown to support higher cognitive development (Frost, Wortham & Reifel, 2008). An example of this is when the children were picking up bird feathers from a pile on the ground. The teacher asked the children why they believed the feathers were on the ground and scaffolded the process skill of inference onto an observational activity.

It should be noted that informal lessons focused on basic or mid level process skills and rarely ventured into the realm of classifying or predicting. There were no examples of informal experimenting. Since this study establishes that this age group is capable of using all of the process skills during play the teachers could actively search for teachable moments with the goal of supporting higher level process skills.

Process skills

Examples of each science process skill were found during children's play. Higher level skills were often prompted by a problem arising during the play activity. Most of the play activities at this preschool involved children engaging in associative play, where communication revolves around a common activity and materials are shared but there is no common goal or organization within the group (Frost, Wortham & Reifel, 2008). When problem-solving situations arose the children frequently moved into a cooperative play frame where the group is organized to accomplish a common goal (Frost, Wortham & Reifel, 2008).

Observing

Observation is foundational science process skill most commonly most engaged in by students and teachers at this preschool. Teachers excitably showed their students interesting objects and phenomena and students reciprocated by pointing out things that caught their eye. This group of teachers and children were most likely to point out and describe objects that they found intriguing. The variable outdoor environment encouraged such sharing as elements often changed as plants grew, animals went about their day and seasons changed. Sharing observations appeared to be the driving force behind many learning activities at the preschool and demonstrated the wonder and excitement the preschool's attendees felt for their domain.

Communicating

Almost all of the play activities at this preschool involved a child communicating information to their peers or even aloud as a scaffold for thought, egocentric or private speech, when they were alone (Vygotsky, 1978). It has been shown that when teachers engaged in expanded language with children it results in higher language development (Frost, Wortham & Reifel, 2008). This being established, the teachers were very verbal with students during structured and informal learning activities but kept quiet during naturalistic activities. I think this created a good balance between the need to scaffold higher language skills and allowing children time to practice existing skills.

Students would frequently practice their knowledge aloud, assigning common names to plants and animals, such as the "turks cap" or mosquito larvae. Teachers routinely mentioned many of these common names during hikes and at times the teacher would call on a knowledgeable student to provide an identification.

Comparing

The skill of comparing was tied to the children's egocentric need to describe their possessions or assisted communication by providing a wealth of familiar body knowledge to scaffold conversations with peers (Frost, Wortham & Reifel, 2008, Slaughter & Heron, 2004). Comparing is a basic science process skill that is necessary for classification to occur. Children in this age group are most likely to compare objects based on only one characteristic at a time (Frost, Wortham & Reifel, 2008).

Inferring

The process skill of drawing inferences had an interesting development, showing that this young age group was able to support their arguments verbally. Not all children did this, but many did during play as a means of convincing their audience of their logic. Attempting to sway a peer by reasoning demonstrates thinking outside of egocentrism. Some children were aware that their peers did not share their perspective and were able to construct arguments in an effort to be judged "correct" (Frost, Wortham & Reifel, 2008).

Measuring

Measuring was a common activity and showed how children were able to focus in on the relevant aspects of what they were measuring and give accurate types of measurement, for example, pairing length with feet as a unit of linear measure, or using the nonstandard unit of an ant to indicate a small size. The children however had a tendency to exaggerate quantities not only in number but in the type of unit used. This makes sense in light of Clements and Sarama's work showing units at this age are often assigned by guessing (2009). For example a child would use minutes to describe an amount of time when seconds would be more appropriate. Measurement tool use by the children was nonexistent. Tape measures and yardsticks were frequently used by the teachers but were never taken out by the students.

Classifying

According to Piaget grouping and sorting objects cannot reach the strict definition of classifying, where a subset needs to be present, since this age group can only focus on one attribute at a time (Frost, Wortham & Reifel, 2008). The informal learning example of classifying reflected the classifying done by the children during play. All artifacts were divided into two groups with no extra objects left over. The teachers could begin to start moving the children to a higher level of classification by introducing a third group or perhaps by talking through the process of creating a subset.

Predicting

Most examples of predicting at this preschool occurred when children were attempting to solve a problem. The children would begin an activity that had the potential to be a simple experiment, "what would happen if…?", but then would only try one solution and consider the problem fixed. This may be due to the children only considering problems that appear to be within their ability to solve or that they are so familiar with their environment that they have a strong understanding of how to fix most issues quickly. The teachers limited most of their predicting to structured lessons and even then limited it to simple answers. An example of this is asking a child what color they think will occur when blue and yellow are mixed.

Experimenting

The single example of experimentation occurred with an open-ended material, a slotted flexible pipe, not fitting in with what the children knew about pipes. This created confusion and a desire to work cooperatively to figure out what went wrong. The children manipulated variables, such as who was pouring water and how much sand was in the water, in order to understand why water would not travel through the pipe. This cooperative play activity demonstrates that young children are capable of performing experiments without any adult support. Would more experimenting occur if the adults did model the process?

Physical Environment

Natural Moveable Parts

The physical environment of the play yard and science center grounds was an important factor influencing play. A majority of play scenarios revolved around movable or manipulatable elements. The moveable elements were natural and enhanced by a collection of manmade tools. Moveable elements primarily consisted of sand, water, acorns, leaves, and mulch. The widest variety of science skill play occurred in the sand area of the play yard. In this area children routinely dug trenches to direct the flow of water. The trenches varied in depth, width and number of branches and at times were filled with PVC pipes to channel water under the ground. The ability for students to influence the sand made it especially attractive. Sand could be carried in buckets, formed into “cakes”, made into a garden with acorn seeds and oak leaf seedlings.

The water was also an important element as it added a level of novelty and changeability to the sand. It could turn the sand into "mud" for digging in, water could be poured over the gardens to make the acorns grow, standing water could be turned into "yucky sugar" (a mixture of natural elements resembling an inedible stew), and flowing water was directed into a variety of rivers and ponds.

Manmade Tools

The supporting manmade tools provided for the children assisted in their science play. The most commonly used tools were digging implements, such as shovels, rakes, and hoes, carrying implements, such as pails and cups, and the physical structure of the water maze. The metal digging implements were used to create rivers and gardens, while the pails and cups served as cooking and construction tools. The water maze afforded practice with the physics of water flow, as students created dams and chutes to speed up or halt the streams.

Hikes

Hikes took place daily at this preschool and provided children with a variable play environment. The grounds encompassed a wide variety of elements and terrains that were known to the children but still varied enough to keep an element of novelty. Over the course of the data collection period children went to the dinosaur excavation area, a manmade stream, a pond, an outlook tower on top of a hill, a meadow, to the rescued animal cages, dry creek beds full of large limestone boulders, and trails through wooded areas. The natural elements encountered changed with variables such as weather or mowing schedules and presented the children with a slightly different experience on each trip.

Hikes had the additional element of keeping the children in close physical proximity so they were more likely to notice each others activities, share materials and play together cooperatively (Frost, Worham &Reifel, 2008). Furthermore the proximity of the teacher and her role as hike leader encouraged informal learning activities. These informal lessons had the teachers and students sharing power in the activity and often led to the children using higher order process skills.

Limitations

This study posed a variety of problems. The first being the method of following only one child per day, ignoring any other spontaneous activities that occurred not involving the designated child. I know that I missed many interesting scenarios just because I was tied to watching a child who was not interested in joining in. In a new study, I think two people should be in the field, one following a specific child for the entirety of the school day and the other following spontaneous group interests focusing on how the children interact together due to a novel idea or situation. This would facilitate understanding the amount of time a child will engage in process skills and also record the variety of innovative and imaginative play activities children in the setting are capable of devising. Another possibility is to have a researcher following the teacher to observe how she supports the students as they play.

Another issue is the interrelatedness of science process skill categories. It was nearly impossible to separate observation and communication from other categories. For example, the following excerpt from the data has aspects that could be categorized as observation, communication, measurement and inference.

> Dylan packs back up his lunch box. He gets up to ask Teacher a question but Teacher is with a group looking at a ¼ inch hole in a tree. Dylan suggests a "walking stick" did it "'cause they drill holes." He kicks over a 4-inch rock and finds an animal "longer than an ant." (9-15-10, p.3)

The observation occurs as Dylan is noticing the hole and animal. He communicates his ideas to the teacher verbally, infers the cause of the hole and supports his inference. Then Dylan uses a nonstandard measurement comparing the found animal's length to that of an ant. For the purposes of categorizing in this study, I classified this scenario with all of these aspects but it felt imprecise. In a future study I would focus more globally on the process skills to limit cross identification. I would also begin the study with the assumption that comparing, measuring, inferring, predicting and experimenting all contain observations. Communication was almost universal among observed skill use as well but there were a few examples that occurred silently.

Another limitation related to data collection is encountered as there was only one person gathering data in the field. I arrived at the school with a systematic protocol for observing children but my observations were no doubt colored by my personal experience teaching this age group. I was also the sole photographer and the photos, while being a concrete recording of events, are influenced by what I deemed important to document and how the pictures were framed to capture aspects of events. It would have been impossible to record every angle and aspect of a child's day with any recording method or device as there is always the human factor deciding how and what to record (Yin, 2010).

Implications

Implications for the field are that teachers should be aware of how they are modeling science process skills. Making their inner speech audible, talking through how they are accomplishing an activity to model their thought processes. For example, a teacher could make an enthusiastic observation of a phenomena on the play yard and then proceed to verbally scaffold a simple experiment to find out "what would happen if …?" The data supports children independently practicing skills modeled by the teacher. Perhaps if the teacher frequently modeled higher order process skills, such as predicting, it would increase the chidren's use of these skills as well. Since the children often used the types of observation skills the teachers used in outdoor environments with materials available to everyone, it follows that the higher order skills could be scaffolded in a similar manner.

The teacher's enthusiasm in experiencing the natural environment directly translated to the children's enthusiasm for their environment. Whenever something new was observed the teacher wondered aloud at the sight. Respecting contributions the children made to activities also bolster the children's enthusiasm. The self-confidence displayed by these young children when they gave their input and modified activities was due, at least in part, to the teacher accepting the children's interruptions with a supportive attitude.

Further Study

Possible future questions regarding science process skills and play with preschool children could range from alternate contexts and demographics to alternate focuses of study.

Alternate contexts could be explored to see if science process skills are used by preschool children who only have access to fixed, constructed environments as well as by children who have access to natural ones. In essence, this would show if the affordances in the science-based preschool's play yard and grounds encourage a wider range of skill use than a play yard consisting of fixed jungle gyms.

An alternate focus of this study could be related to the pro-science attitude cultivated in the school. At this preschool, science play is encouraged even through the attitudes of parents who allow their children to come home covered in mud. Other preschools, whose parents want their children to return home looking better than when they arrived, may have to limit the types of play children can engage in and thereby may limit their process skill use.

This preschool is a highly sought after learning environment, with children being put on the waiting list even before conception. The enthusiasm of the parents, teachers and students combine to create a unique scientific learning context.

Appendix A

How children in a science-centered preschool pursue their own science interests while modifying and fulfilling program goals

by

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Introduction

Everyday young children engage in various aspects of the scientific inquiry process as they play (Ashbrook, 2006). Children wonder about their world, ask questions, try different techniques to solve or answer questions, integrate new knowledge into their worldview, and share discoveries with friends (Ashbrook, 2006). At one preschool in Austin, Texas children are immersed in both life and earth sciences. All aspects of this preschool converge to provide students with a strong science learning experience. Parents bring their children dressed and ready for school with the expectation of returning just four hours later to find their children's clothes and bare feet smeared with dirt from playing outdoors. While encouraging students to make observations and explore on their own, teachers talk about science, from naming flowers to describing a chemical reaction. The school itself is designed to encourage science, from its play yard with rocks for turning over to its physical location on the grounds of a nature and science center.

As a result, children are engaged in science at this preschool and take steps to pursue their own interests. As they engage in science play the students often participate is what could be interpreted as misbehavior. It turns out that this play "mis"behavior is actually fulfilling parent, teacher and school goals because students are actively engaging with the natural environment as scientists. These behaviors tend to veer children away from the main group of learners in order to follow up on their own, independent questions and explorations. Through their play children are pursuing their own interests by experiencing science concepts, performing scientific processes, and having a sustained engagement in science. This paper presents the three main ways children at a science-centered preschool modify group activities to pursue their own interests. The goal is to highlight aspects of science instruction that motivate children to engage in science exploration without the impetus of an explicit science activity.

Review of the Literature

Investigating how children interact with nature is nothing new in American education. Nature study began to gain popularity in the early 20^{th} century as the best way for children in the first eight grades of school to learn science (Tolley, 2003). The urbanization of America led to the first generation of children growing up without a strong connection to the land, living in cities void of rural commonplaces such as fields of wheat, forests or wildlife (Tolley, 2003). Americans were beginning to realize that nature was not infinite in its abundance and the U.S. government started taking steps toward conservation through the establishment of wildlife refuges and national parks (Tolley, 2003). As the government was preserving wilderness, educators were beginning to take city children out into it (Tolley, 2003). Children were encouraged to closely observe the natural world; taking notes, making sketches, and asking questions while teachers worked diligently to extend student knowledge into all areas of the curriculum (Tolley, 2003). Science education has undergone many incarnations since the nature study movement, however nature study still remains relevant in our modern world, most notably in the field of early childhood education.

According to the National Science Education Standards there are currently "no nationally accepted learning standards for early childhood science education" (NSES, 2006, p.31). However as children enter into kindergarten science education standards are in effect. In Texas these standards are described in a curriculum framework called the Texas Essential Knowledge and Skills (Texas Education Agency, 1998). The focus of Kindergarten science, as outlined in the TEKS is to introduce "simple classroom and field investigations to help students develop the skills of asking questions, gathering information, communicating findings, and making informed decisions" (Texas Education Agency, 1998). Students entering into a Kindergarten classroom where these investigations are being performed could be helped by a strong experiential knowledge of the natural world.

Outdoor environments are beneficial in science learning because "children have a unique, direct and experiential way of knowing the natural world" and nature allows for a wider range of play experiences (Malone & Tranter, 2003, p.300; Tranter & Malone, 2004). A study by Tranter and Malone about children's use of school grounds cites that playing in nature has a positive impact on physical, social and concentration ability (2004). Malone and Tranter found that, "cognitive play allows children to act on the environment and discover and understand relationships through their own behavior. This type of play usually has as its goal problem solving, choosing, constructing, exploring and discovery and is unstructured informal learning" (2003, p.285).

According to Worth and Grollman (2003) three to five year old children are uniquely suited to engaging in a life science program because of their "fascination" with the living things they encounter around them. Science process skill learning is also more successful when the children can physically manipulate objects (Ashbrook, 2006). These two aspects: young children learning life science and physical manipulation of the environment combine to create an outdoor nature environment ripe for scientific discovery.

Research Methods

The data for this presentation were collected as part of a larger qualitative study. This study examines the nature of preschool children's interactions during informal outdoor play in natural settings. Specifically, the kinds of observations children make about the environment and how these observations influence activity. The research question guiding this inquiry is: How do children in a science-centered preschool pursue their own science interests while they engage in a natural environment? Observations/field notes are the primary data source for this study. 39 hours were spent on-site observing outdoor fieldtrips and free play on the grounds of the preschool.

Setting and Participants

Purposeful sampling, as defined by Maxwell, was required in order to find a preschool program featuring nature study (1996). The Austin City Parks and Recreation Department recommended only one site, a Nature and Science Center, as a popular nature field-trip location among local public schools. Upon contacting the Center, I learned that they also maintain an early childhood school on site. The curriculum of the preschool is designed to emphasize learning about nature, science, and the environment through "hands-on exploration, experiments, crafts, songs, field trips, live animals, hikes, and outdoor activities" (Austin Nature & Science Center, 2008). The goal of the preschool is to "…foster a life-long relationship with the natural world" through these experiences (ANSC, 2008).

The preschool is set in a small historic limestone house located on the greenbelt in an urban Texas city. The home is divided into three small classrooms. Two of the classrooms are for mixed-aged classes of four and five-year-old children while the third is set aside for a group of three-year-olds. Each room has a 1:8 teacher to student ratio in order to maximize individual attention, while a fourth teacher floats between rooms assisting where needed (ANSC, 2008). For this study I focused on the two, mixed-age classrooms because the older children tend to produce more dialogue. Groups of students rotate through the school each week according to their enrollment schedule. A child can be enrolled for as little as one and up to as many as four days each week. I observed both classes of 4 and 5 year old students throughout the week for a total of 35 participants, 16 girls and 19 boys.

The school opens at 9 a.m. and closes around 1 p.m. with an additional hour of operation on Friday. The students therefore have a half-day program where they learn and play in a science rich environment. Due to the need for parents/guardians to drop off and pick up their children early in the day I concluded that the attendees were of a mid to high socio-economic status. The ethnicity of the students was predominately European American.

The teachers operate their classrooms with a focus on natural sciences, incorporating hikes through the science center's grounds in the city's greenbelt, a classroom garden, and a play yard featuring natural elements such as a dirt base, shrubbery, live oak trees, stones, sand, and a water feature.

The data for this presentation come from field notes, narrative descriptions, and short informal interviews of children. Total time for gathering data was thirteen days within March and April of 2007. Each day I would arrive at the school at the opening and observe until the end of a hike or until the close of a nature interaction in the garden or in the play yard for a total of 39 hours. During the outdoor activity I closely observed the students' actions and wrote extensive field notes. I carefully watched for any interactions and tried to capture moments when the children were actively debating or experimenting. After each outdoor activity I spent time writing up general field notes on the activity and then elaborated on any moments I believed to be important, such as how the children's play dynamic emerged through the activities (Emerson, Fretz & Shaw, 1995; Maxwell, 1996). According to Maxwell, such memos generated during the elaboration of field notes record your thinking about the data and stimulate analytic insights (1996). I answered any questions the children had about the purpose of my note taking and then tried to fade into the background. My role was strictly as an observer.

Triangulation of data was achieved by observing a range of children in a variety of outdoor settings and by informally questioning children for clarification during observations. I also enlisted a professor in my field to serve as a peer debriefer.

I used an approach grounded in the constant comparative method to analyze the student discourse (Bogdan & Bilken 1998). I entered the field with the goal of observing students' interactions in the outdoor environment, I soon began to notice interactions clustering around physical manipulation of the environment, peer discourse, types of movement occurring and outdoor settings. Analysis of the data was carried out informally after each observation to look for emerging themes and to guide future observations. Student activities took precedence during my analysis; sorting, categorizing, distinguishing properties of materials, and using tools to explore the world around them, were main categories that I assembled from the data. After collecting the data I then went through the text and coded each unit. The categories were then examined for relationships.

Analysis of the observations highlighted the types of activities in which children engaged that could be initially construed as misbehavior, but upon closer examination, fulfilled the purposes for students attending this school.

Findings

The children at the preschool seem to feed off of their teachers' enthusiasm and begin to think of themselves as scientists and explorers. They approach each morning at school exuberantly, frequently by running up the hill from the parking lot, leaving a parent trailing behind carrying their belongings. The children greet their teacher and immediately jump into the morning science activity while they talk about what related science experiments, or information, they are working on at home. When it is time for children to go on teacher-planned hikes, opportunities for lesson adjustments begin to appear. These little science explorers equate science with play, and find ways to modify outings to maximize fun and satisfy their scientific curiosity.

As I first began to observe children as they played in nature, I noticed them putting a bit of space between themselves and the teacher. Once a comfortable bit of distance was established, the children proceeded to behave in ways that I, as an educator, would feel necessary to halt. This personal desire arose due to my past experience working within a day care culture where children are expected to come home as clean and presentable as when they arrived. The children at this school would pick up rocks and sticks, use science tools in alternative ways, and above all they pursued their own knowledge without a backward glance at the teacher. After adjusting to this new environment I began to notice that these "mis" behaviors actually served the goals of the science program by connecting children to the natural world through experience. Through their play the children pursued their own interests by experiencing science concepts, engaging in scientific processes, and having a sustained engagement in science.

Experiencing science concepts

The students experience science concepts, such as the properties of objects, characteristics of organisms and the ability to distinguish between natural and human made objects, as they apply a keen interest to the space around them. In this vignette, students can be seen modifying the group activity to make additional observations, manipulating materials found in the natural environment and sharing discoveries with their peers. The students are not exactly disobeying the teacher as they modify the activity, instead they make decisions regarding what they want to learn and pursue it as they follow the teacher.

> *A typical hike starts with the teacher leading her eight children along well-trodden paths on the Nature and Science Center grounds. The children reach up their hands and help their teacher push open the heavy metal gate guarding the entrance to the botanical garden. The gate opens no more than eighteen inches before the bottom begins to drag on the ground and stops. The children easily pass through into the garden as Ms. C and I gingerly shuffle in and drag the gate closed again. The children have gathered on a stone bench near the entrance to wait for us. Ms. C takes a deep breath and scans the scene, her eyes alighting on a series of raised planting beds behind the children. The closest bed is overflowing with a variety of red blooms. The flowers are either a simple orange red blossom or a dark red compound bloom. Ms. C leads the class to the bed and many children kneel down at its edge to examine the flowers more closely. She asks the children to choose which flower they like better. Many of the children*

choose the dark red flower. After they answer, Ms. C begins to lead the students away. Some of the children choose to linger at the planter's edge and caress the flowers with their fingers, being careful to not knock off any petals. As they see the remainder of their class walk away these children rise and begin to follow along, leaving about ten feet of space from the teacher's group. A couple more students fall back in the line and begin to examine the dirt trail for interesting rocks and snail shells. One child was interested in a crushed bottle cap. Another stooped down and picked off a piece of a green feathery fern, holding it up to the cheek of a nearby classmate so that they could feel its softness

These children examine their surroundings as a matter of course, finding out all they can through the use of their senses. The students have discovered that they can follow their own interests during class excursions by keeping to the back of the group, away from a teacher's casual glance which may be inclined to intervene. This vignette showed students who hung back from the main group to examine blossoms, the trail itself, and to share the tactile sensation of a feathery fern with a friend. The curriculum and goal of the preschool were upheld as students engaged in hands-on exploration during a hike.

Engaging in science processes

Children at this preschool can often be seen doing aspects of the scientific inquiry process. The students engage with natural materials and appear to effortlessly follow a pattern of exploration. Many steps of scientific inquiry such as developing a question, figuring out how to the answer the question, data collection, and sharing findings are common in young children (Ashbrook, 2006). Although the latter part, regarding sharing data may not be immediately demonstrated.

One example of the inquiry process can be observed when a little girl attempts to participate in a mock sword fight. First she randomly selects a stick from the ground with which to fight. When this stick is easily broken, due to rot, she begins a process of selecting a sound stick. Her question would be: how do I choose a strong stick? Using her powers of observation, and a method of trying out the strength of each stick, she solves the problem and is able to effectively engage in a sword fight.

> *Larger limbs are chosen upon arriving at the pond. Two boys forage through the brush and manage to each find a large branch. These branches are about as thick as each child's arm and are almost equal the boys in height. The "swords" are then slowly raised and clash into each other, gingerly at first and then with more enthusiasm as they measure their strength. A small girl watches the fighting pair then grabs up a cudgel of her own. She yells, "let's fight" and draws a boy to the side so she can try out her stick. As the sticks meet, hers' gives off the thud of rotten wood and breaks in half. She continues to try out cudgels in this manner, with similar results. Finally she finds a green branch and engages a fencer. She violently whacks her "sword" against her opponents until she manages to break his stick. With a satisfied smile she discards her victorious weapon to begin the selection process again.*

One child was having difficulty finding a branch that was strong enough to withstand a hit. She used the simple experiment of trying out a branches' strength by hitting it against another. The following trials of branches led to the child looking more closely at each branch and trying to find physical indicators that were present in a "good" branch. When she solved the problem, the little girl was satisfied in her discovery and moved on to another activity.

Another example of scientific processes in action was observed on a day when children were given minnow nets to take on a hike. The intended use of the nets was to search for and capture tadpoles at a pond mid-way through the hike. The curriculum of the preschool emphasizes learning through experimentation and hands-on exploration and the nets were a new means of gathering data on a pond environment. The children however were intrigued with a tool whose shape suggested a new way of carrying materials. Rather than waiting to gather data about the inhabitants of a pond, the students launched into experiments regarding the properties of the nets' fabric and the gravel composing the trail's base. The misbehavior of this vignette is using the net in a way unsanctioned by the teacher. Ms. C even corrects the misuse, but in such a way that the children can finish their exploration.

> *As she hands out the minnow nets Ms. C gives instructions on their proper use and tells the children they are going to the pond today to search for tadpoles. The nets are composed of green plastic coated wire and fine pliable mesh.*
>
> *Ms. C keeps up an almost continual stream of talk about the plants she walks by. When she sees a plum tree in full bloom she stops the class. The children climb up on the wooden railing next to the tree. Ms. C grabs a laden branch and pulls it towards the uplifted faces, instructing the children to inhale the fragrance. She*

tells them that this is a Mexican Plum tree and will soon be full of little dark fruit. She then begins the hike again.

The children occasionally stoop down, scoop up rocks with one hand and deposit them into their minnow nets. A boy looks curiously at the bulging net gripped in the hand of a classmate. He informs her that the small rocks she has picked up will fall through her net. She looks at her net before responding, "No, the rocks are big enough to stay in." The boy, wanting to prove his point, continues on to explain that if you scoop up a handful of rocks off the ground some will fall through. The girl holds her net up to her eye level and examines the mesh. It seems to be holding the rocks just fine to her. The boy temporarily abandons this line of argument and instead asks the girl to watch him scoop up rocks from the ground using just the net. He squats down on the trail and pushes the wire edge of the net against the ground. He pushes the net until the edge has created a small mound of pebbles. He sweeps the gravel into the net with his free hand and bounds back to his feet. Lifting the net in front of their eyes he shakes it back and forth dislodging the fine particles that drift back toward the ground. He has demonstrated the sieve-like effect of the mesh but it doesn't seem to intrigue his classmate.

At the next stop in the path Ms. C warns the children to not carry rocks in their net because they might "split the seam" of the mesh. The children now become more discrete in their rock collecting but continue on.

In this instance one child has noticed the variety of rock sizes on the pebble-strewn path. He has put together when you select rocks one by one they tend to be larger and if you scoop up a handful the sizes are more varied. He has also grasped that the net is a sort of strainer and its porosity is determined by the size of the holes in the mesh. In order to demonstrate his knowledge the boy quickly performs an experiment for his classmate. He is essentially sharing his findings with his classmate, completing the process of scientific inquiry. This little boy created a self-directed experiment, using a demonstrative process to share his knowledge with a peer in a similar way his teacher would share her knowledge with the class.

Sustained engagement in science

Nearly all of the outside play activities demonstrate a sustained engagement with the natural materials and with the topic of personal study. Every day of observation revealed children constantly gathering observational data and bits of natural materials in equal measure. In every vignette presented thus far the children spend their travel time to the field trip goal, either pond or garden, just as occupied in science exploration as when they arrive. They stop and touch flowers, examine the base of the trail itself, discuss scientific concepts as in the porosity of a minnow net, all the while keeping a sharp awareness on what they are doing. An exemplar of sustained engagement occurred one morning as a class of children was walking a trail on the way to the pond.

> *Alert eyes are scanning the ground ahead while managing to keep pace with the rest of their class. Every so often a child's body drops toward the ground in a semi-kneeling attitude, fingers quickly select a small twig and the child easily*

bobs back into a walking pace. Twigs are soon bristling from small fists. When fingers are unable to grasp any more, their burdens are cast into the brush. Twigs are soon given up in favor of small pebbles and the selection process continues all the way to the pond.

The given purpose of this hike was to get to the pond, but the children were augmenting that purpose with one of their own. The students were observing the forest trail for objects that stood apart based on color, shape, size and texture. The collectors were keeping a running, internal, criteria and would only stoop down to pick up objects that fit into their category, either of small straight twigs or medium sized rocks. So while everyone arrived at the pond in the end, a majority of the children also had a sustained practical experience in categorizing using the attributes of natural objects.

All of the children were traveling the same trails but along the way they each modified their journey to take in the sights and experiences that were personally meaningful. Consequently they fulfilled parent, teacher and school goals by actively engaging with the natural environment through hands-on exploration, experiments, hikes, outdoor activities and beginning their life-long relationship with the natural world.

Discussion

By modifying class activities, the students at the preschool were demonstrating their understandings of the science curriculum. The children had internalized the goals of their parents, teachers and school and desired to pursue knowledge on their own through play. The play behaviors that could be considered by some to be off-task were tolerated and in some instances celebrated by teachers due to their desire for children to develop a relationship with the natural world.

The teachers had the strong support of parents and the physical grounds of the school in able to allow children this degree of freedom. Parents brought their children to school with the expectation of finding them covered in dirt and maybe a few scratches at pick up. If the parents were unable to tolerate having a child arrive home dirty, the program would have needed to be drastically altered. Shoes and socks would have remained on all day, the base of the play yard would most probably be changed to a "cleaner" material than Texas dirt, and the students would have not been able to pick up every interesting thing they came across for fear of mussing clothes. There is evidence that parents were also supporting science at home by encouraging experiments, family trips to see animals, and discussing topics being covered that week at school with their child.

The school itself was in an ideal location to allow for daily interactions with nature, both inside the play yard and out on the grounds of the Nature and Science Center. The play yard had an area for depositing shoes and socks so the children could squeeze their toes through the dirt and sand. A large shrub was in the yard, affording a place to crawl beneath and leaves to manipulate. Large limestone rocks circle the live oak trees giving children obstacles to overcome and the opportunity to turn over the rocks in search of roly-polys. The grounds of the Nature and Science Center just outside the play yard gate were full of trails, trees, and seasonal ponds, along with all the accompanying flora and fauna.

With these supports, teachers were able to provide experiments, crafts, songs, field trips, live animals, hikes, and outdoor activities to children. The teachers showed their appreciation of science as they interacted with students, talking about questions the students have, sharing the names and uses of the plants around them, and making a space for students to modify their activities. The teachers allowed their students to lag behind in the group and manipulate natural materials during hikes. If they had enforced a stricter pattern to the hike, with all of the students clustered about the teacher and following along quietly, many of the learning experiences I observed would not have occurred. The teachers appeared to be fully aware of where their children were and what they were doing at all times, but intervened infrequently. Essentially the teachers gave their students the gift of determining what they would learn.

Teachers of preschool children can glean an important lesson from the instructors at this science-centered school. Before intervening in a child's playful misbehavior, stop for a moment and determine why the behavior is wrong. It might just be, the child showing that they are capable and motivated to do a learning activity on their own.

This preschool follows many of the ideas of the nature study movement by having children connect with natural settings that are rare in urban landscapes, studying natural materials, and fostering a desire to conserve natural resources (Tolley, 2003). Through the nature study occurring at this preschool children are provided with a scaffold for not only the sciences but other curriculum areas, by providing concrete examples in vocabulary development and experience with math in patterns and sorting. Literacy and math are of great importance when Texas children begin their public school education. I believe that the variety of experiences these students have with nature give them an advantage as they enter Kindergarten and begin to apply their vocabulary and pattern skills to new challenges.

The independence students at this preschool experience could work for or against their favor depending on the rules of their new school. I think that the confidence children glean from their preschool experience can only help empower them with the belief that they are capable of learning.

Possible next steps could be discussing with teachers how they cultivate student confidence in science learning. I was impressed by how both sexes of children were engaged with their environment as scientists and wish to gather more information on how their interest is encouraged and sustained.

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Raw data:
March 5, 2007
11:08 a.m.
- given green minnow nets
- start with instructions from teacher on proper use of nets, going to tadpole pond.
- teacher almost a continual stream of talk about the plants & how to watch where you are walking.
- Saw a plum tree in full bloom. She lowers branch to everyone can smell the blooms.
- children occasionally pick up rocks with one hand & put them in the net.
- Boy warns girl that the rocks will fall through her net. She says no the rocks are big enough to stay in. He says if you scoop up rocks off the ground some will fall through. Girl hold up net & looks at it in front of her eyes. Boy gestures about how to scoop up rocks.
- at next stop teacher warns not to carry rocks because it might split the seam.

Analytic memo:

(March 5) As she hands out the nets Ms. C gives instructions on the proper use of the nets and tells the children they are going to the tadpole pond today.

(March 5) The children occasionally pick up rocks with one hand and put them into their minnow net held level in their other hand.

(March 5) A boy warns a girl that the small rocks she has picked up will fall through her net. She says no, the rocks are big enough to stay in. He continues on by explaining if you scoop up a handful of rocks off the ground some will fall through. (I think he has noticed the variety of rock sizes on the pebble-strewn path. He has put together that when you select rocks one by one they tend to be larger and if you scoop up a handful the sizes are more varied. He has also grasped that the net is a sort of strainer and its porosity is determined by the size of the holes in the mesh).
The girl holds her net up to her eye level and examines the mesh. The boy gestures with his net how you can

Process Skill Categories:

Observing: Children engaging with their tools and environment
Prediction: Boy predicts rocks will fall through net
Observing: Girl observes rocks in her net
Experimenting: Boy performs two experimental tests to try to get proof rocks will sift through net

Communicating: Boy shares results of his experiment

Narrative Description:

As she hands out the minnow nets Ms. C gives instructions on their proper use and tells the children they are going to the pond today to search for tadpoles. The nets are composed of green plastic coated wire and fine pliable mesh.

Ms. C keeps up an almost continual stream of talk about the plants she walks by. When she sees a plum tree in full bloom she stops the class. The children climb up on the wooden railing next to the tree. Ms. C grabs a laden branch and pulls it towards the uplifted faces, instructing the children to inhale the fragrance. She tells them that this is a Mexican Plum tree and will soon be full of little dark fruit. She then breaks off and begins the hike again.

The children occasionally stoop down, scoop up rocks with one hand and deposit them into their minnow nets. A boy looks curiously at the bulging net gripped in the hand a classmate. He informs her that the small rocks she has picked up will fall through her net. She looks at her net before responding "no, the rocks are big enough to stay in." The boy, wanting to prove his point, continues on to explain that if you scoop up a handful of rocks off the ground some will fall through. The girl holds her net up to her eye level and examines the mesh. It seems to be holding the rocks just fine to her. The boy temporarily abandons this line of argument and instead asks the girl to watch him scoop up rocks from the ground using just the net. He squats down on the trail and pushes the wire edge of the net against the ground. He pushes the net until the edge has created a small mound of pebbles. He sweeps the gravel into the net with his free hand and bounds back to his feet. Lifting the net in front of their eyes he shakes it back and forth dislodging the fine particles that drift back toward the ground. He has demonstrated the sieve like effect of the mesh but it doesn't seem to intrigue his classmate.

At the next stop in the path Ms. C warns the children to not carry rocks in their net because they might "split the seam" of the mesh. The children now become more discrete in their rock collecting but continue on.

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