An Analysis of the Influence a Teacher's Level of Science-Based Questioning Had on the Level of Science-Based Questioning of Students in a Montessori School

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AN ANALYSIS OF THE INFLUENCE A TEACHER’S LEVEL OF SCIENCE-BASED QUESTIONING HAD ON THE LEVEL OF SCIENCE-BASED QUESTIONING OF STUDENTS IN A MONTESSORI SCHOOL

by

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A Thesis Submitted in Partial Fulfillment of the Requirements for a Degree with Honors (Child Development and Family Relations)

The Honors College

University of Maine

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ABSTRACT

Teachers use questions every day to assess their students’ knowledge, allow for more practice with critical thinking, and to help promote collaborative, meaningful classroom discussions. This observational study aims to analyze the effect that the level of science-based questioning the Head Teacher uses has on the level of science-based questioning the students use in a Montessori classroom while they are learning science topics/concepts and/or using science related materials. In this study, observations were performed on preschool aged students enrolled in a Montessori school in rural Maine. These observations consist of science-based questions the Head Teacher asked the students and the science-based questions the students asked their peers and their teachers while they were learning science/using science-related materials. These questions were then categorized using Bloom’s Taxonomy of Questions to determine the level of questioning that stemmed from the teacher, and how these levels of science-based questioning influenced the level of science-based questioning the students then used. This study contributes to previously completed research on this topic, as it provides more information on the effect a teacher’s level of questioning has on the cognitive development of preschool aged students. This cognitive development of students shows through the level of questioning the students use in the classroom. This study is beneficial to both public school and Montessori school teachers, as it provides them with information on what kinds of science-based questions they should be asking their students to elicit higher level thinking/questioning and to develop all levels of thinking/questioning within the cognitive domain. The conclusions of this study do not display with 100% confidence that the Head Teacher’s level of science-based questioning
was the only factor influencing the students’ level of science-based questioning, however, it does play a large role
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INTRODUCTION

Throughout the years, early childhood education has become more and more the focus of significant research that has shown that a child’s first learning experiences “deeply affect their future physical, cognitive, emotional, and social development” (Centre of Excellence for Early Childhood Development, 2011). The education of young children is a very important topic, as the early years consist of the time when a child’s brain develops more quickly than at any other time in life (2U, Inc., 2018). Providing the best possible education for a young child could help determine how they develop throughout their childhood and into adulthood. It can also have an impact on the strengths and weaknesses that each child experiences within the developmental domains, these developmental domains being: physical development, social/emotional development, cognitive and language development, and their self-help and adaptive development.

When it comes to deciding what kind of education a child will have early on, there are a variety of different programs parents/guardians can choose from, such as Reggio Emilia, HeadStart, Waldorf, and Montessori. Upon entering preschool, usually around the ages of three or four, students are exposed to varied opportunities to engage in learning experiences. Different types of preschool programs offer parents educational choices for their children as students engage in different learning experiences. One of these preschool types that rose in popularity among American parents is the Montessori Preschool Program, as “it has undergone sustained growth; today, there are over 22,000 Montessori schools worldwide” (Whitescarver & Cossentino, 2008). Developed by Maria
Montessori, the Montessori Preschool Program, for students ages 3 through 6 years, was designed as a student-centered program that values hands-on learning experiences and focus on the whole development of the child: social, cognitive, physical, emotional, and academic (American Montessori Society, 2018). While there are so many different types of preschool programs, many of these programs have curriculums that are developed to engage students through play. The Montessori curriculum (Appendix A) relies heavily on play and exploration around science topics that include nature studies, creatures of the night, habitats in regions all around the world, food, animals in winter, dinosaurs, space, farm life and the animals included, the rainforest, the ocean, and gardens/wildflowers. Students are engaged in a new science topic each month throughout the school year. While the curriculum is so science-heavy, students are able to learn this content through the unstructured and student-directed play of interdisciplinary materials provided by the Montessori school. Interdisciplinary materials might include such items as: puzzles of a habitat that children categorize animals into (math and science), sentence building activities that involve science topics like the solar system (reading/writing and science), and the floating magnet pattern learning game (math and science)- discussed in the Inquiry-Based Science Education section of the literature review.

As a way to help engage students in these science content areas, Montessori preschool teachers ask students science-based questions that come from all levels of Bloom’s Taxonomy of Questions (see Early Childhood Cognitive Development section of the literature review) to help influence student levels of scientific inquiry in the classroom. One study on scientific inquiry in early childhood that exists looks at the “impact of an
intervention designed to promote inquiry-based instruction among early childhood/elementary preservice teachers in Earth science” (Leonard, Boakes, & Moore, 2009). During this dual case study, researchers analyzed (compared and contrasted) two different inquiry-based Earth science lessons- each one taught by a different teacher, either Hannah or Cora. Both of these teachers took part in the intervention described above prior to teaching their lessons. One of the findings of this study was that neither Hannah nor Cora were able to engage their students in guided or open inquiry, due to their limited experience in teaching in this manner. This study also found that both the learning environment students are taught in and the teachers’ conceptions of inquiry directly influenced their implementation of inquiry-based practices (Leonard, Boakes, & Moore, 2009). Looking at the findings of this study, the quality of the learning environment and the conceptions of inquiry stemming from the teacher are both very important aspects of learning through inquiry-based practices, and are both aspects of learning that are focused on in Montessori Education. While numerous studies surrounding scientific inquiry and cognitive development exist, there are few that exist that look at the influence the Head Teacher’s level of science-based questioning has on their students’ level of science-based questioning, specifically in a Montessori preschool program.

In comparison to Montessori preschool programs, traditional public preschool settings are more structured, with classrooms divided by the age of the children. In a traditional public preschool setting children are generally three and four years old. Typically, once children turn five and the next school year begins, they move on to Kindergarten.
Traditional public preschool settings provide structured schedules for students; students are expected to complete specific work/activities at certain times. An example of a difference between the Montessori preschool setting and the traditional public preschool setting, is that in Montessori, students are allowed to retrieve a snack on their own at any time of the school day. In the traditional public preschool setting, generally speaking, students are given snack at a specific time in the school day and all students are expected to eat at that time together. Traditional public preschool settings may also follow a specific curriculum using pacing guides set forth by the school district they are a part of; Montessori preschool settings set their own curriculums, and are not provided with pacing guides.

In this study I will be taking a closer look at one example of a Montessori preschool science curriculum from a school located in rural Maine (U.S.), The Stillwater Montessori School, as their curriculum is centered around science content areas. Taking a look at this heavy science-based curriculum (Appendix A), each month the Head Teacher shifts the classroom focus to a planned (planned yearly) different major science topic/area, and the majority of their group lessons are centered around the science content they are focusing on. The students at this school are taught the basic content they should know for each science content area by the Head Teacher during periods of the school day when they meet as one large group. During this time, the Head Teacher reads books, discusses information, and presents materials to the students in order to help them better understand the topic they will be working on/learning more about. These conversations start out with the Head Teacher leading the discussion, and once students feel
comfortable enough with the discussion/topic, the discussion takes a turn and the students lead through questions and observations. They are then presented with various inquiry-based learning experiences as a way to help them further understand the content they are being taught, and to allow them to build their skills in terms of asking and answering science-based questions. Not only are teachers in Montessori schools able to deliver a richer science education to their students, they are also giving their students the tools they need to encourage them to observe more closely and build a foundation of experiences that help them construct later understanding of content in various subject areas.

At the Stillwater Montessori School, Head Teacher Joanne Alex has had a 40+ year teaching career. During this career, she has served as head teacher at the Stillwater Montessori School, an adjunct faculty member at The University of Maine (Orono, ME) and at College of the Atlantic (Bar Harbor, ME), Project WILD and PLT facilitator, and advocate for environmental education. Joanne Alex has received numerous recognitions for her outstanding teaching, including 1998 Maine Teacher of the Year. She is author of the book, *I Wonder What’s Out There? A Vision of the Universe for the Primary Classes*.

The Head Teacher of the Stillwater Montessori School’s preschool/kindergarten program, Joanne Alex, uses science-based questioning as a way to probe student knowledge on each science topic they cover in their classroom. In this observational study of the preschool/kindergarten students at this specific Montessori School, the various science-based questions the Head Teacher and students ask will be recorded, as well as when they ask the questions, where they are when they ask them, which Science Unit they are on at the time the questions are asked, and what level of Bloom’s Taxonomy of Questions these
questions fit into. These science-based questions will then be analyzed using *Bloom’s Taxonomy of Questions*—discussed in the *Early Childhood Cognitive Development* section of the literature review.

My hypothesis states: The level of science-based questions the Head Teacher asks will positively influence the level of science-based questions the students ask.

I will test this hypothesis by analyzing the questions in terms of their level based on *Bloom’s Taxonomy* in order to help show the impact the Head Teacher’s level of science-based questioning has on the resulting level of science-based questioning of the young children in the Montessori School classroom.
LITERATURE REVIEW

Section 1: Early Childhood Education

The term “early childhood”, according to the National Association for the Education of Young Children (NAEYC), extends from birth through age eight and can be organized into three separate age groups: Babies and Toddlers, Preschoolers, and Children in Kindergarten through Third Grade (Hyson & Tomlinson, 2014). In the text, *The Early Years Matter*, Marilou Hyson and Heather Tomlinson (2014) stress the importance of using appropriate, quality services and early childhood care and education programs provided for children age birth through age eight. Early childhood care and education “includes educational programs and a wide array of other services that support development and learning across the early childhood years” (Hyson & Tomlinson, 2014). *The Early Years Matters* really sets the stage using research-based information to detail why the early years (birth through age eight) matter so much; the text states, “what happens in the early years does not stay in the early years; it contributes to the quality of later education, to society as a whole, and to our future” (Hyson & Tomlinson, 2014). Quality programs and services that are developed specifically for children in early childhood may contribute to better social and academic experiences for children in their early years. The education of young children sets the stage for the child’s expectations of education, and these expectations will follow them in their future and affect them either positively or negatively; academically, personally, and professionally. This effect will depend on whether their expectations are viewed through a positive or negative light, so
having quality and universally-accessible early childhood care and education programs and services be readily available to children is extremely important.

When it comes to early childhood care and education, there are a variety of different programs and services available for parents to choose from. These programs and services include, but are not limited to: head-start, private and public preschools, early childhood special education, individualized family service plans (IFSP), daycare, and speech therapy. There are a couple of important things to look at when choosing a program/service that is best for a specific young child. These important things include the goals of the program/service (are their goals centered around what is best for the child?) and the research that has been gathered on the outcomes of these programs/services.

It is important to choose a program/service that is right for each individual child because the early moments these children have in these environments can have a huge impact on their future. Regardless of where or when they occur, “these moments can alter the development of a child’s brain and as a result, impact [their] health, happiness and ability to learn” (Britto, 2017).

There is a well-known debate centered around early childhood known as the “nature vs. nurture” debate; realistically, both nature (the genetics of a child) and nurture (how the child is raised and the environment they are raised in) build a child’s brain, resulting in a combination of genes, environment, and experiences (Britto, 2017) influencing neural connections in their brains. The time young children spend in their environments and the experiences they have in these environments create neural connections in their brains that
help to “create the foundation for continuing brain development” (Britto, 2017), which is an important part of early childhood development. Skills that are acquired as a result of these environments and experiences help children think, solve problems, communicate with others, express their emotions, and form relationships with the people around them (Britto, 2017). How these skills are acquired and the advancement of these skills depends on the environments in which the children exist in and how the adults around them take advantage of these environments to fuel knowledge growth in the children.

Preschool is one kind of early childhood program that is available to most children in the United States. There are several different kinds of preschools parents/guardians can choose from such as: Head Start, Community Preschools, and Montessori Preschools. Which program parents choose would depend on what kind of learning experiences they want their children to have throughout their early education. An example of one kind of preschool/kindergarten that differs greatly from traditional public school settings is the Montessori school setting. The Montessori school setting was founded and the first school was opened by a woman named Maria Montessori in the year 1907. The biggest difference between traditional public preschool settings and Montessori school settings is that while traditional school settings are more teacher-directed, Montessori school settings are almost completely student-directed. This means that students are given more ownership and accountability when it comes to their education; students have a significant impact on choices made related to their education. While the direction and schedule of learning experiences in a traditional school setting are generally decided by
the teacher, “Montessori students move about a classroom freely, ask questions while they engage in activities, [and] talk as they work” (Williams & Keith, 2000).

One of the main goals of Montessori school settings are to help children become independent/resourceful learners, foster intellectual inclusivity, and teach children both academic content/skills and life skills (Williams & Keith, 2000). Looking back at the literature written by Pia Britto (2017), Montessori school settings strive to help young children acquire the skills laid out in the writing, thinking, problem solving, communication, emotional expression, and the forming of interpersonal relationships (Britto, 2017). At this age, the brains of young children are incredibly malleable; this is because of how early experiences have an incredibly strong influence on brain architecture (UNICEF, 2012). Maria Montessori took full advantage of this vulnerability and used it to create educational experiences for children that revolve around increasing the development of a child’s brain.

This brain development includes the cognitive development of a child; the study that was conducted and will be explained in later pages is a study that looks at the cognitive development of a young child by looking at how they ask questions involving scientific materials/content.
Diving deeper into Montessori School/Curriculum and the vision it was founded under, this study is conducted in a Montessori setting to look at how the level of the student’s science-based questioning is influenced by the level of the Head Teacher’s science-based questioning while learning in a Montessori environment. The woman who founded the Montessori learning style, Maria Montessori, was a woman born in Chiaravalle, Italy, in the year 1870. After attending grade school, Maria Montessori chose to pursue a career in Medicine, contrary to the beliefs that were held around women being in the male-dominated sphere of medicine (Montessori Australia, 2007-2018).

In 1901, Maria began creating and studying her own educational philosophy, and began working with the children of Rome in a school she opened in 1907, her “Casa dei Bambini” (Montessori Australia, 2007-2018). She believed children needed engaging materials to learn. After spending some time working with these young students and using these development-specific materials with them, Maria Montessori realized that “children who were placed in an environment where activities were designed to support their natural environment had the power to educate themselves” (Montessori Australia, 2007-2018). The vision of Montessori education is summed up in words spoken by Maria Montessori herself: “Before elaborating any system of education, we must therefore create a favorable environment that will encourage the flowering of a child’s natural gifts.
All that is needed is to remove the obstacles. And this should be the basis of, and point of departure for, all future education” (Montessori, 1936).

In a study conducted by Association Montessori International (AMI), the academic outcomes of two groups of students who graduated from Milwaukee public schools were compared in the years 1997-2001. Prior to completing this study, AMI took a close look at prior research/studies that have been conducted on student academic outcomes as a result of attending Montessori schools. While looking at previous research/studies, AMI revealed important issues when it came to the research that had been conducted. One issue that was of utmost importance, was the fact that a number of Montessori schools where research had been completed, had little integrity in terms of the quality of the programs. Due to the discovery of this issue, AMI chose to ensure their study would be a carefully constructed, long-term study of the outcomes of Montessori Education (Dohrmann, 2003).

The first group of students studied had attended Montessori schools up to the 5th grade, while the second group of students had never attended Montessori schools (Dohrmann, 2003). In order to make the comparison between these two groups of students, researchers took a close look at student scores from the ACT and other standardized tests and looked at the overall and subject-specific grade point averages of each student. What they were able to conclude at the end of this study was “the association between a Montessori education and superior performance on the Math and Science scales of the ACT”; in other words, students who attend Montessori schools from preschool to 5th grade (around ages 3-11 years) have a higher chance of producing significantly higher
standardized test scores in the Math and Science sections in their high school years (Dohrmann, 2003). Seeing as how this study supports the hypothesis that Montessori education has positive long-term impacts (Dohrmann, 2003), it would be interesting to look more closely at what parts of Montessori education create these positive outcomes/impacts. What will be identified in the following study is how the Head Teacher’s (at the Montessori school) level of science-based questioning affects the students’ level of science-based questioning while learning science content and/or using science related materials.

According to information compiled by Montessori Compass (2018), the topics and content taught in Montessori allow students to “learn to ask questions, follow a systematic process of observation, collect and analyze data, and conduct controlled experiments” (Montessori Compass, 2018). It’s important to take a look at the whole child; looking at what children are capable of and feeding off of those capabilities can really help them reach their full potential academically.

In a text called Montessori: The Science Behind the Genius, Angeline Lillard discusses the materials and curriculum developed by Maria Montessori and how Maria found that children “are much more capable than traditional curricula hold them to be” (Lillard, 2005). Throughout the school year, students in Montessori education learn through the use of a science-based curriculum, and are able to advance significantly in areas such as reading and math. Through this heavy science curriculum, students are challenged and encouraged to ask questions to further understand the content being laid out for them,
regardless of the unit they are on; this allows the child’s critical thinking and cognition to be further developed.

Critical thinking skills, a cornerstone of Montessori education, are imperative. A study by Tammy LaPoint-O’Brien looked at the development of critical thinking skills in students in the ninth-grade who lacked the motivation to use their critical thinking skills. One thing concluded from this study was that critical thinking skills “are a necessity in and outside the classroom and without the facilitation and fostering of such skills within the classroom students are at a loss and lack the ability to develop to their capacity” (O’Brien, 2013). Developing critical thinking skills and cognition in children opens up doors to all other forms of positive achievement in their future education. Also in this study, students were asked to complete minute papers in which they reflect and further analyze what is was they were learning, and were also expected to formulate an insightful question “as a tool to be utilized for the development of critical thinking skills” (O’Brien, 2013). As a result of students asking these questions, researchers found that when students ask a question “about a prompt which goes beyond the scope of the question, they are really getting to the essence of the prompt without rewording the it and they are using higher-level thinking” (O’Brien, 2013).

To conclude previous research, asking insightful questions and developing critical thinking skills in students is a great way to allow them to use higher-level thinking skills. One form of questioning that allows students to use higher-level thinking skills is science-based questioning, as it requires high levels of analytical skills and cognitive development.
Section 3: Early Childhood Cognitive Development

Language Acquisition

Cognitive development in early childhood is a domain of development that is centered around the child’s language acquisition (a person’s capacity to perceive and comprehend language), the development of the child’s “theory of mind”, and the child’s ability to perform mental operations such as: understanding conservation (something-object, number, etc.-stays the same if any change occurs to this thing’s shape or size), symbolic function (the use of symbols to represent other objects/events) and intuitive thought (knowing something- having a “gut” feeling about something). Early childhood happens to be the point in a child’s life where language skills develop most dramatically and where thinking becomes representational (Arnett & Maynard, 2013). Representational thinking, the use of symbols to represent other objects, is closely related to language acquisition because “language requires the ability to represent the world symbolically, through words” (Arnett & Maynard, 2013).

As an important part of a child’s cognitive development, language development happens through a process known as “fast mapping.” Fast mapping occurs as young children learn new words and “begin to form a mental map of interconnected sets of word categories” (Arnett & Maynard, 2013). Even though children go through the process of fast mapping, not all children go through language development at the same pace. Actually, the language development of a child lies heavily on the socioeconomic status of the
home/family they come from; relatively recent research has been able to connect poverty to differences in brain functions, more specifically the areas of the brain that language functions in (Perkins, Finegood, & Swain, 2013).

*Early Intervention Programs*

In order to battle these discrepancies in the language development of children in early childhood, several early intervention programs came into being. One of the largest early intervention programs in the United States was developed, Project Head Start. Project Head Start was developed by a panel of experts (pediatricians, psychologists, professors) as a “comprehensive child development program that would help communities meet the needs of disadvantaged preschool children”, one of these needs including the language development of these preschool children (U.S. Department of Health and Human Services, 2018). Overall, Project Head Start was designed with the hopes of “providing preschool children of low-income families with a comprehensive program to meet their emotional, social, health, nutritional and psychological needs” (U.S. Department of Health and Human Services, 2018).

Another form of preschool that was developed as a “new approach to enhancing the cognitive development of young children” (Arnett & Maynard, 2013), was the Montessori Preschool Program. When it comes to the cognitive development of young children, research has found that children attending Montessori schools were more advanced than children who had not attended Montessori schools, especially in their cognitive and social development, and content knowledge (Dohrmann, 2003).
**Bloom’s Taxonomy of Questions**

In this study, the science-based questions asked by both the Head Teacher and the students of the Stillwater Montessori School will be analyzed using *Bloom’s Taxonomy of Questions* (see Figures 1.1 & 1.2). *Bloom’s Taxonomy of Questions* helps to organize and compose questions on different levels of thinking; the taxonomy ranges from lower to higher levels of cognitive thinking (Anderson & Krathwohl, 2001). There are six levels of cognitive thinking that the taxonomy is divided into: Remember, Understand, Apply, Analyze, Evaluate, and Create. The lower levels of cognitive thinking involve students using their ability to define, recall and list information (Remember), their ability to describe, explain, and discuss information (Understand), and their ability to demonstrate and interpret information (Apply). The higher levels of cognitive thinking involve students comparing/contrast and analyzing information (Analyze), defending and assessing information (Evaluate), and constructing/designing a finished product related to learned information (Create).

![Bloom's Taxonomy of Questions](http://prakovic.edublogs.org/2015/06/23/not-all-questions-are-created-equal-be-careful-when-measuring-comprehension/)

Figure 1.1 – Figure 1.2 –
Using higher levels of cognitive thinking is more beneficial than using lower levels of cognitive thinking, not only for children in early childhood, but for anybody of any age as well. One of the reasons behind this is the fact that the use of higher levels of cognitive thinking is directly related to the development of critical thinking skills (Adams, 2015). Critical thinking is, as defined by Michael Scriven and Richard Paul in 1987, “the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information” (Scriven & Paul, 2017). For example, lower levels of cognitive thinking such as remembering and understanding only require a person to recall information, describe information, demonstrate information, etc., which are skills that don’t require any critical thinking; this information would be something a person already knows/understands. However, in order for a person to use higher levels of cognitive thinking, they would need to tap into critical thinking skills they have already acquired, or develop new critical thinking skills, in order to do things such as analyzing information, assessing/defending information, and/or constructing/designing a finished product related to learned information.

A child’s brain/cognitive development at different ages impacts how a child asks science-based questions at each of those different ages. Looking at a developmental review completed by Ronfard, Zambrana, Hermansen, and Kelemen (2018), experts argue that the “specifics of adult question-asking as well as the occurrence of within- and between-subject variability can be explained using a question-asking model composed of four components: (1) initiation, (2) formulation, (3) expression, and (4) response evaluation.
and follow-up” (Ronfard et al., 2018). See Figure 2 for specifics on each of the four components of question-asking.

**Figure 2 –**

![Diagram showing the four components of question-asking: Initiation, Formulation, Expression, and Response Evaluation & Follow-up.]

Looking more closely at this developmental review, experts go into more specific detail surrounding the four components of question-asking by looking at question-asking of children in specific age groups. As this observational study focuses on students ages three to six, information that was pulled from the developmental review came from the preschool (three to five years old) section of the review. In this section, experts found that “research on question-asking behaviors in preschool reveals important developments in preschoolers’ ability to request information in response to uncertainty (i.e., Initiation) as well as concomitant developments in their monitoring of the responses they receive and in their follow-up to these responses (i.e., Response Evaluation & Follow-up)” (Ronfard et al., 2018). The developmental review experts stated that not as much information has
been revealed to explain how preschool-aged (three to five years) children use the Formulation and Expression components of question-asking (Ronfard et al., 2018). An example of a conversation between a preschool-aged (three years, 10 months) child and her mother was recorded in the developmental study:

Child: Is our roof a sloping roof?

Mother: Mmmm. We’ve got two slopping roofs, and they sort of meet in the middle.

Child: Why have we?

Mother: Oh, it’s just the way our house is built. Most people have slopping roofs so that the rain can run off them. Otherwise, if you have a flat roof, the rain would sit in the middle of the roof and make a big puddle, and then it would start coming through.

Child: Our school has a flat roof you know.

Mother: Yes it does actually, doesn’t it?

Child: And the rain sits there and goes through? (Ronfard et al., 2018).

From this exchange between the preschool-aged child and her mother, the experts of the developmental review were able to conclude how preschoolers are able to help “their ability to learn from other people by allowing them to initiate and extend question asking exchanges about topics that interest them” (Ronfard et al., 2018). Experts also concluded that preschool-aged children reflect on their previous knowledge in order to identify situations that are different from the situations they have encountered in the past; children use this information and ask questions in order to find information they seek (Ronfard et al., 2018).
This study is completely focused around the cognitive development of young children in a Montessori setting, because the ability to formulate science-based questions requires the development of language acquisition and intuitive thought, both important advances in the cognitive development of a child.
Section 4: Inquiry-Based Science Education

Science in Early Childhood Education

In early childhood, science education can be described as “Developmentally appropriate engagement with quality science learning experiences” (Trundle, p. 2). Science education with students still in early childhood does not have to necessarily be textbook heavy or full of big words/arbitrary facts; science education in early childhood can be as simple as providing science related materials for students to interact with or even taking them outside to explore science in nature. Young children can just as easily connect with and understand scientific experiences both in and out of nature as people of older age, as children interacting with nature and having scientific experiences is something that occurs naturally (Trundle, p. 2).

Although these scientific experiences can and do occur naturally in children, it still becomes necessary to expose them to rich scientific experiences in their education, guiding them and teaching them along the way. Dr. Kathy Trundle writes, “research studies in developmental and cognitive psychology indicate that environmental effects are important during the early years of development, and the lack of needed stimuli may result in a child’s development not reaching its full potential” (Trundle, p. 1). Scientific learning experiences come around full swing in the overall cognitive development of a child, so planning for these experiences is vital and highly recommended.

One common roadblock classroom teachers report around teaching science to young children is how to teach science to young children effectively; so that it provides them
with the most positive, active learning experiences they can receive. One education program in the United States known as Project Learning Tree (PLT) found a way to develop environmental experiences for early childhood that are hands-on and interdisciplinary in nature; the environmental experiences laid out in a text that was developed by PLT members “helps young people learn how to think, not what to think, about complex environmental issues” (American Forest Foundation, 2016). When it comes to implementing inquiry-based science education in early childhood settings, creating experiences that are interdisciplinary (involving two or more different subjects/areas of knowledge) can allow children to make positive advances in more than one domain of development at a time.

Not only do programs like PLT provide positive environmental experiences for children in early childhood, preschool programs/teachers and early childhood teachers also have the ability to implement these experiences into their classroom curriculums. Implementing experiences like this is quite simple, as it can be done in a way that creates a more interdisciplinary curriculum, which allows teachers to still meet the standards they are required to help their students meet throughout the school year.

Inquiry-Based

What makes science “inquiry-based”? A former teacher and consultant in broad aspects of educational reform by the name of Joe Exline defines effective inquiry as more than just asking questions; effective inquiry is a complex process that involves individuals attempting to convert the information acquired through asking questions and turning this
information into useful knowledge (Exline, 2004). Looking at the outcomes of inquiry-based learning is important, as these outcomes are positive and beneficial to a child’s development of knowledge. In a research synthesis completed in 2009, researchers looked at findings from research conducted between 1984 and 2002 to address the research question: “What is the impact of inquiry science instruction on K-12 student outcomes?” (Minner, Levy, & Century, 2009). A common goal among significant efforts to improve science education is to encourage teachers to use scientific inquiry in the classroom as so they can advance their students’ understanding of scientific concepts and procedures (Minner, Levy, & Century, 2009). This study looked at various research completed primarily in the United States, in which the researched instruction took place in a typical K-12 classroom of traditional setting. When it came to the impact of inquiry-based science instruction, this study looked to see if there was any impact on student science content learning and retention; it was found that the majority of the research that was synthesized indicated positive impacts of “some level” of inquiry science instruction on student content learning and retention (Minner, Levy, & Century, 2009). One significant finding of this study was, of the 34 moderate to high rigor category studies, 19 (56%) of them “demonstrated a statistically significant increase in student conceptual understanding for instruction with higher amounts of inquiry saturation compared with instruction with lower amounts of inquiry” (Minner, Levy, & Century, 2009).

When it comes to inquiry-based science instruction, different kinds of preschool programs deliver this form of science instruction quite differently. An example of a preschool program that differs from traditional preschool settings is the Montessori
preschool setting. This form of preschool setting differs greatly from the traditional preschool setting, as the curriculum in a traditional preschool setting has more of a heavy focus on reading, writing and math, while the Montessori preschool setting intertwines their heavy science curriculum with reading, writing and math skills, making it more of an interdisciplinary education. Montessori preschool curriculums consist almost entirely of inquiry-based learning experiences (especially science-related), as most of the materials provided to students in the classroom are materials that the students can decide to either use or not use each day, and the students can use these materials in a variety of different ways for a variety of different reasons. For example, one material that is provided to students at many Montessori schools involves the use of magnets and copying color patterns (floating magnet pattern learning game). The student uses cards that have pictures of the pattern of magnets on a pole, and depending on which way you flip the magnets and drop them on the pole, some will stick together and some will repel from one another. The students can use this material and inquiry-based thinking to not only learn more about patterns (a math skill, making this material interdisciplinary), they can also use this material to learn more about the properties of magnets, a science skill.
METHODS

Participants

The 24 children included in this observational study are between the ages of three and seven years old. Each of the 24 children are part of the preschool/kindergarten program offered at the Stillwater Montessori School in rural Maine. Due to the fact that this study was intended for preschool/kindergarten students, the students in the other classroom located in the school were not included as part of the study, as they are elementary students in grades 1 through 5. Each child is scheduled to spend the entire school day, each day Monday through Friday beginning at 8 am and ending anywhere from 3 pm to 4:30 pm, at the Stillwater Montessori School. At this specific Montessori School, all students are welcome, as inclusion in the classroom is something they take seriously; the students that attend the school all come from different backgrounds and come in with different abilities. As far as teachers go at the Stillwater Montessori School, there is one Head Teacher, two assistant teachers, a student teacher (the second half of the observation period), and several work study students that come from the University of Maine in Orono.

Due to the anonymity of this study, parental consent was not required in order to complete this study. Prior to the start of the observational study, permission was requested and granted by the Head Teacher of the Stillwater Montessori School to complete the study in that location and with those students. During the times the students were being observed, the Head Teacher was always present in the classroom, as well as up to 6 assistant teachers appointed by the Head Teacher.
During the study, the participating students were not asked to answer any questions or do/say anything they wouldn’t normally do on their own. Each student was observed from afar, and were told by their Head Teacher to participate in their learning and classroom activities as if I wasn’t there. If the students chose to speak with me or ask me questions, anything that would have been influenced by something I said or did was not included in the data. However, if a student said something to me that they chose to say on their own, it was included in the data if it related to the type of data being collected.

The Classroom Environment

Due to the nature of the school being located in a large, older style house, the preschool/kindergarten classroom space is comprised of several separate rooms. Each of the individual rooms are set up to focus almost entirely on one subject or developmental area, and contains materials students use to progress further in each subject or development area. There are specific materials that are laid out in specified ways, so no matter what, there will always be materials that will meet the developmental needs of each child at their difficulty level that will challenge them and help them move forward in their learning. There are six of these rooms; the reading and music room, the science/math room and peace corner, the room used for group time and writing, the sensorial (visual, audial, kinesthetic learning) room, the kitchen/practical life room, and the art room. When the students aren’t at lunch/recess, special, or group time, they are given time to move freely between these six rooms; they are given a lot of academic freedom and choice.
During each school day, the Head Teacher is the person that sets the tone for each group time, decides the daily class schedule, contacts and conferences with parents, and takes care of paperwork and office tasks associated with the school and its employees. Also during the school day, there are generally anywhere from two to six assistant teachers; some of these teachers have already earned their degree in Education and some coming in as work-study students from the University of Maine; about five miles from the school. Because the Stillwater Montessori School embraces student-led, independent learning, teachers only step in to lead a lesson or choose “work” (the use of materials in the classroom as a learning tool) for a student if it is necessary to help them move forward in their learning; students learn that the majority of the time, they have to approach a teacher themselves if they want help or a lesson with a material. In a Montessori School, “the teacher thoughtfully prepares a classroom environment with materials and activities that meet [their] students’ unique interests, academic level, and developmental needs. These [they] introduces to each child sequentially, laying the foundation for independent learning. Always, the teacher is aware of each student’s progress as [they work] toward mastering the particular concept or skill. [The teacher] knows when to step in to offer special guidance, and when to challenge a student with the next step in a learning sequence” (American Montessori Society, 2018).

The students arrive to school each day, Monday through Friday, anywhere from 8:00 am to 9:30 am. The students begin their day (if weather permits - students are not allowed outdoors to play/learn if there is a storm warning; snow or rain, if the temperature outside is below zero, or if the ice on the playground is deemed too dangerous in the winter)
outside on the playground; the teachers at this Montessori school believe it is important to allow children to have as much time outside as possible.

Once the students come inside, they meet in the writing/group room in a circle where they greet each other and are given a quick reminder of the science unit they are focusing on at that time. The students are then released for individual work time for about an hour and a half, where they freely use classroom materials and ask teachers for lessons when needed.

On Wednesdays in particular (the day of the week observations were completed for this study), the preschool/kindergarten has a teacher come in around 10:15 in the morning to teach the students music during the last 45 minutes of their first individual work time. This music lesson is something this specific Montessori school wants children to participate in as a group, even though traditionally, Montessori schools would not require students to participate in a group lesson such as this. After the students finish with music, they enjoy lunch and then they have recess (outdoors if weather permits). Also exclusively on Wednesdays, a gym teacher comes in right after recess around 1:00 in the afternoon to work on physical fitness with the students. The students then have another group lesson with the teachers; this is the time when they usually read a book aloud to the students. There is another individual work time, lasting about an hour, snack around 2:30 pm, and then the students are released outside to play while they wait for their parents/guardians to pick them up from school, anywhere from three o’clock in the afternoon to four-thirty in the afternoon. (See Appendix B for the full daily schedule)
Procedures

Observations for this study begin January 24, 2018, and took place for the entire school day every Wednesday that school is in session until May 9, 2018, from 8am to 3pm. Observations only cease during lunch time each Wednesday; this time is used as a break so I can eat, and observations continue as soon as lunch is over anywhere from noon to 12:30 pm. These observations are recorded in a notebook that is locked in a safe place when not in use; this safe place is only accessible to the advisor of the study, Julie DellaMattera, and myself.

At this Montessori school in particular, their curriculum is a hands-on environmental curriculum. At the beginning of each month the study took place, the Head Teacher reorganized each room in the classroom and swapped out materials to match the science-related topic they were focusing on for that month. Due to this change in the learning environment every month, the first Wednesday of each month (prior to taking any student observations), I took notes on any changes in the classroom materials; this helped with analyzing student observations, as I indicated the materials the children were using and the area of the classroom they were using the materials in. At the beginning of each Wednesday, I began with recording the number of students and teachers present in the classroom, the date the observation took place, and any special events that may have gone that could influence the amount of observations that are useful to the study as a whole.

For every observation recorded, several things are indicated with the observation: any materials used by the student or teacher, the area/room of the classroom the observation
occurred in, and whether the observation was of a student-student interaction, or a student-teacher interaction. Observations were recorded with the use of a pencil or pen, and one consistently used notebook. Observations were taken throughout the school day as I moved between rooms, pausing to listen and watch students interact with their teachers and their peers. An observation was recorded if two factors were present:

1. If a student asked a science-related question to another student or a teacher (Head or assistant)
2. If Head Teacher (specifically) asked the students a science-related question; this is so, during the analysis of the study, relationships can be found between the teacher’s level of scientific questions and the student’s level of scientific questions.

The level of questioning asked by a student or by the Head Teacher was determined using Bloom’s Taxonomy of Questions. This process was repeated every Wednesday, for 13 weeks, that school was in session.

Limitations of the Study

The first limitation is due to having only one observer. Because of the large size of the classroom and only one person observing throughout the study, it was impossible for 100% of the students’ and Head Teacher’s science-related questions to be observed. In addition, with only one observer present for the duration of the study, observations could only occur one day out of the week; more observations may have been recorded if there were more observers in the study.
The second limitation revolves around the analysis, discussion, and conclusion of this observational study. The observer may have had a lack of overall expertise compared to other experts in the field of Child Development and Education. The observer of this observational study was only a third – fourth year undergraduate student at a State University.

A third limitation of the observational study is that the study could have been influenced by the demographics of the school itself. The students at the Stillwater Montessori School come from, generally speaking, a higher socioeconomic status. The community of students in this school come from many different cultures, resulting in more multicultural learning and exposure.
ANALYSIS

After completing my observations at the Stillwater Montessori School, I took the data that had been collected and compiled the science-based questions both from the Head Teacher and the preschool/kindergarten students into an Excel spreadsheet. This spreadsheet data was organized into five separate sections: (1) the question that was asked, (2) who asked the question, (3) where in the classroom the question was asked, (4) the science unit the class was studying when the question was asked, and (5) the level on Bloom’s Taxonomy of Questions each question falls into. The only questions that were recorded in both the observations and the spreadsheet were science-based questions.

Questions were determined to be science-based because they were asked:

- when the student/Head Teacher was handling science related materials
- when the student/Head Teacher was engaged in a science lesson
- when the student/Head Teacher was reading a science related book
- when the student/Head Teacher was completing a science related activity or project
- when any lesson or situation involved animals or nature
- when the conversation involved a science concept

The questions asked and who asked the questions

After engaging in observations every Wednesday for seven hours each day, from January 24th, 2018 to May 9th, 2018, I recorded 192 science-based questions. Out of these 192 science-based questions, 76 of them (~40%) were asked by the Head Teacher and 116 (~60%) were asked by the preschool/kindergarten students. Of the 116 questions asked
by preschool/kindergarten students, 21 of them were asked by students of other students, and 95 of them were asked by students of the teachers.

*Where in the classroom the questions were asked*

Of the 116 student science-based questions recorded, the majority, 26% (30/116), of these questions were asked in the Kitchen. In addition, 25% (29/116) of these questions were asked while the Head Teacher and students were engaged in Group Time and 16% (18/116) were asked in the Sensorial Area.

There were also areas in the classroom/school where fewer science-based questions occurred. These areas include outside, where 12% (14/116) of the science-based questions were asked; the Reading/Writing Area, where 6.5% (8/116) of the questions were asked; the Fine Motor/Literacy Area, where 6.5% (8/116) of the questions were asked; and the Science/Math Area, where 5% (6/116) of the questions were asked. Three of the areas in the classroom/school - the Art Area, the Elementary Room (grades 1-5), and Music Lessons - only had 1% (1/116 each) of the science-based questions asked.

*The Science Unit the class was studying when the questions were asked*

The science-based questions asked by the Head Teacher and the preschool/kindergarten students at the Stillwater Montessori School were also organized in terms of what Science Unit the class was studying when the questions were asked. The first way I organized the data, was by how many student science-based questions were asked in each unit from least questions to most questions. The second way I organized the data, was by
the order the units were taught over the course of the semester from the first unit to the last unit.

First, I organized the data by how many science-based questions were asked in each unit from least questions to most questions. Of these 116 student science-based questions, 5% (6/116) of the questions were asked during the Arctic Unit and 5% (6/116) of the questions were asked during a week the class wasn’t focused on any Unit. Next, 7% (9/116) of student science-based questions happened during the Unit on the Rainforest and continent of South America, and 13% (15/116) of student science-based questions happened during the Unit on Earthworms. The next four Units had much larger percentages of science-based questions asked during them: 15% (17/116) of the questions were asked during the Unit on Dinosaurs and the continent of Asia, 16% (18/116) of the questions were asked during the Unit on Space and the continent of Africa, 17% (20/116) of the questions were asked the week the preschool/kindergarten students were meeting a hedgehog for the first time, and 22% (25/116) of the questions were asked during the Unit on the Ocean and the continent of Australia.

I then organized the data by the order in which the units were taught over the course of the semester from the first unit to the last unit. Of the 192 science-based questions asked, 5% (6/116) of the questions were asked during the first Unit on the Arctic, 15% (17/116) of the questions were asked during the second Unit on Dinosaurs and the continent of Asia, and 16% (18/116) of the questions were asked during the third Unit on Space and the continent of Africa. To continue, 7% (9/116) of the questions were asked during the
fourth Unit on the Rainforest and the continent of South America and 13% (15/116) of the questions were asked during the fifth Unit on Earthworms. After the Unit on Earthworms, there was a week I completed observations in which the class wasn’t focus on any Unit, where 5% (6/116) of questions were asked. To follow, 17% (20/116) of the questions were asked when the preschool/kindergarten students were meeting a hedgehog for the first time, and during the final Unit on the Ocean and the continent of Australia, 22% (25/116) of questions were asked.

The level of Bloom’s Taxonomy the questions fall into

After entering each of the 192 scientific questions into an Excel spreadsheet, each question was categorized under one of six levels of questioning on Bloom’s Taxonomy of Questions. The six levels, from lowest to highest levels are: Remember, Understand, Apply, Analyze, Evaluate, and Create.

Where these questions were categorized on Bloom’s Taxonomy of Questions can be somewhat subjective. However, in an effort to be rigorous, each of the 192 science-based questions was placed into a category based on the situation in which the question was asked, the action verb used in the question, and the context the action verb was used within the entire question. I used the REVISED Bloom’s Taxonomy Action Verbs chart from Anderson and Krathwohl (2001) to help me categorize the action verbs.

Out of the 76 questions that were asked by the head teacher, 28 of them were categorized under “Remember” in Bloom’s Taxonomy of Questions, three were categorized under
“Understand”, three were categorized under “Apply”, 23 were categorized under “Analyze”, 18 were categorized under “Evaluate”, and one was categorized under “Create”. Out of the 76 questions that were asked by the Head Teacher, approximately 45% of those were lower level thinking questions (bottom 3 tiers of the Taxonomy), and approximately 55% of them were higher level thinking questions (top 3 tiers of the Taxonomy), according to Bloom’s Taxonomy of Questions.

Out of the 116 questions that were asked by the preschool/kindergarten students, 61 of them were categorized under “Remember” in Bloom’s Taxonomy of Questions, eight were categorized under “Understand”, four were categorized under “Apply”, 23 were categorized under “Analyze”, 15 were categorized under “Evaluate”, and five were categorized under “Create”. Out of the 116 questions that were asked by the preschool/kindergarten students, approximately 63% of those questions were lower level thinking questions, and approximately 37% were higher level thinking questions.
Figure 3 –

Level of Head Teacher's Questions

Level of Students' Questions

- Percentage of Lower-Level Questions
- Percentage of Higher-Level Questions
DISCUSSION

Teachers ask questions of their students every day in the classroom, whether it be in math, literacy, social studies, science, or virtually any other subject. This observational study aimed to analyze the influence the level of scientific-based questioning from the teacher had on the level of scientific-based questioning from the students, who ranged in age from three to seven years old. This study was completed in the preschool/kindergarten classroom of a Montessori school in rural Maine. Observations were recorded of any scientific-based question that was asked by a student or by the Head Teacher. Observations were completed every Wednesday, for 7 hours, from January 24th, 2018 to May 9th, 2018. Once these observations were completed, the questions recorded were analyzed based on: who asked the questions, where in the classroom the questions were asked, what unit the class was on at the time the questions were asked, and where on Bloom’s Taxonomy of Questions the questions fell into. At the end of the analysis, four bar graphs were created as a visual for the percentage of higher-level questions in students and the Head Teacher vs. the percentage of lower-level questions in students and the Head Teacher throughout the observation period.

The questions asked and who asked the questions

Looking at this section of the analysis, it is quite obvious that the amount of science-based questions asked by the students was greater than the amount of science-based questions asked by the Head Teacher. Something that could have contributed to the fact that the amount of science-based questions came more from the students than from the Head Teacher is the fact that there are 24 students and only one Head Teacher. This
doesn’t necessarily mean the science-based questions asked by the students were of higher-level thinking questions than those of the Head Teacher, but it could mean that the students had a tendency to use more science-based questioning throughout the school day than the Head Teacher did.

Also looking at this section of the analysis, there is an obvious difference in the amount of questions the students asked of other students (21/116 - the numerator being how many science-based questions were asked of other students, and the denominator being how many science-based questions were asked by students in total) vs. the amount of questions the students asked of teachers (95/116 - the numerator being how many science-based questions were asked of teachers, and the denominator being how many science-based questions were asked by students in total).

The fact that the students asked more scientific-based questions than the Head Teacher, and that the students asked more questions of the teachers than of other students, could have been for many reasons; one of these reasons may have been because the students didn’t know the content as well as the teacher(s), and therefore asked more questions to help clarify the information. These clarifying questions can also be the reason why I had recorded significantly more lower-level thinking questions from the students than from the Head Teacher. Another reason why more scientific-based questions came from the students than from the Head Teacher could be the fact that “it is a child’s internal desire to learn what motivates them to seek out new experiences, which leads to success in
school over the long term. Curious children not only ask questions, but they seek the answers” (Trautner, 2017).

*Where in the classroom the questions were asked*

The preschool/kindergarten classroom in the Stillwater Montessori School is divided up into several different rooms, that all have different materials that are related in some way: the Kitchen, the Sensorial Area, the Reading/Writing Area, the Fine Motor/Literacy area, the Science/Math area, and the Art Area. In addition, the preschool/kindergarten students at the Montessori School also spend time playing and learning outside and also in the Elementary Classroom on the other side of the school. The observations taken of the students’ and Head Teacher’s science-based questions were recorded in all of these areas of the school.

Prior to beginning my observations at the Stillwater Montessori School, I hypothesized the majority of students’ science-based questions would take place in a combination of the Science/Math Area and outside. Looking at the data that was collected once my observation period was complete, I could see immediately that my hypothesis had been proven very wrong. The largest percentage of science-based questions stemming from students happened in the Kitchen; this is because when the Head Teacher prepares the preschool/kindergarten classroom for the next science unit every month, she doesn’t just arrange the materials in the Science/Math Area, where one might think she would. The Head Teacher prepares *every* area of the preschool/kindergarten classroom with materials related to the science unit. She does this so no matter what students are engaging in, or
where they are while they are engaged, they are still being exposed to and interacting with materials related to the science unit they are currently focusing on. For example, when the Head Teacher was preparing to teach the Unit on Dinosaurs and the Continent of Asia, she had Dinosaur books out in every room, coloring materials and Dinosaur figurines in the Sensorial Area, Dinosaur habitats, figurines, and information in the Science/Math Area, and a table with information and materials related to Dinosaur Fossils in the Fine Motor/Literacy Area.

The area in the school with the second largest percentage of science-based questions stemming from students happened while the students and the Head Teacher were engaged in Group Time. This is very likely because of the fact that the Head Teacher was engaging students in novel material during Group Time and initiating conversations about science-related content. This engagement in the novel material and science-related content would then prompt students to ask questions that would automatically qualify as science-based questions.

*The science unit the class was studying when the questions were asked*

The data on the science-based questions asked by the Head Teacher and the preschool-kindergarten students at the Stillwater Montessori School was also organized in terms of what science unit the class was studying when the questions were asked. Taking a look at the analysis, I organized the data in terms of what science unit the class was studying in two different ways: how many scientific questions were asked in each unit
from least questions to most questions and by the order the units were taught over the course of the semester from the first unit to the last unit.

Looking at this section of the analysis, the unit that contained the most amount of student questions was the Unit on the Ocean and the continent of Australia (25/116 of questions asked - the numerator being the number of student science-based questions asked during this Unit, and the denominator being the number of student science-based questions asked in total). One likely reason for this may be because this unit was the last unit students were observed engaging in during the observation period. Because this was the last unit observed, and the students had spent approximately eight months growing and learning in this school, the students may have been more comfortable asking science-based questions of their peers and teachers.

The science unit with the least amount of student science-based questions observed was the Arctic Unit (6/116 of questions asked), most likely because it was the first unit the students had begun working on after their winter break. Because this unit occurred earlier in the school year than, for example, the last unit on the Ocean and the continent of Australia, students may have not been as comfortable asking questions of their peers and teachers in the classroom. The second science unit with the least amount of student science-based questions observed was the week that the class wasn’t focused on any unit (6/116 of questions asked). Because the Head Teacher didn’t have the students focused on a science unit (in which they normally would be), the students didn’t have the
opportunities to asked as many science-based questions as they may have had if they were focused on a science unit that week.

During the observation period, the Head Teacher of the Stillwater Montessori School had a student teacher that attended the University of Maine spending time in the classroom, Monday through Friday, as part of a requirement for her to graduate with her Degree in Education. One of the requirements for this student teacher to successfully complete student teaching was for her to take over the classroom for one week. During this week, the student teacher chose to engage the students with a Unit on Earthworms. The day I spent observing student science-based questions while they were engaged in this unit revealed only 15/116 of questions asked throughout the observation period (see “Worm Unit (Student Teacher)” in Figure 3). This may have been due to the fact that instead of the Head Teacher leading the majority of discussions with students on science-related concepts/topics, the student teacher was the one leading the majority of discussions. This may be because the student teacher isn’t as experienced in teaching students not just in general, but especially not in a Montessori environment. This doesn’t mean the student teacher isn’t as capable as the Head Teacher of the Stillwater Montessori School, it just means she hasn’t had the experience that the Head Teacher has had from years of teaching Montessori Education, making it so she doesn’t have as many tools/experiences under her belt to probe student curiosity in the way the Head Teacher does.

Continuing to take a look at the data collected during the observation period, there was a week in which the second largest amount of student science-based questions were asked -
during the week the students were meeting a hedgehog for the first time. During this week, all of the observed science-based questions (20/116 of questions asked) asked by students were questions related to the hedgehog they were meeting. This was because the Head Teacher created an additional activity to add to the classroom that involved students decorating a hedgehog cut-out and writing any question they may have about hedgehogs on the back of the cut-out. This week, all of student science-based questions observed were questions about hedgehogs most likely because students were (1) excited they were being introduced to a hedgehog for the first time and (2) influenced to ask questions by the new activity the Head Teacher set out for them related to asking questions about the hedgehog they were meeting.

Although the Unit on Dinosaurs and the continent of Asia was only the second science unit the students were introduced to after their winter break and during the observation period, 17/116 of questions asked were observed during this unit. One of the reasons why there was a larger amount of questions during this unit than for comparison purposes, the first Unit on the Arctic, even though the two units were so close together, could have been because of the fact that students were introduced to a topic that was observably more exciting for them. During the Unit on Dinosaurs and the Continent on Asia, students were engaged in an activity that allowed them to explore why they thought the Dinosaurs went extinct, which is a topic (as the Head Teacher described to the students) that is heavily debated and has no right answer. Not only that, but Dinosaurs are something the students learned about that they have and will never be able to see alive, making the subject that much more intriguing, probing student curiosity on the topic.
The Unit with the third largest amount of student science-based questions asked was the Unit on Space and the Continent of Africa, in which 18/116 of questions were asked. This may have been because of the students’ observable excitement over the content they were learning about things that exist outside of the planet they live in, or the fact that the Head Teacher introduced them to how astronauts live in space (much different from when they are on Earth), and even was able to show them what someone would look like in a space suit (she had one of her own). Space is a topic the students didn’t have any non-visual information on, and none of the family members of students had ever been to space. This lack of non-visual information prompted students to ask many lower-level thinking questions (according to Bloom’s Taxonomy of Questions) while engaging in content related to Space.

*The level of Bloom’s Taxonomy the questions fall into*

By taking a look at the percentages above, it appears as though the level of science-based questions the Head Teacher asked didn’t have much effect on the level of science-based questions the preschool(kindergarten) students asked. However, if you take a closer look at the level of science-based questions the students asked, according to Bloom’s Taxonomy of Questions, as they progressed through the school year during the observation period (see Figure 3 in Analysis), you may notice otherwise. Note: When I analyzed the first two bar graphs created as part of Figure 3, I chose to pull out three of the Units - the Earthworm Unit, the week with no Unit focus, and the week the students met a hedgehog - due to the fact that these three weeks were not included in the planned month-long Unit curriculums. The Earthworm Unit and the week with no Unit focus were
given their own bar graphs, as a way to further analyze the difference between the students’ and Head Teacher’s questions during those weeks, and their questions during the planned month-long Unit curriculums.

Looking at the bar graph in Figure 3 corresponding with the Earthworm Unit, there was an interesting piece of data that was collected and analyzed. This piece of data included the information on the level of the questions asked by the student teacher and how these questions (1) only consisted of two total questions and (2) consisted of one higher-level question and one lower-level question. Looking at the described graph in Figure 3 (“Worm Unit (Student Teacher)), it appears as though the level of the students’ science-based questions were negatively affected by the questions asked by the student teacher. However, as previously mentioned in the discussion, this could have been due to a number of circumstances (see information on the student teacher in the “The science unit the class was studying when the questions were asked” section of the discussion).

As mentioned in the introductory section, the Stillwater Montessori School utilizes a planned yearly science-based curriculum in which the classroom materials are changed to supplement the major science topic/area the students are engaging in each month. Because each major science topic/area is planned into the curriculum yearly, the Head Teacher has the time to make sure there are enough supplemental materials and lessons to engage the students in the content and stimulate their ability to use higher-level thinking and ask higher-level science-based questions.
Having said that, there was one week during the observation period in which there was no Unit focus, meaning the work the students were completing wasn’t based around a yearly planned major science topic/area. Looking at the bar graph included in Figure 3 that corresponds with the week with no Unit focus, both the students’ and the Head Teacher’s questions consist of more lower-level science-based questions than higher-level science-based questions. The reason behind why the Head Teacher’s questions consisted of more lower-level science-based questions, may be due to the fact that this week was not part of the planned yearly science-based curriculum; the Head Teacher had not planned this week as extensively prior to teaching as she did with the major science topics/areas in the year-long science-based curriculum. The reason behind why the students’ questions consisted of more lower-level science-based questions, may be because (looking at previous data), the level of the students’ science-based questions appear to be positively influenced by the Head Teacher’s level of science-based questions. Because the Head Teacher’s questions consisted of more lower-level science-based questions, that might have impacted the students’ level of science-based questions, making their questions more lower-level as well. This is not necessarily a bad thing; this data shows that both the level of the Head Teacher’s science-based questions and the planned yearly science-based curriculum have a positive impact on the students’ level of science-based questioning.

Prior to beginning my observations of science-based questioning at the Stillwater Montessori School, I hypothesized the amount of higher-level science-based questions the students asked would be positively influenced by that of the Head Teacher. Looking
more closely at the data in Figure 3 in the analysis section, it is clear that the Head Teacher’s science-based questions always contain more higher-level science-based questions (during one Unit, the ratio from lower-level to higher-level is 50/50) than lower-level science-based questions. I then looked more closely at the data in the “Level of Students’ Questions” bar graph in Figure 3 in the analysis section. Starting with the first Unit - the Unit on the Arctic - you can see that the science-based questions the students asked during that Unit turned out to be 33% higher-level questions. In the second Unit - the Unit on Dinosaurs and the Continent of Asia - the students asked questions that were 35% higher-level questions. In the third Unit - the Unit on Space and the continent of Africa - the students asked questions that were 39% higher-level questions. In the fourth Unit - the Unit on the Rainforest and the continent of South America - the students asked questions that were 56% higher-level questions. Lastly, in the fifth (which would have been the sixth, but I pulled out three of the weeks prior to this one) Unit - the Unit on the Ocean and the continent of Australia - the students asked questions that were 60% higher-level questions.

Taking a look at the percentages of higher-level, science-based questions the preschool/kindergarten students asked across these five Units, it is easy to see a quite interesting trend. As the students progressed through these units, the percentage of higher-level science-based Questions they asked continually rose, first by 2%, then by 4%, then by 17%, and then finally by 4% once again.
CONCLUSION

Digging deep into the upward progression in the level of science-based questions the students asked as the observation period went on provides evidence that the students’ level of science-based questions seems to have been positively influenced by many factors. Possible factors for the positive influence on the level of student science-based questions include the Head Teachers’ level of science-based questions, the Science Unit the class is focusing on, and the way the classroom is prepared/arranged to enhance the students’ level of interest in the Science Unit they are focusing on. There is no way to determine whether or not one of these factors played a larger role than the other; more research would need to be completed to help determine this. Although I can’t conclude 100% that the Head Teacher’s level of science-based questioning was the only factor that influence the students’ level of science-based questioning, I can say that my hypothesis was correct in stating that it was one of many factors that influenced the students’ level of science-based questioning, with evidence to support that statement.
REFERENCES


APPENDICES
Basic Year – Long Curriculum for the Primary Classrooms at Stillwater Montessori School, Old Town, Maine

Developed by Joanne DeFilipp Alex, Educational Director

“LET US GIVE THE CHILD A VISION OF THE WHOLE UNIVERSE... FOR ALL THINGS ARE CONNECTED TO FORM ONE WHOLE UNITY.”

—Maria Montessori


OCTOBER- 1. Global Child Curriculum includes UNICEF (service learning project) and a focus on a country, region or group of people, 2. Creatures of the Night Unit, 3. Fire Safety Week


DECEMBER- 1. Europe, 2. Holidays around the World, 3. The Toy Box (service learning project for local shelter)


APRIL- 1. South America, 2. Farm Curriculum, 3. Spring Celebrations around the World, 4. Rainforest Project (service learning project)

MAY- 1. Australia, 2. Oceans Curriculum, 3. Adopt-A-Whale (service learning project)

JUNE- 1. Penobscot Watershed includes wetlands, insects, flowers (garden and wildflowers), 2. Personal Safety, including bike day, 3. Trike-A-Thon (service learning project)
# APPENDIX B: DAILY SCHEDULE

## Stillwater Montessori School
### Primary Daily Schedule of Activities

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 am</td>
<td>Before school care Drop-off</td>
</tr>
<tr>
<td>8:30</td>
<td>Student Drop-off/Outdoor or Indoor Playtime</td>
</tr>
<tr>
<td>9:00</td>
<td>Group Meeting Time</td>
</tr>
<tr>
<td>9:30</td>
<td>Individual Work Time</td>
</tr>
<tr>
<td>11:00</td>
<td>Group Time-Read Aloud/Shares</td>
</tr>
<tr>
<td>11:30</td>
<td>Lunch/Outdoor or Indoor Activities</td>
</tr>
<tr>
<td>12:30 pm</td>
<td>Nap Time</td>
</tr>
<tr>
<td>1:00</td>
<td>Read Aloud (chapter books/stories)</td>
</tr>
<tr>
<td>1:30</td>
<td>Individual Work Time</td>
</tr>
<tr>
<td>2:30</td>
<td>Group Snack</td>
</tr>
<tr>
<td>3:00</td>
<td>Closure to the day &amp; Transition to Outdoor/Indoor Time</td>
</tr>
<tr>
<td>3:30</td>
<td>Parent Pick-up/Continued Outdoor/Indoor Time</td>
</tr>
<tr>
<td>4:30</td>
<td>After school care Pick-up</td>
</tr>
</tbody>
</table>

## Special Weekly Schedule for the Primary Class

- **Monday**: Share Day, New Units shown
- **Tuesday**: Spanish- Shelli Batuski  
  Optional Art- Valerie Wallace
- **Wednesday**: Creative Movement- Cid Dyjak  
  Music- Instructor TBD
- **Thursday**: Regular Schedule
- **Friday**: Special Unit Celebrations and Activities

*Special Child of the week celebration day determined by Parents and Joanne*
APPENDIX C: IRB APPROVAL LETTER

APPLICATION COVER PAGE

KEEP THIS PAGE AS ONE PAGE - DO NOT CHANGE MARGINS/Fonts!
PLEASE SUBMIT THIS PAGE AS WORD DOCUMENT

APPLICATION FOR APPROVAL OF RESEARCH WITH HUMAN SUBJECTS

Protection of Human Subjects Review Board, 400 Corbett Hall

PRINCIPAL INVESTIGATOR: Desiree Labbe EMAIL: desiree.labbe@maine.edu
CO-INVESTIGATOR:
EMAIL:
CO-INVESTIGATOR:
EMAIL:
FACULTY SPONSOR: Julie DellaMattera EMAIL: julie.dellamattera@maine.edu
(Required if PI is a student):

TITLE OF PROJECT: An investigation of the social development that occurs in preschool aged children when learning in a science-based curriculum in a Montessori School in rural Maine.
START DATE: January 24, 2018 PI DEPARTMENT: Education
FUNDING AGENCY (if any):

STATUS OF PI: FACULTY/STAFF/GRADUATE/UNDERGRADUATE Undergraduate (F.S.G.U)

1. If PI is a student, is this research to be performed:
   - [X] for an honors thesis/senior thesis/capstone?
   - [ ] for a master's thesis?
   - [ ] for a doctoral dissertation?
   - [ ] other (specify)

2. Does this application modify a previously approved project? N (Y/N). If yes, please give assigned number (if known) of previously approved project:

3. Is an expedited review requested? N (Y/N).

Submitting the application indicates the principal investigator’s agreement to abide by the responsibilities outlined in Section I.E. of the Policies and Procedures for the Protection of Human Subjects.

Faculty Sponsors are responsible for oversight of research conducted by their students. The Faculty Sponsor ensures that he/she has read the application and that the conduct of such research will be in accordance with the University of Maine’s Policies and Procedures for the Protection of Human Subjects of Research. REMINDER: if the principal investigator is an undergraduate student, the Faculty Sponsor MUST submit the application to the IRB.

Email this cover page and complete application to UMRIC@maine.edu

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FOR IRB USE ONLY Application # 2017-12-17 Review (F/E): D

ACTION TAKEN:

[X] Judged Exempt; category 2 Modifications required? Y Accepted (date) 1/8/2018
☐ Approved as submitted. Date of next review: by Degree of Risk:
☐ Approved pending modifications. Date of next review: by Degree of Risk: Modifications accepted (date):
☐ Not approved (see attached statement)
☐ Judged not research with human subjects

FINAL APPROVAL TO BEGIN 1/8/2018 Date 01/2017
AUTHOR’S BIOGRAPHY

I came into the University of Maine in 2015 with a major in Biochemistry. It wasn’t until the end of my first semester, that I realized Biochemistry was not what I wanted to pursue a career in; I had decided with the help of my first semester Honor’s Preceptor, Julie DellaMattera, that Education was where I belonged. I decided to pick up a new major in Child Development and Family Relations with a concentration in Early Childhood Education. My journey as a preservice teacher has had its hills and valleys, and I would say right now, I’m definitely on a hill! Choosing a topic for my Honors Thesis project was easy; I knew it would be something related to Education and something science-related (because I love science). After I decided I knew that much, I went and spoke to my advisor (both my academic advisor and my advisor for this thesis), Julie DellaMattera. We were finally able to narrow down my topic to what it is now, and I couldn’t thank her enough for all of her help and support. Thank you so much for taking the time to read my thesis and all of the hard work I put into it, and I hope I was able to give you a glimpse into the wonderful things that go on inside of a classroom, more specifically, a Montessori classroom.