PRESCHOOL SCIENCE: AN EXAMINATION OF CLASSROOM AND TEACHER PREDICTORS

by

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ABSTRACT

Preschool Science: An Examination of Classroom and Teacher Predictors

by

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Preschool science is important for children's development and is an important indicator of school readiness. This exploratory study examined several variables of teacher demographics, teachers' attitudes, and classroom characteristics in relation to the amount of time teachers spent on preschool science. This study used questionnaires (including the Preschool Teacher Attitudes and Beliefs Toward Science Teaching Questionnaire and the Dimensions of Attitudes of Science) as well as open-ended questions to understand what barriers teachers may be facing. A sample of 122 teachers was recruited from a variety of different types of preschool programs throughout Utah.

Findings suggest that preschool teachers are quite comfortable with teaching science, but that time spent on science is low with teachers reporting science activities to occur one to three times a month. Higher levels of education and comfort levels with science are associated with more time spent on science. Furthermore, teachers' comfort levels with teaching science was a significant predictor of time spent on science in the classroom, above and beyond the percentage of children who were eligible for free and reduced lunch and teachers' education level, years of experience, and age. These results suggest that helping teachers feel more comfortable teaching science should be an important target for professional development practices and pre-service education.

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PUBLIC ABSTRACT

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Donna S. Blaylock

Science experiences during the preschool years is important because it helps build brain development in children, and improves school readiness. This exploratory study examined several characteristics of teachers and classrooms to see if any factors predicted time spent on science. Over 120 teachers participated, with teachers from Head Starts, university child development laboratories, home-based preschools, and other private preschool programs.

Findings suggest that preschool teachers are quite comfortable with teaching science, but science activities are reported to occur infrequently—one to three times a month. Teachers with higher levels of education and comfort levels with science are reported to be more likely to spend time on science. Additionally, comfort levels with science had the greatest impact on time spent on science after accounting for teacher and classroom demographics. These results suggest that helping teachers feel more comfortable teaching science should be an important target for professional development practices and preservice education.

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INTRODUCTION

Background and Setting

Preschoolers are at a perfect age of discovery. Children are developmentally inquisitive and eager to learn about the world around them. Children ages 3 to 6 years old are often observed asking *why* questions (Clements & Sarama, 2016; Guo, Piasta, & Bowles, 2015). Science, which involves the use of inquisitiveness and discovery, is an important aspect of a child's preschool curriculum, but it can be the most challenging subject to teach (Greenfield et al., 2009). Past studies have shown that while preschool is an ideal time to introduce science concepts, teachers are often unwilling or unable to teach it effectively (Clements & Sarama, 2016; Pendergast, Lieberman-Betz, & Vail, 2017). This study took an exploratory look into what are some common barriers preschool teachers encounter with teaching science, and how these barriers related to the amount of science activities in the classroom. It also explored some common teacher characteristics and classroom characteristics that are associated with current teaching practices in the preschool setting.

There is much to consider within the realm of preschool science. The first thing to look at with this is the background of science activities in preschool settings. Science has recently shifted into focus as there is a national push for more knowledge in this particular area, but it still is not taught as much as literacy or math (White House, 2010). The United States is behind other developed countries in the areas of science and math, and U.S. students are consistently outperformed on science and math tests in later grades

(Provasnik et al., 2012). In fact, in 2009 the United States scored 17th out of 33 other developed countries on an international series of assessments administered to 15-year-old students, which led to a subsequent push from President Obama for more science (White House, 2010). Recent studies have found that young students entering kindergarten are unprepared in the areas of science and math (Guo et al., 2015). This may be because of inadequate exposure, poor teaching supports, or poor curricula for preschool teachers to follow. As of 2009, almost every state had curricula suggestions for preschools, and associations such as the National Association for the Education of Young Children (NAEYC), set standards for science teaching as well (Brenneman, Stevenson-Boyd, & Frede, 2009). Even with these standards in place, there is an average of only 26 minutes of science learning opportunities [opportunities not necessarily participated in] in full and part day preschool classrooms, and most of that time is based in experiences not designated for science specifically (Piasta, Pelatti, & Miller, 2014). In addition, many preschools create or follow very different curricula, making science teaching inconsistent. The demographics of the children and preschool settings also seem to play a role in how much science is being taught, and at what level of quality (Piasta et al., 2014).

Statement of the Problem

Understanding the world through scientific discovery is a natural part of childhood exploration that should be fostered and encouraged (Clements & Sarama, 2016; Fleischman, Hopstock, Pelczar., & Shelley, 2010). Through observations of preschool aged children and their daily dealings, it does not take long to realize children are “little scientists” who possess a natural inquisitiveness and are continually discovering the world around (Akerson, Buzzelli, & Donnelly, 2010). Although children are capable of developing the foundations of scientific inquiry themselves, having teachers who skillfully answers children's questions and provide depth for investigation, furthers children's learning abilities and excitement about science (Clements & Sarama, 2016). Preschool children need to begin school prepared with a background of science knowledge and processes. Some preschool teachers seem to have barriers about incorporating science curriculum and it is not clear what these barriers might be. Not teaching science or poor teaching practices in preschool classrooms is problematic because children need this area of focus to fully develop their problem solving and critical thinking skills (National Association for the Education of Young Children, 2018). Teaching science at this young age is important to children not only because this knowledge can help them to understand the world around them, but additionally because there is evidence that science is associated with an increase in school readiness, communication skills, higher-level reasoning, and executive functioning (Greenfield et al., 2009; Nayfeld, Fuccillo, & Greenfield, 2013). Children's preschool involvement in science is also correlated with academic success in science, technology, engineering, and mathematics (STEM) and reading literacy (Clements & Sarama, 2016). This study looks at teacher demographics (age, education level, years of experience, etc.) to understand the background of preschool teachers. Teachers who have more years of experience and education tend to feel more conformable teaching science concepts (Akerson et al., 2010). In addition to demographics, the attitudes and perceptions of teachers have also been shown to play a role in their science teaching, especially when there are feelings of inadequacy or anxiety about science (Pendergast et al., 2017). It is important for us to understand the teacher demographics, attitudes and comfort levels related to teaching science to better understand the personal barriers that influence teaching practices. This study also examined the preschool demographics (type of preschool and percentage of children who qualify for free or reduced lunch) in relation to teaching science because there are typically more barriers to learning for low-income children (Nayfeld et al., 2013).

Purpose and Objectives

The purpose of this study was to explore some of the common characteristics, attitudes, and perceptions that preschool teachers share when teaching science to children. This study also examined the different classroom characteristics that are associated with teachers' current practices. The following research questions were addressed during this study.

1. What are the characteristics of preschool teachers and their preschool classrooms from various preschool types in Utah?
   1a. What are the demographic characteristics of teachers in this study?
   1b. What are the attitudes, comfort levels, and current practices of preschool teachers teaching science in these preschool settings?
   1c. What are the classroom demographics of the preschool classrooms?
   1d. Are there significant differences related to teacher and classroom characteristics among the program types?
2. What are the associations among teacher and classroom characteristics?

3. Do teacher attitudes and comfort levels contribute to the amount of time teachers spend teaching science above and beyond teacher demographics, classroom demographics and program type?
4. What do teachers report regarding teaching preschool science (including feelings, benefits, barriers, and actual activities)?

CHAPTER II

REVIEW OF LITERATURE

Introduction

Preschool can be a very exciting experience for children. In preschool settings, children can discover many different areas of learning such as literacy, art, social skills, social studies, mathematics, and science. While each area of learning plays an important role in child development, science is often underrated, overlooked, and taught much less than other areas (Greenfield et al., 2009). Preschool science can have positive impacts on school readiness, executive functioning, STEM and language arts (Greenfield et al., 2009; Nayfeld et al., 2013). Given the potential impact science can have, in addition to its interconnectedness with other subjects, it is important to know what is holding teachers back from teaching more science in preschool classrooms. A handful of studies have looked at teacher attitudes in relation to teaching science, finding that teachers often feel uneasy about science (Akerson et al., 2010; Pendergast et al., 2017). Few studies have looked at attitudes and comfort level in relation to teacher demographics and preschool demographics, which is the focus of this study. The conceptual framework for this study is from Alberta Bandura's Social Cognitive Theory (Bandura, 2018). This theory relates to how each factor plays a role in the amount of science taught in preschool classrooms.

Social Cognitive Theory

Teachers function as learners and doers as they learn science material and teach the concepts to their students. For this study of science predictors, it is appropriate to use Social Cognitive Theory since the tenets of this theory help explain why the teacher characteristics and demographics influence science time. Some of the basic principles of Bandura's theory are based around observational learning, triadic codetermination process of causation, and self-efficacy.

Social Learning Theory has four basic components of observational learning which include: attentional processes, retention processes, motor production processes, and reinforcement/motivational processes (Bandura, 2018). To really learn something, one must first be drawn to it and pay attention to what is happening. For example, if a teacher is interested and intrigued with science, she will probably pay attention to what other teachers are doing with science. The second step is to retain information learned in the process. Teachers need to remember the process of how to do the science activity. Committing the process to memory could be accomplished by taking notes, or even putting the steps in a lesson plan so she sees it on the schedule later that day. The third step for teachers learning how to teach science, would be for her to physically reproduce the science activity herself. She might have seen an experiment done ten times, but she may not feel like she has learned it confidently until she has experienced it for herself. She must be able to reproduce the action she has learned. The fourth step is reinforcement or motivational processes. If the science project was well received by her students, the teacher is more likely to continue to incorporate science projects, or further the investigation on that science experiment. These components of observational learning lay the theoretical foundation on the rationale to explore the factors involved in the current study.

The triadic codetermination process of causation (also known as triadic reciprocal determinism) can be thought of as a triangle that is made up of behavioral, personal factors, and environmental factors that influences how a person will behave (Bandura, 2018). To explain this, it is helpful to look at each side of the triangle individually before putting it together. For example, environmental factors for teachers can be seen in the classroom setting with the demographic of children served (percentage of children who qualify for free or reduced lunch) and the preschool type, as these might influence the behavior of the teachers differently for each situation. On the other side of the triangle, teacher demographics, such as years of experience and education would give teachers different science skills and therefore would be behavioral factors. Personal factors can be the teacher characteristics, such as attitudes and beliefs about science, that influence their teaching of this subject. All three of these factors can be seen as influences on the amount of teaching preschool science.

Self-efficacy is defined as how confident and comfortable one feels about something (Bandura, 2018). Self-efficacy appraisals within the teacher herself influence her teaching. If she tells herself that she is bad at science, or has low confidence in the success of a project, that could affect her motivation and success. This would influence the desire to repeat the science activity.

To summarize, observational learning processes, the triadic codetermination process of causation, and self-efficacy are all tenants of Bandura’s Social Cognitive

Theory that can help explain teaching behaviors and interest related to the amount of science in preschool classrooms. The four components of observational learning processes (attentional processes, retention processes, motor production processes, and reinforcement/motivational processes), add to the three factors of triadic codetermination process of causation (behavioral, personal factors, and environmental factors), and all of this can be influenced by how much comfort and confidence (self-efficacy) teacher experience. Taken together, Social Cognitive Theory makes for a solid framework for understanding preschool science predictors.

Need for Preschool Science

Preschool is an essential time to introduce science. Children in preschool have a natural interest in science and express this by asking *why* questions (Clements & Sarama, 2016; National Research Council, 2007). The National Research Council (2007) propagates that during the preschool years, children are poised to begin learning about the world by asking questions, and Greenfield et al. (2009) identified eight process skills children need to have before school: observing, describing, comparing, questioning, predicting, experimenting, reflecting, and cooperating. The scientific method creates a good setting for this exploration to take place as children move along the steps of asking questions, researching, creating hypotheses, experimenting, analyzing, and concluding. Questions such as why the sky is blue, or how fish breathe are typical examples of children's questions at this age and are starting points for how a teacher could set up scientific investigations in a classroom setting.

During this inquisitive time, if children have access to high-quality programs where science is being taught effectively, they can readily accept science knowledge and skills, which can lead to higher-level reasoning skills, as well as increased executive functioning (Greenfield et al., 2009; Nayfeld et al., 2013). Nayfeld et al. (2013) tested 278 preschool children on executive functioning, and school readiness in math, literacy, and science. They discovered that science readiness was significantly correlated with executive function in preschool children, even stronger than math or literacy readiness (Nayfeld et al., 2013). They suggest that science has the capacity to engage and interest the children, which can increase their executive functioning skills (Nayfeld et al., 2013).

Unfortunately, the majority of preschool classrooms still are not receiving enough science and therefore not reaching these desirable outcomes (Greenfield et al., 2009; Whittaker, Kinzie, Williford, & Decoster, 2016). In a study of almost 5,000 Head Start preschool children in Florida, Greenfield et al. found that science readiness was significantly lower than other domains by the end of the school year, and that science activities in the classroom were oftentimes informal or sporadic (2009). Piasta et al. (2014) observed 65 full- and part-day classrooms and found that there was an average of 26 minutes for science learning opportunities each day, including teacher-managed (e.g. if a teacher was reading a book about weather) or child-managed (e.g. if a child placed ice in the sun to watch it melt). Previous studies, such as one done from Connor, Morrison, and Slominski in 2006, had estimated science time much less, at an average of 3 minutes per day. Piasta et al. (2014) have reasoned that this discrepancy is due to their observations for learning *opportunities* in math and science, and that the observations done by Connor et al. (2006) were focused mostly on literacy growth, with all learning domains coded. It is an important note that nonetheless science was coded as occurring the very least often in the average classroom compared to other subjects.

One often overlooked benefit of teaching science, is that it fundamentally incorporates other content areas such as literature, language arts, math, and social science (NAEYC, 2018). For example, by setting up a well thought out science experiment, a teacher can set up a research question with a story (which encompasses literature or social studies), new vocabulary (language), measurement of materials/ingredients (math), and then proceed to work through the scientific method to engage children in an educational science experiment using reasoning, observation and critical thinking. In their meta-analysis of program evaluations on a mathematical curriculum called Building Blocks, Clements and Sarama (2016)discovered transfer occurring when the children in their intervention group would often score higher in multiple areas of oral language competencies. The children's ability to recall, use correct grammar, tell narratives, and make inferences all increased, although the specific mechanism of why this happens exactly is still unclear (Clements & Sarama, 2016). They suggest that creating interesting projects the children are excited to talk and think about could be one reason why this domain of reading literacy increased simultaneously (Clements & Sarama, 2016).

It is important to foster the natural curiosity of children since science interest during preschool has been shown to be correlated with later interest and knowledge in sciences (Leibham, Alexander, & Johnson, 2013). Leibham et al. (2013) investigated boys' and girls' science interest and self-concepts in preschool and how these factors related to their achievement and self-concepts at age eight. They found that boys often had a higher interest in science than girls in the preschool years. Furthermore, they found that girls with high levels of positive self-concept with science in preschool also had higher levels of later science achievement at age 8 when compared to other girls with low self-concepts in regards to science. A pipeline effect of females performing lower than males in areas of STEM, is noticed in 4^{th} and 8^{th} grade, and perpetuated in college degree attainment (Hanewicz & Thackeray, 2019). Contrastingly, when children are introduced to science at a young age, with positive role models and support systems, they are more likely to internalize an early love for learning and science inquiry, and subsequently are more likely to continue STEM interest in future school learning (Hanewicz & Thackeray, 2019; Kesar, 2017). Unsurprisingly, the results from a meta-analysis of over 400 studies indicate that women are continually underrepresented in the science and STEM professions as adults (Ceci, Williams, & Barnett, 2009). The Utah Department of Workforce Services (DWS) data show that in Utah, women only represent 19% of the computer/engineering science field, and that nationally women only represent 28% of the entire technological workforce (2019). This research suggests that our society needs to make science a priority for preschool children (especially girls) so that girls might have more positive outlooks on science which may contribute to more women entering the science and STEM professions as adults (Leibham et al., 2013).

The integration of science learning may be especially important for children in Utah. The state of Utah has been called an economic powerhouse for technological prowess, and is quickly becoming a center for businesses based in STEM fields (Hanewicz & Thackeray, 2019). *Forbes* rated Utah second in the United States for "2018 Best States for Business, and the city of Provo, Utah was ranked first in the category of "Highest STEM Employment Growth" (*Best States for Business*, 2018; McCann, 2019).

Having a population of skilled and diverse workers is needed to continue these achievements in STEM, with on aspect of diversity being female workers.

Preschool is an important time for children because they are developmentally ready for the science concepts. In addition, teaching science promotes many different areas of learning at once and increases the chance of having positive long-term benefits for children as future learners (Clements & Sarama, 2016; Greenfield et al., 2009; Leibham et al., 2013; NCR, 2007).

Preschool Demographics

For this study, preschool demographics consist of preschool type and the demographics of children served. The demographics of the preschool may play a role in how much overall learning and academic success is taking place in various classrooms (Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Zhai, Brooks-Gunn, & Waldfogel, 2014).

Most studies often delineate child care arrangements into four mutually exclusive categories of Head Start, other center-based care, home-based care (relative/nonrelative), or parental care (Levine Coley, Votruba-Drzal, Miller, & Koury, 2013; Zhai et al., 2014). The literature is somewhat inconsistent when it comes to the academic differences between child care arrangements. Zhai et al. (2014) used data from 3,790 children who participated in the longitudinal Head Start Impact Study to better understand the comparison among different preschool and child care types. Using a randomized experimental design with principal matching scores to examine the difference in child outcomes among child care arrangements, they found that the most significant difference came from comparing Head Start to parental or relative/nonrelative child care. Children who participated in Head Start experienced more benefits (e.g. fewer behavioral problems and higher school readiness) compared to parental or relative/nonrelative child care, but interestingly, no significant differences were found between Head Start compared to other centers. Another study done by Fitzpatrick et al. (2014) compared the difference between wealthy private preschool centers and needs-based centers in New York City, with a sample of 226 children. There were striking differences with disadvantaged children scoring lower on executive functioning than the children attending the private preschool centers. Lower executive functioning was in turn related to lower overall school readiness scores (Fitzpatrick et al., 2014). While the literature is extremely sparse regarding the effects of preschool type on science outcomes, there is a connection between executive functioning and school readiness with science (Nayfeld et al., 2013), as well as teacher education/quality with science (Gerde, Pierce, Lee, & Van Egeren 2018; Zinsser, Christensen, & Torres, 2016). Universities around the US sometimes offer child development lab preschool programs which often involve student-teachers and undergraduates, which I believed could be an interesting difference in comparison to the other types of preschools for the purposes of this study. For this study I looked at Head Starts, other private center-based care, university child development lab preschools, and home-based care. Since parental care fundamentally differs in teaching, structure, and other activities, I did not include this type of child care arrangement for this study.

The demographics of children served in preschool classrooms can make a difference for science outcomes as well. Literature shows that socioeconomic status

(SES) levels plays a role in preschool child's opportunity to learn (Duncan, Magnuson, & Votruba-Drzal, 2014; Fitzpatrick, et al., 2014; Piasta et al., 2014). Children from low SES families receive significantly fewer minutes of science learning opportunities in their classrooms, regardless of preschool type (Piasta et al., 2014). This conclusion was reached after pre and post intervention observations were made on a variety of classroom types for 65 teachers in Ohio (Piasta et al., 2014).

Current Attitudes and Perceptions

Part of Badura's Social Cognitive Theory states that people will perform better when they feel higher levels of self-efficacy and have been positively reinforced (Bandura, 2018). One slowly growing area of research in relation to preschool science teaching is the role of teacher attitudes and perceptions (Pendergast et al., 2017). It is likely that teachers will teach in a variety of circumstances, and their attitudes and perceptions might be a significant factor influencing the amount of science teaching that occurs. More information examining this potential link is needed.

There seems to be a predominant theme of discomfort, or negative feelings toward preschool science (Nayfeld et al., 2013; Pendergast et al., 2017; Sundberg & Ottander, 2013). To start, it is possible teachers are not receiving enough science specific education at pre-service. For example, in a study conducted in Georgia, 112 preschool teachers reported that science is not emphasized in most early education preparation programs, college classes, or practicums which leaves teachers feeling "unprepared, anxious, or apprehensive" (Pendergast et al., 2017, p. 50). It seems these preservice concerns can, in some cases, be remedied by explicit teaching by lead teachers of practicum experiences, or with more professional development (Akerson et al., 2010). After receiving their pre-service education, preschool teachers in Sweden reported that teaching science was "awkward" when they started, and 54% of first-year student teachers reported they did not provide any science activities (Sundberg & Ottander, 2013). These studies suggest that teacher attitudes are correlated with teacher practices in regards to the amount of time spent on science. Other fears teachers may experience might stem from the feeling that they do not know how to do the science activities correctly, or that the students would ask more difficult questions than they knew answers to, resulting in feelings of teacher inadequacy (Pendergast et al., 2017).

There are also some cultural barriers that may be at play and contribute to teachers' attitudes and perceptions, as well as teaching practices. In a related topic using qualitative methods, teachers' beliefs that math education was age appropriate was associated with how the preschool children learned math (Clements & Sarama, 2016). Specifically, teachers teach less math if they did not think children were developmentally ready for the subject. Those teachers also believed that "math achievement largely depends on native ability" (Clements & Sarama, 2016, p. 87). The idea that children are born with a natural tendency to be better at science or math than others is unfounded and leads to incorrect practices of less science or math in the classroom (Clements & Sarama, 2016). From interviews and questionnaires, the sample of Swedish teachers mentioned before stated that they also felt that teaching science in preschool is too early. They expressed that they feared teaching science to children so young seemed too similar to grade school culture, and they expressed a desire to protect young children from this culture (Sundberg & Ottander, 2013). However, research suggests that even at a few months of age, infants can begin to understand that objects move when touched, or that objects need support from falling which is the beginning of science concepts (Clements & Sarama, 2016). Clements and Sarama (2016) have suggested that all preschoolers, regardless of SES, race, social stance, or other demographic differences; begin to explore shapes, colors, counting, and spatial relations. This research suggests that most typically developing children are born with the same propensity for exploration.

In contrast to previous negative research, Pendergast et al. (2017) were pleasantly surprised with the positively reported attitudes and perceptions of science from their research with preschool teachers. Their study used the Preschool Teacher Attitudes and Beliefs Toward Science, and found that 97% of the teachers included in their sample indicated they “strongly agreed” to statements of enjoying teaching science, with the majority of their sample reporting that they perceived science positively (Pendergast et al., 2017). However, these teachers also reported low levels of comfort with the use of science tools (e.g. rulers, scales, magnets, microscopes.). The researchers of an intervention study that involved active teacher-led instruction about science materials suggest that simply having science tools available in an area of the classroom is not enough and children learn significantly more when children are able to actively explore science tools with teachers’ guidance (Nayfeld, Brenneman, & Gelman, 2011).

While the recent study from Pendergast et al. (2017) is encouraging, overall it appears that teacher attitudes and perceptions of science are still quite negative, and the majority of teachers associate many different fears and worries with teaching science. More information is needed to understand what teachers are still facing, and what can be done to promote more science teaching in preschool classrooms.

Teacher Demographics

Teacher demographics typically include years of experience and highest level of education obtained. These demographics may influence the amount of preschool science taught, although the level of significance has been controversial.

In terms of education level, research suggests associations between higher quality of teaching, and different science delivery methods, but no direct associations with the amount of science included in the classroom (Erden & Sonmez, 2011; Zhai et al., 2014). Not all preschool teachers are required to hold the same degree which can lead to a large degree of variability in education levels. Interestingly, in Turkey, Erden and Sonmez (2011), found that education level was not associated with science comfort overall, but that higher education levels were significantly related to science delivery methods, with teachers with Master's degrees significantly more diverse in their means of delivering scientific concepts. A replication of this study in a US population could inform professional development practices in the U.S.

Teacher education often occurs during in-service teaching through professional development opportunities. Inadequate professional development for teachers is another barrier to science teaching identified in recent studies (Clements & Sarama, 2016). Focusing on an increase in preschool teachers' understanding and implementation skills through professional development can increase the likelihood of science teaching (Piasta et al., 2014). The more professional development teachers are exposed to in regards to science and math, the more likely they are to enjoy science activities and feel more comfortable with the topics. These benefits are likely to contribute to better academic outcomes for the students in their classes (Piasta et al., 2014). Whittaker et al.

(2016), who implemented an intervention based on curricula and professional development, found that the combination of specified math and science curricula, along with professional development education increased the facilitation of math and scientific thinking in preschool classrooms.

Recent research suggests that teaching experience and education are related to teacher self-efficacy, which in turn is related to teaching science (Hu, Fan, Yang, & Neitzel, 2017; Lippard, Lamm, Tank, & Choi, 2018; Zinsser et al., 2016). Self-efficacy has been shown to be related to teachers' education levels or teaching experience (Klassen & Chiu, 2010). However, recent studies suggest a host of factors that can indirectly be related to the amount of science in the classroom (Erden & Sonmez, 2011; Gerde et al., 2018; Zinsser et al., 2016). From Bandura's Social Cognitive Theory, we are reminded that the better teachers feel about something the more likely they are to engage in that practice. The results from a recent study conducted in China suggested teacher education and experience were predictors of teachers' attitudes and beliefs. In addition, teacher practices and knowledge were mediated by teachers' beliefs (Hu et al., 2017). Interview and observational data gathered from hundreds of Head Start teachers, provide additional support for the finding that education and experience cannot always predict science amounts, but that it can influence the quality and technique of instruction for teaching science (Gerde et al., 2018; Zinsser et al., 2016). For 498 Head Start teachers throughout the nation, Zinsser et al. (2016) found that quality and technique skills were associated with comfort with science, better teacher-child relationships (e.g. warmth and child engagement strategies), less teacher stress, more mindfulness, and more job satisfaction. In contrast, Gerde et al. (2018), analyzed data from 67 Head Start teachers and did not find an association between education or experience with self-efficacy when compared to their control group. They did, however, find an association between teacher self-efficacy and the amount of math and science instruction that teachers provided in their classrooms. Teachers reported being much more confident in their teaching ability with literacy than math or science, and would subsequently teach less math and science. These two studies of teacher self-efficacy suggest that more research is needed to understand the role of teaching experience, education, and teacher self-efficacy as predictors for teaching science.

There also appears to be a link between self-efficacy and years of experience for most teachers. In a study of 1,430 teachers, three types of self-efficacy (teaching strategies, classroom management and confidence in student engagement) were positively correlated with years of experience, rising steadily until about 23 years of teaching experience (Klassen & Chiu, 2010). After about 23 years of teaching, all three types of teacher efficacy slowly declined. In the US, the average amount of teaching experience is about 14 years, which means most teachers should experience a fair amount of teaching efficacy, but would not attain the highest peak that teachers with 23 years of experience might. Relatedly, Erden and Sonmez (2011) discovered that new teachers, with less than one year of teaching experience, have the highest positive attitudes toward teaching science specifically, especially when they have recently come from an educational program that regards science as developmentally appropriate.

In summary, these studies suggest that teacher education and experience play an important role in the quality of a child's preschool experience. In addition, teacher education and experience may not directly correlate with the amount of science in a preschool classroom, but that these factors can play an indirect role through self-efficacy as these factors influence self-efficacy which is associated with the likelihood of science in the classroom.

Current Study

Considering the empirical literature on the subject of science, science teaching is important for preschool-aged children. Understanding the teacher and classroom predictors of preschool science is a salient research question to address right now because science education is critical for children. The focus of this study is to increase the understanding of the role that teacher characteristics, teacher demographics, and preschool demographics play in regards to the amount of science time in classrooms.

The current study will explore a combination of science predictors in a way that has not been addressed in the literature. Some studies have been done in the states of Ohio, North Carolina, New York, or Georgia, but, to my knowledge, no studies of preschool science predictors have been done in the state of Utah. Given the thriving future of STEM employment specifically in Utah, the need for diversity in the workplace, and the importance of introducing science to young children, a greater understanding of teacher beliefs and attitudes about preschool science, in addition to how these factors relate to the amount of science in preschool classroom, could be useful for researchers and practitioners alike.

Another gap in the literature that this study will address is the variety of types of preschools investigated. Many of the existing research studies focus mostly on Head Start centers, whereas the current study will investigate four different types of preschool arrangements, including head start, home-based arrangements, other private preschools, and university child development laboratories. Different types of preschool arrangements may play a role in how and what aspects of science are being taught, as each location may have different standards and requirements. Including different types of centers can give us a more representative sample of teachers as well. I hope by including a diverse sample of teachers that I may discover some of the predictors that influence preschool teachers' implementation of science activities in their classroom. Guided by Social Cognitive Theory and past empirical research, I hypothesize that:

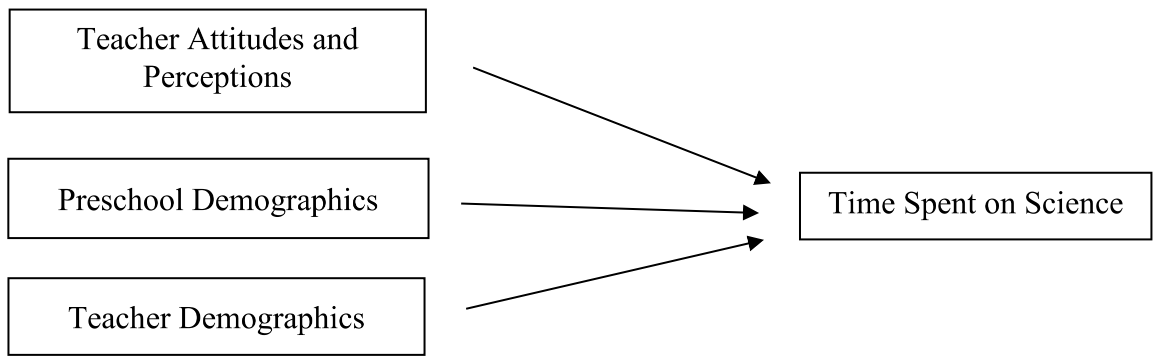
Hypothesis 1: Preschool teachers will vary greatly on education level, years of experience, and age. The majority of the preschool teachers in this sample will be female and will report low levels of comfort, high levels of anxiety, and minimal time teaching science.

Hypothesis 2: Teachers with higher levels of education and more years of experience will report greater comfort, more positive attitudes and more science time than teachers with less education and experience.

Hypothesis 3: Teacher attitudes and comfort level contribute to the amount of time teachers spend teaching science above and beyond teacher or classroom demographics.

Hypothesis 4: Teachers will describe a variety of feelings, benefits, barriers, and activities involved with teaching preschool science.

Figure 1. Hypothesized relations among key variables. –



CHAPTER III

METHODS

Participants

The sample of 122 teachers for this study included teachers who developed and implemented lesson plans and who taught or were engaged with the children for at least two hours of instructional time per day. The teachers could teach from home-based preschools, Head Starts, University child development lab preschools or other private preschools. To be included, participants were required to be at least 18 years old, have at least five children enrolled in their classroom, and speak English. The children in their classrooms ranged from ages 3 to 6 years old. Based on G*Power Analysis software, for a medium to large effect size, I needed a sample size of 111 teachers. I had sufficient power to detect if any of the independent variables made a medium to large amount of difference on the dependent variable.

For this mixed-methods study, most potential participants were identified through Utah State University's (USU) Care About Childcare online database of in-home providers, center-based care, and other private preschools throughout the state of Utah. I sent out 641 emails using emails collected from that database, and 27 emails were found using the Google search engine for regional Head Start directors and directors of university-run preschool or child care facilities in Utah. Those directors were asked to send out an email invitation to participate in this study through their listserv of teachers in their areas. Snowball sampling was also used to encourage teachers who have agreed to participate in the study to also invite their colleagues to participate.

Four counties in the USU CAC database did not list a single child care provider, but other counties had anywhere from one (Garfield and Wayne Counties) to 566 (Salt Lake County). For counties that had over 90 programs I randomly selected 45 center child care providers and 45 family care providers to email the study information to. Each county that had under 90, I elected to email all the providers available, with the majority being family care providers.

The email included information about the study, as well as a link to the anonymous online survey, housed within Qualtrics, which is an online survey software platform. This survey contained a Letter of Information approved by the Institutional Review Board, under Protocol #9849. The Qualtrics survey then included open-ended questions first so that teachers would not be led by the later questions on the survey. Questionnaires related to attitudes and beliefs about science were the Preschool Teacher Attitudes and Beliefs Toward Science Teaching Questionnaire (PTABS; Maier, Greenfield, & Bulotsky-Shearer, 2013) and the Dimensions of Attitude toward Science questionnaire (DAS; van Aalderen-Smeets & Walma van der Molen, 2013). Next were the questions about how many minutes are usually spent on science in their classrooms weekly, and lastly, a demographic questionnaire. The open-ended questions were about the overview of teaching science in their classrooms. The teachers were asked to respond within two weeks and a reminder email was sent out after one week.

As an incentive and reward for their time, a science e-book written by Donna Blaylock (myself) and an electronic Amazon gift card worth $10 were given to each participant. Once teachers completed the Qualtrics survey, the last page had a link to a separate survey where they filled out their contact information (name, email and phone number) which I used to send them their incentives.

Of the 668 email invitations to participants, five were returned as bounce backs, seven reported they did not believe they qualified for the study, 55 surveys were partially completed or contained missing data, and 122 participants finished the entire survey, which provided a 25% return rate.

Measures

Teacher Characteristics

Two measures were used to assess teacher characteristics, the PTABS and the DAS. The PTABS (Maier et al., 2013) assesses the attitudes and perceptions that the teachers have and has been shown to be a reliable instrument with an overall Cronbach's alpha of .91 (Maier et al., 2013). The three factors measured include: teacher comfort (Cronbach's alpha = .89), perceived child benefit (Cronbach's alpha = .85), and challenges (Cronbach's alpha = .71). Cronbach's alphas for my sample were slightly lower, with the overall Cronbach's alpha of .73, teacher comfort .83, child benefit .83, and teacher challenges .74. There were 35 items overall, with 17 for the subscale of comfort, 11 for perceived child benefit, and 7 for challenges for teaching science. Sample items for comfort include: "I feel comfortable planning and demonstrating classroom activities related to life science topics (e.g., living things, plants, animals)," "I make an effort to include some science activities throughout the week," and "I discuss ideas and issues of science teaching with other teachers." Sample items for perceived child benefit include: "It is important for my classroom to have a science area that can be freely explored by children", "Young children are curious about scientific concepts and phenomena," and "Science-related activities help improve preschoolers' math skills." Items on the challenges subscale include: "Planning and demonstrating hands-on science activities is a difficult task," "I am afraid that children may ask me a question about scientific principles or phenomena that I cannot answer", and "Given other demands, there is not enough time in a day to teach science." Each item was scored on a 5-point Likert scale ranging from 1 to 5, where 1 is *Strongly Disagree*, and 5 is *Strongly Agree*. High scores suggested that teachers identify that item as very important to them. Negatively worded questions were reverse scored and items were summed for a total score. In addition, the subscales were created by summing the individual items for each subscale.

Part of the Dimensions of Attitude toward Science questionnaire (van Aalderen-Smeets & Walma van der Molen, 2013), which measures the in-service attitudes of teachers toward science, was administered to teachers through the online survey. I adjusted the DAS down from seven factors to the three most relevant factors for this study. I felt the additional three DAS factors would offer insight to the questions already asked in the PTABS. The DAS was developed in the Netherlands and was designed for primary teachers. Primary teachers in the Netherlands teach children who are ages four to 12. This measure was still useful as the majority of preschool children fall between the ages of 3 and 6 years old. The original seven factors included: relevance of teaching science, difficulty of teaching science, gender-stereotypical beliefs regarding teaching science, enjoyment in teaching science, anxiety in teaching science self-efficacy, and perceived dependence on context. This study used the scales of anxiety in teaching science (Cronbach's alpha = .74), difficulty of teaching science (Cronbach's alpha = .85), and perceived dependence on contextual factors (Cronbach's alpha = .93; van Aalderen-Smeets & Walma van der Molen, 2013). Cronbach's alphas were computed for each subscale, as the subscales were too different to have a valid overall score. The Cronbach's alphas for the subscales for the current sample are as follows: anxiety in teaching science (Cronbach's alpha = .96), difficulty of teaching science (Cronbach's alpha = .93), and perceived dependence on context factors (Cronbach's alpha = .72). The anxiety subscale was measured by four items, while difficulty and context subscales were measured with three items each. Sample items for these factors include: "I feel nervous while teaching science" (from the anxiety subscale), "I think that teachers find the topics that come up complicated" (from the difficulty subscale), and "For me, the support of my colleagues and the school is decisive for whether or not I will teach science in class" (from the context subscale). Each item was again scored on a 5-point Likert scale ranging from 1 to 5, where 1 is *Strongly Disagree*, and 5 is *Strongly Agree*.

I also included five qualitative questions about the feelings, challenges, solutions, and current activities teachers occurring while teaching science. These questions were posed at the beginning of the Qualtrics survey so that the later answers would not sway their results. The questions were as follows, "What are some of your feelings with teaching science to preschool children," "What are some challenges you experience when trying to teach science," and "What helps you overcome these challenges; what would help you in the future." These results will be analyzed for themes.

Preschool and Teacher Demographics

For assessing the preschool and teacher demographics of this sample, I posed multiple choice questions in the Qualtrics survey. Demographic information collected included age, years of experience, highest level of education completed, percentage of children in their classroom who qualified for free or reduced lunch, and what type of preschool they taught at.

Science Time

To measure the dependent variable of time spent in science each day, I used two different methods. First, I used part of the Dimensions of Attitudes in-service measure to assess how often teachers were teaching science. This section of the DAS consisted of seven 5-point Likert scale questions, that asked about the frequency of science activities occurring in their classrooms. Sample questions include, "How often do you carry out an investigation together with your students," or "How often are your students allowed to genuinely carry out an investigation or try to discover something without following a pre-set procedure" (van Aalderen-Smeets & Walma van der Molen, 2013). The options in the 5-point Likert scale ranged from "*seldom or never,*" "*couple times a year,*" "*1-3 times a month*," "*weekly,*" and "*daily.*" The overall Cronbach's alpha for my sample was .78 for this in-service measure, while the Cronbach's alpha from van Aalderen-Smeets and Walma van der Molen (2013) was .84.

The second way I measured the amount of science, was with an open-ended question about how many minutes they formally taught science per day. Follow-up questions asking for a description of the activities were also included.

Data Analysis

Once the data was collected, I first cleaned the data to look for missing data, errors, or outliers. The items on the PTABS and DAS within the questionnaires that were negatively worded were reverse coded. Next, participant demographic statistics were examined for means, standard deviations, skewness and kurtosis. Cronbach's alphas for the PTABS and DAS subscales were calculated from the study sample to examine the internal validity. A chi-squared test was run to understand the differences between types of preschool and the categorical demographics. Bivariate correlations were run to examine associations among the variables. Once those were determined, they were entered into a hierarchical regression analysis. All analyses were conducted using R Studio, version 1.1.447.

CHAPTER IV

RESULTS

In this chapter, the results for the four research questions will be reported. For this study, a p-value of .05 or less was used as the cutoff point to determine statistical significance. The outline for this section will follow the order outlined by the research questions in Chapter II.

Research Question 1: What are the characteristics of preschool teachers and their preschool classrooms from various preschool types in Utah?

All variables were examined for potential skewness and kurtosis. Since the demographic data was collected as categorical data, viewing percentages and counts is the best way to view normality, available in Table 1. Using less than -1 or greater than 1 as a rule of thumb, the variables of PTABS benefit (skewness = -1.31) and DAS anxiety (skewness = 1.11) were found to be highly skewed (SPC for Excel, 2016). PTABS comfort was moderately skewed (skewness = -.78), and all other variables were approximately symmetrical. Kurtosis for all variables were roughly symmetrical as well (between the bounds of -3 and 3), with the exception of the gender variable, which was unsurprisingly highly irregular (kurtosis = 115.05; (SPC for Excel, 2016).

Teacher Characteristics

An overview of teacher demographic characteristics is presented in Table 1 and Table 2. The vast majority of participating preschool teachers were women (99%), and most teachers were 44 years or more (31%), followed by 34-37 (12.3%) and 26-29 years old (also 12.3%). More than one-third of teachers reported 10 or more years of experience (38%) and almost one-quarter of teachers reported 1 to 3 years of experience (24.6%). When asked how much education they had completed, 44.3% reported having obtained a Child Development Associate (CDA) or other associate's degree, and 39.3% held bachelor's degrees.

Table 1

Demographic Characteristics of Participants

	Percentage of Category Totals
Age	
18-21 years old	5.7%
22-25	6.6
26-29	12.3
30-33	9.8
34-37	12.3
37-40	10.7
41-44	11.5
44+	31.1
Sex	
Female	99.2
Male	0
Other (Reported as Non-binary)	0.8
Years of Experience	
Less than 1 year	9
1-3	24.6
4-6	20.5
7-9	7.4
10+	38.5
Level of Education	
Less than a High School Diploma	0
High School Diploma	12.3
Child Development Associate (CDA)	44.3
Bachelor's Degree	39.3
Master's Degree	3.3
Doctoral Degree	0.8
Type of Preschool	
Home-Based Preschool	27.9
Head Start	32
University Child Development Lab	16.4
Other Private Preschool	23.8
Percentage of Children who Qualify for Free or Reduced Lunch	
0-9%	28.7
10-14	13.9
25-49	9
50-74	9.9
75-100	38.5

Teacher Attitudes and Comfort Levels

The means and standard deviations for the time spent on science, and PTABS and DAS subscales are summarized in Table 2. The mean for time spent on science suggests that the frequency of science activities occurs "1-3 times a month" The mean rating for the PTABS subscale of teacher comfort suggests that teachers "somewhat agree" with the items. The mean rating for DAS subscale of anxiety suggests that teachers "somewhat disagree" with the items. Overall, teacher attitudes reported to be in agreeance with the positive aspects of teaching science (comfort and benefit), also reporting minimal challenges, anxiety, difficulty, or contextual issues.

Table 2

Means and Standard Deviation of Time, and PTABS and DAS Subscales

Variable/Subscale	Mean	SD
Time Total	3.0	.7
PTABS		
Teacher Comfort	4.2	.5
Child Benefit	4.6	.4
Challenges	2.7	.8
DAS		
Anxiety	1.9	1.0
Difficulty	2.8	1.1
Contextual Factors	2.7	1.0

Note. N = 122. Means and standard deviations based on a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5)

Classroom Characteristics

As shown in Table 1, all types of preschools were represented, with 32% of the sample teaching at Head Starts, 27.9% at home-based preschools, 23% at other private preschools, and 16.4% at university child development laboratories. The percentage of children in their classrooms who qualified for free or reduced lunches was a bimodal distribution, with over one-third (38.5%) of teachers reporting 75-100% of their class to qualify and more than one-quarter (28.7%) reporting less than 9% of their class qualify.

Differences among Program Types

Chi-square goodness of fit tests were calculated to determine if the teacher and classroom frequencies were different than expected among the four program types. These results are presented in Table 3. One of the assumptions with chi-squared tests is that each of the variables are expected to contain at least five counts per subcategory, so eight of the smallest subcategories were combined. The age subcategories of "18-21 years old" and "21-25 years old" were combine into an "18-25 years old" subcategory, and the years of experience subcategories of "Less than 1 year of experience" and "1-3 years of experience" were also combined. The level of education subcategory of "Less than high school diploma" was combined with "High school diploma," and "Master's degree" was combined with "Doctoral degree."

The amount of time spent in science did not differ from what would be expected among the four program types. The time variable was an interval level of measurement, so a one-way analysis of variance was performed. The type of preschools did not show an effect on science, $F\,(3,122) = 2, p = .12$, in the ANOVA, indicating that all program types were comparable on the time spent teaching science. The remaining variables, however, were not equally distributed among the program types as shown with the chi-squared goodness of fit tests. As presented in Table 3, the age of participants was different than expected across program types, $\chi^2\,(21, \text{N} = 122) = 36.27, p < .01$).

When looking at the frequencies of each subcategory, almost half (47.1%) of home-based preschool teachers reported being over the age of 44 years old. Head start teachers were also more likely to be older, with 46.1% reporting to be 41 years or older. Teachers in the university child development labs, were quite different, with 60% under the age of 29 years old. Interestingly, other private preschool teachers were split, with 27.6% in the 44 years or older category, 17.2% in the 30-33 years old category, and 17.2% in the 18-25 year old category.

The years of experience also differed by the types of preschools, χ^2 (9, N = 122) = 22.43, $p < .01$. The majority of home-based teachers (61.8%) reported more than 10 years of experience, while head start teachers showed a split between 10 or more years (38.5%) and 0-3 years (28.2%). Unsurprisingly, 60% of university CDL teachers reported 0-3 years of experience, which is fitting since many teachers in that setting also reported to be quite young. Almost half (48.3%) of other private teachers reported to have 0-3 years of experience, along with 24.1% in the 10 or more years of experience category.

The goodness-of-fit results, χ^2 (9, N = 122) = 21.72, p = .01, indicate statistical differences in the level of education and type of preschool as well. A little over half of home-based teachers held CDA's or other associate's degrees (52.9%), and Head Start teachers almost entirely held CDA's or bachelor's degrees (53.8% and 43.6%, respectively). More than half (60%) of university CDL teachers reported having bachelor's degrees, and other private preschool teachers were split between CDA and Bachelor's degrees (44.8% and 37.9%, respectively).

Lastly, the reported percentage of children who qualify for free or reduced lunch was not equally distributed in the sample, $\chi^2 (12, N = 122) = 84.79, p < .001$). Almost half (47.1%) of home-based preschool teachers reported few if any of the children in their classroom to be eligible for free and reduced lunch. In contrast, almost all (92.3%) of Head Start teachers reported the majority (75-100%) of children in their classrooms to be eligible for free and reduced lunch. Exactly half of university CDL teachers reported less than 9% of children in their classroom to be eligible for free and reduced lunch, with an additional quarter of university CDL teachers reporting to have between 25-49% of the children in their classroom to be eligible for free and reduced lunch. This category was another that other private preschools were divided in, with over one-fourth (27.8%) of teachers reporting only a small portion (between 0-9%) of their children to be eligible to free and reduced lunch. Together these results indicate that the four types of preschools differ significantly on the age, years of experience, and education of the preschool teachers. They also differ on the number of children attending their preschool who are eligible for free and reduced lunch.

Table 3

Chi-Squared Goodness-of-Fit Analysis of the Types of Preschools in Relation to Demographics

	Types of Preschools				
	Home-Based Preschool	Head Start	University CDL	Other Private	Chi-Square Tests for Goodness of Fit
	n = 34	n = 39	n = 20	n = 29	
Age Observed Frequencies					χ^2 (21) = 36.27
18-25 years old	1 (2.9%)	2 (5.1)	7 (35)	5 (17.2)	*p* = *0.007*
26-29	3 (8.8)	5 (12.8)	5 (25)	2 (6.9)	*N* = 122
30-33	3 (8.8)	3 (7.7)	1 (5)	5 (17.2)	
30-34	3 (8.8)	7 (17.9)	1 (5)	4 (13.8)	
37-40	7 (20.6)	4 (10.3)	1 (5)	1 (3.4)	
41-44	1 (2.9)	8 (20.5)	1 (5)	4 (13.8)	
44+	16 (47.1)	10 (25.6)	4 (20)	8 (27.6)	
Age Expected Frequency (prop.)	30.5 (17.4)	30.5 (17.4)	30.5 (17.4)	30.5 (17.4)	
Years of Experience Observed Frequencies					χ^2 (9) = 22.43
0-3 years	4 (11.8)	11 (28.2)	12 (60)	14 (48.3)	*p* = 0.008
4-6	7 (20.6)	8 (20.5)	4 (20)	6 (20.7)	*N* = 122
7-9	2 (5.9)	5 (12.8)	0 (0)	2 (6.9)	
10+	21 (61.8)	15 (38.5)	4 (20)	7 (24.1)	
Experience Expected Frequency (prop.)	30.5 (30.4)	30.5 (30.4)	30.5 (30.4)	30.5 (30.4)	
Level of Education Observed Frequencies					χ^2 (9) = 21.72
High School Diploma or Less	6 (17.6)	0 (0)	4 (20)	5 (17.2)	*p* = 0.01
CDA or Associates	18 (52.9)	21 (53.8)	2 (10)	13 (44.8)	*N* = 122
Bachelor's	8 (23.5)	17 (43.6)	12 (60)	11 (37.9)	
Graduate Degrees	2 (5.9)	1 (2.6)	2 (10)	0 (0)	
Education Expected Frequency (prop.)	30.5 (30.4)	30.5 (30.4)	30.5 (30.4)	30.5 (30.4)	
Free/Red. Lunch Observed Frequencies					χ^2 (12) = 84.79
0-9%	16 (47.1)	1 (2.6)	10 (50)	8 (27.6)	*p* = <.001
10-24%	8 (23.5)	0 (0)	2 (10)	7 (24.1)	*N* = 122
25-49%	2 (5.9)	0 (0)	5 (25)	4 (13.8)	
50-74%	3 (8.8)	2 (5.1)	1 (5)	6 (20.7)	
75-100%	5 (14.7)	36 (92.3)	2 (10)	4 (13.8)	
Free/Red. Lunch Expected Frequency (prop.)	30.5 (24.4)	30.5 (24.4)	30.5 (24.4)	30.5 (24.4)	

Note. *N* = 122. Numbers in parentheses are proportions. Freq. = Frequency, Free/Red. Lunch = Percentage of children who qualify for free or reduced lunch, and prop. = proportion.

Research Question 2: What are the associations among teacher and classroom characteristics?

Pearson Product-Moment correlations were employed to examine the potential association among teacher and classroom characteristics to answer research question two. Table 4 contains the bivariate correlations among the demographic variables along with the PTABS subscales, Table 5 shows the results for the bivariate correlations among the demographics with the DAS subscales, and Table 6 shows the correlations between the PTABS and DAS subscales themselves.

From the data in Table 4, one can see that there are several significant associations among the variables. Time and the level of education, as well as each of the PTABS subscales were moderately correlated, while age and years of experience have a large correlation, r (120) = .61, $p < .001$. Not surprisingly, level of education has a negative association with the PTABS challenges subscale, although this correlation is moderate, r (120) = -.25, $p < .01$. PTABS comfort and PTABS child benefit were largely correlated, r (120) = .59, $p < .001$, while PTABS comfort and PTABS challenges showed a negative and moderate association, r (120) = -.50, $p < .001$.

These results suggest that teachers who have higher levels of education, higher levels of comfort, and believe science to be of great benefit to their students, report spending more time on science. Unsurprisingly, teachers who report experiencing science as challenging report spending less time on science.

Table 4

Bivariate Correlations With the Demographics and PTABS Subscales

Variables	1	2	3	4	5	6	7
1. Time Total	-						
2. Age	-.10	-					
3. Years of Experience	-.01	.61***	-				
4. Level of Education	.23**	.06	.07	-			
5. Free/Reduced Lunch	-.03	.12	.04	.00	-		
6. PTABS Comfort	.50***	.13	.14	.10	.03	-	
7. PTABS Benefit	.40***	.01	-.02	.17	.09	.59***	-
8. PTABS Challenges	-.39***	-.08	-.03	-.25**	.03	-.50***	-.19

Note. $N = 122$. $^{**}p < .01$, $^{***}p < .001$

As shown in Table 5, there were again numerous significant correlations among the variables. Time spent on science was negatively correlated with each subscale, although each correlation was weak with correlations ranging from -.23 to -.26. In addition, age, percentage of free and reduced lunch, anxiety and difficulty teaching science were all weakly correlated with the contextual subscale with correlation coefficients ranging from .20 to .30. The DAS context subscale items asked if the availability of ready-to-use existing packages of material, science teaching methods, or supportive colleagues were considered to be essential. These results suggest that older teachers are less likely to be influenced by the presence of contextual factors than younger teachers and teachers who report more children who qualify for free and reduced lunch rely more heavily on contextual factors than teachers with fewer children eligible for free and reduced lunch. The negative correlation with time spent on science, $r\ (120) = -.26$, $p < .01$, for the context variable indicates that teachers feel that that these contextual factors are essential for their teaching, which is further evidenced with the positive correlations with anxiety, $r\ (120) = .29$, $p < .00$, and difficulty, $r\ (120) = .30$, $p <$

.001. Unsurprisingly, anxiety was also positively correlated with difficulty, r (120) = .44, p <.001. The most striking result to emerge from the data in Table 5, is that teachers who report greater anxiety or difficulty also report spending less time on science, and report that contextual factors influence their teaching practices.

Table 5

Bivariate Correlations With the Demographics and DAS Subscales

Variables	1	2	3	4	5	6	7
1. Time Total	-						
2. Age	-.10	-					
3. Years of Experience	-.01	.61***	-				
4. Level of Education	.23**	.06	.07	-			
5. Free/Reduced Lunch	-.03	.12	.04	.00	-		
6. DAS Anxiety	-.26**	-.05	-.09	-.08	.03	-	
7. DAS Difficulty	-.23**	-.17	-.12	.06	-.13	.44***	-
8. DAS Context	-.26**	-.20*	-.09	.00	.20*	.29***	.30***

Note. $N = 122$. $^{**}p < .01$, $^{***}p < .001$

In Table 6, the correlations among the PTABS and DAS are reported. Most of the subscales are significantly correlated, with the exception of PTABS benefit with anxiety, difficulty, or context. The strongest correlations are between PTABS comfort with PTABS child benefits, r (120) = .59, p <.001, followed by PTABS challenges with DAS anxiety, r (120) = .55, p <.001. Another interesting observation is that PTABS comfort and DAS context are negatively correlated, r (120) = -.29, p < .001, suggesting that teachers who report more comfort with teaching science, also report being less influenced by adverse contextual issues, like unsupportive peers. Furthermore, the rest of the PTABS and DAS subscales are highly correlated in the direction that would be expected.

Together, these results provide important insight into the associations among the two different measures with time spent on science. All six of the measured teacher attitudes are correlated with time, either positively (comfort and benefit), or negatively (challenges, anxiety, difficulty and contextual factors being negatively correlated). The numerous correlations among the subscales suggest that several of the variables are measuring similar attitudes.

Table 6

Bivariate Correlations With the PTABS and DAS Subscales

Variables	1	2	3	4	5	6
1. Time Total	-					
2. PTABS Comfort	.50***	-				
3. PTABS Benefit	.40***	.59***	-			
4. PTABS Challenges	-.39***	-.50***	-.19*	-		
5. DAS Anxiety	-.26**	-.48***	-.17	.55***	-	
6. DAS Difficulty	-.23**	-.29***	-.10	.40***	.44***	-
7. DAS Context	-.26**	-.29***	-.04	.41***	.29***	.30***

Note. $N = 122$. ** $p < .01$, *** $p < .001$

Research Question 3: Do teacher attitudes and comfort levels contribute to the amount of time teachers spend teaching science above and beyond teacher demographics and classroom demographics?

A hierarchical linear regression model (see Table 7) was tested to determine if teacher or classroom characteristics uniquely contributed to time spent on science. These analyses were conducted to examine whether teacher attitudes would contribute to science time above and beyond classroom characteristics. The correlations presented in question two guided variable selection for the regression models to select the strongest correlates while still minimizing multicollinearity. Teacher and classroom variables that were significantly correlated with the outcome (dependent) variable of the amount of time teachers spend teaching science were included. Correlations among potential predictor variables were examined for multicollinearity. When two variables were highly correlated then the variable with the highest correlation with the outcome variable was included. For instance, PTABS comfort and PTABS child benefit were highly correlated, r (120) = .59, $p < .001$, but PTABS comfort had a higher correlation with time spent on science, r (120) = .50, $p < .001$, so PTABS comfort was included in the second step of the hierarchical linear regression model. PTABS challenges and DAS anxiety were also highly correlated, with PTABS challenges having the higher correlation with time, r (120) = -.39, $p < .001$. Thus, the subscales of PTABS comfort, PTABS challenges, DAS difficulty, and DAS context were included in the hierarchical linear regression model.

To create the most parsimonious model for the hierarchical linear regression, I used the most relevant teacher and classroom predictor variables. The variables in the first regression model were years of experience, level of education, and percentage of free and reduced lunch. Level of education was significantly correlated with time spent on science (as shown in Tables 4 and 5), but years of experience and percentage of free and reduced lunch were also relevant from my theoretical framework (see Figure 1). Taking the subscale variables together meant eliminating all but the PTABS comfort and DAS difficulty variables. The adjusted R^2 did not change when PTABS challenges or DAS context variables were removed.

The results of the hierarchical linear regression model are presented in Table 6. In Model 1, level of education significantly predicted time spent in scienc, (b = .46, SE = .15, β = -.11, $p < .01$, while controlling for years of experience and the percentage of students who qualified for free and reduced lunch. In Model 2, level of education of the preschool teacher continues to be a significant predictor of time spent on science, *b* = .10, *SE* = .04, β = .21, *p* < .01. In addition, the teacher attitude of comfort with science was a significant predictor of time spent on science above and beyond teacher education level, years of experience, and the percentage of students eligible for free and reduced lunch, *b* = .62, *SE* = .11, β = .45, *p* < .00). Teacher comfort with time spent on science accounted for an additional 24% of the variance of time spent on science in the classroom after the common demographic variables, and this change in adjusted R^2 was statistically significant, *F* (1,114) = 20.42, *p* < .001.

Table 7

Summary of Hierarchical Linear Regression for Variables Predicting Science Time

	Model 1			Model 2		
Predictor	*B*	*SE*	beta	*B*	*SE*	beta
(Intercept)	1.43*	.62	-	-.65	.72	-
Years of Experience	-0.01	.02	-.03	-.02	.02	-.11
Level of Education	.11**	.04	.24	.10**	.04	.21
Free/Reduced Lunch	.00	.00	-.02	.00	.00	-.04
PTABS Comfort				.62***	.11	.45
DAS Difficulty				-.09	.05	-.13
R^2	.06			.30		
Adjusted R^2	.03			.27		
F Change	2.34			20.42***		

Note. *N* = 122. ***p* < .01, ****p* < .001

Research Question 4: What do teachers report regarding teaching preschool science (including feelings, benefits, barriers, and actual activities)?

To answer the last research question, I used a phenomenological qualitative approach to understand the commonalities of the teachers' experiences. The teacher responses from five survey questions were used to assess these collective experiences.

After much analysis, reconstruction and merging, common themes and similarities were solidified to try to capture the essence of experiences reported by teachers.

Feelings about Science

The first qualitative question asked teachers, “What are some of your feelings with teaching science to preschool children?” Three main themes emerged which involved teachers’ conflicting attitudes toward science, the benefits or importance of science for the children, and teachers’ thoughts about how their science teachings were received by the children.

Most of the teachers expressed very positive feelings toward teaching science by writing that they enjoy teaching science, although some expressed feelings of inadequacy. The smaller part of teachers reported that they wished they did more or had greater knowledge about science. One teacher reported her mixed feelings by writing, “I love the idea but haven't figured out how to implement it very well yet. Working on it....”

The second theme that emerged was the acknowledgment of the importance of science as well as the benefit that science is for children. Teachers wrote about how science helps children naturally develop a love of learning and curiosity about the world, as well as increases their ability to think critically. Thinking critically was one way that they indicated science would help the children with future learning in school. Incorporating science into other areas of learning (for example with stories or physical activity) and through multiple topics was an additional way teachers pointed out the importance and usefulness of science. One teacher emphasized the importance of science with her answer:

"Teaching science to preschoolers is all about helping them stay curious about their world. Asking questions. It is one of the best, most natural ways to teach. We spend too much time on literacy and not enough time on science. Science is so important to later academics. In other words, when students explore patterns in nature, they learn to recognize patterns so later on they will recognize patterns in math and reading."

The third theme from this initial question centered on how teachers perceived their science teachings to be received. Many teachers were enthusiastic about the wonderful reactions students had for science experiments. Teachers reported that many of their students were engaged and excited with science and that having hands-on discovery gives children a fun way to explore with their senses. One teacher wrote, "…they light up with joy when they see the changes and get to try new things." Another wrote,

"I think that science is very important to teach to preschool-aged children. It can be difficult to teach and help them understand, but can be very fun for them! When we do science in class, all my students love to experiment!"

These comments seem to provide evidence for overall positive feelings about science teaching on the part of teachers and children alike. Teachers additionally appear to recognize the importance of science and express multiple different benefits teaching science has for children.

Challenges Experienced

The second qualitative question was, "What are some challenges you experience when trying to teach science?" This question drew two main themes: barriers before teaching, and barriers that arise during teaching. While a few teachers expressed having no challenges, the majority of those who described barriers before teaching felt that time for preparation was a critical obstacle specific to science. Teachers expressed the need for prep time to (1) find innovative and engaging ideas, (2) prepare or test materials beforehand to ensure the activity would go as planned, and (3) take time to study the explanations behind the science activities. This need for preparation led a few teachers to report that they were unsure of where to start, and since science was placed on a backburner at their schools, it was not a high priority for them. Money was another barrier commonly reported. The (often disposable) consumable materials, the need for tools or other supplies, and money to access some types of lesson plans/activity ideas were the reasons that money was mentioned as a barrier for these teachers. One teacher captured several of these thoughts when she wrote,

> Science activities take more time to prepare for and the supplies for them cost more money. I like to be able to find science experiments on the internet but in order to access all the information for some of these experiments, they want you to have memberships to access the information. I am not a science guru, I have to do my research and studying to be able to teach the kids.

The other recurrent theme for this question was the barriers that occur during the science activities. Approximately half of those surveyed discussed several barriers that arise during the teaching process, including lack of attention span (specifically for younger children and mixed age groups), inability to understand or follow directions, and chiefly the complicated task of explaining concepts in vocabulary that is age appropriate. One individual stated:

> Science is a subject that is tricky to teach since it is a harder subject. I think the areas I always find a bit of a struggle is being explicit in my instruction to the activity and finding the right questions to ask while observing an experiment. It can be tricky to use language these students understand and explain it clearly.

A few teachers also explained that science activities can also get messier than other subjects, which involves more time, effort and energy to clean up. This variety of responses was an important glimpse into what may hold teachers back from embracing science in their classrooms.

Overcoming Barriers

In response to the third question: "What helps you overcome these challenges or what would help you in the future?" a range of responses were elicited. Three themes were found, and they corresponded with obstacles reported in the second question. The responses to this question were often short, naming one or two ideas that might help them in the future. Having more resources and better planning abilities were reported to help overcome barriers before teaching. For combating barriers during teaching, participants suggested better delivery methods and techniques. Some of the resources that teachers would like to see included having accessible activity ideas and several teachers shared where they find or look for these ideas. Science books, Pinterest, blogs, YouTube or other instructional videos, or compilations of their own lesson plans were some places teachers sought for age-appropriate ideas. In addition, teachers wrote that communicating ideas with other teachers or professionals in the field of science was helpful for coming up with new activities. A few teachers reported that they wished they had some specific professional development training to better assist them with teaching science. Better planning was another theme that could assist teachers overcome some of the barriers before teaching. This reported planning involved researching more deeply so that they would know how to simplify explanations and anticipate problems so the science activity could run smoothly. Planning also involved separating the children into smaller groups (or different age groups), creating back up activities (for those that might lose interest quickly), finding inexpensive and reusable materials, knowing the children's interests or developmental needs, and knowing how to simplify explanations. One participant commented,

> For some experiments, I think that study on my part is helpful. The more I understand, the better able I am to think of ways to simplify the explanation. I would really love to be guided towards resources that explain science on a preschool level.

For overcoming barriers during science, a theme of better delivery methods was reported to help. For teachers struggling with keeping all their students engaged at the same time, having hands-on activities, or going on field trips were reported to help keep children (of all ages) more engaged. A few teachers also alluded to the notion that sometimes science activities do not turn out as planned, but it is helpful to look at it as a learning opportunity (for the teachers and students) and to keep trying over and over, improvising whenever possible. Since science can get messy, going outside for certain experiments would be helpful to some teachers. A small number of participants suggested that eliciting the involvement of children or their families was another way to help with setting up, cleaning up, or explaining complicated science vocabulary.

Most Recent Science Activities and Time Spent

The last two qualitative questions examined the actual science experiments going on currently. Question number four asked teachers to describe their most recent planned/formal science activity, and question five asked them to report the average of how many minutes per day they formally taught science.

The activities that teachers reported often followed classroom themes such as those of learning letters, animals, or seasons and many activities involved hands-on participation and active exploration for the children. Three classifications of activities were identified; life science (plants, animals), earth science (weather, natural materials), and physical science (movement, properties of matter, and change). These are the areas covered by Utah Core Curriculum standards in elementary schools as well (Utah Education Network, 2018). Since the surveys were returned in early spring, the activities mentioned were not unexpected. Many of the life science activities mentioned by teachers talked about their classrooms planting seeds, looking at plant life cycles, exploring how water travels through petals or leaves, exploring bugs, and one teacher even reported watching chicks hatch with her class! Earth science activities often centered on weather, with most experiments involving water or ice. Thunder cans, rainbows, shaving cream rain cloud experiments, water cycle explanations, and melting tests were also mentioned. Another set of earth science activities involved observing and classifying materials such as fabrics, shells, or acorns. The largest amount of activities fit into the area of physical sciences, with a long and varied list of activities. Chemical or physical reactions (elephant toothpaste, baking soda and vinegar type experiments, Alka-Seltzer and oil, etc.), sensory play (playdough, slime, water beads, etc.), mixing colors (with paints, pipettes, paper towels, etc.), sink or float activities, and technological activities (magnets, simple machines, coding bee-bots,), were some of the recent activities listed by teachers. Five out of the 122 responses reported that they have not done any science activities. The diversity of science activities is evident in their responses.

The fifth question about the average amount of formal time spent on science prompted 85% of teachers to give a specific number or range of minutes, while the other participants simply wrote that they could not give a number based on the variability of day to day requirements. Sixteen of the 122 teachers (13%) expressed that they did not have formal science, with about half reporting that their science was completely child-led natural discovery and the other half giving no explanation for reporting 0 minutes. A normal distribution was reported for the numeric responses, with a minimum of 0 minutes and a maximum of 120 minutes (1 participant). It is difficult to compare responses especially on the highest end of the spectrum (6% reported 35 minutes or over) since a definition of formal science could be different for every participant. As one teacher put it, “Formally: 15 minutes. Informally throughout a typical 6-hour shift: probably 45 min to an hour total in various methods.” Overall, the vast majority of participants (71%) reported between one and 30 minutes of formal exploration while the largest portion of teachers (38%) reported their formal science activities to last between 5 and 15 minutes.

To summarize, the qualitative questions were a snapshot into teachers’ experiences in relation to preschool science. They reported quite positive feelings about science, a range of challenges before and during science (prep time, affordability, explaining concepts), with several ideas for how to overcome those same challenges (better resources, planning, and delivery methods). They also reported an exciting assortment of life, earth, and physical science activities, with many teachers taking about 5-15 minutes of formal science per day. Together these results provide important insights into the daily successes, challenges, and happenings of these participating teachers.

CHAPTER IV

DISCUSSION

The purpose of this study was to understand how the characteristics of teachers and classrooms predicted time spent on preschool science. Preschool science is important to understand because of the role it plays in facilitating the development of learning and critical thinking, understanding the world around us, and its contribution to promoting school readiness (Clements & Sarama, 2016; NAEYC, 2018; Nayfeld et al., 2013). This study adds to the growing body of research that aims to investigate science time with regards to teacher attitudes, and teacher and/or classroom characteristics.

This study found that teacher attitudes are overall quite positive about science. The teacher and classroom demographics are significantly different between the types of preschools evaluated, for instance with home-based teachers reporting to be older and having more years of experience than any other preschool type. The level of education and all the teacher attitudes measured were significantly correlated with time spent on science. The key new finding in this study was that teacher comfort uniquely predicted time spent on science above and beyond teacher and classroom characteristics.

Teachers and Classrooms Characteristics

To be included in this study, preschool teachers met the following requirements: developed and implemented lesson plans, taught for at least two hours of instructional time per day, were at least 18 years old, had at least five children enrolled in their classroom, and spoke English. I first hypothesized that preschool teachers would vary greatly on education level, years of experience, and age. Results indeed revealed a great variety of age, education level, and years of experience, and that 99.2% of this sample were female. The largest percentages of this sample reported to be at least 44 years old, with 10 or more years of experience, and to hold Child Development Associate's degrees. All types of preschools were represented with the largest proportion of program type being Head Start programs. These teacher and classroom demographic results reflected those of similar samples from Piasta et al. (2014) and Pendergast et al. (2017). It is important to understand the landscape of preschool programs so we can have a better sense of what is occurring within preschools, and so we can better tailor professional development or other professional practices for the needs of the teachers and programs.

The significant differences among program types with teacher and classroom characteristics suggest several important associations. The majority of university child development lab (CDL) teachers reported holding a bachelor's degrees or higher which could be reflective of the academic atmosphere present on a university or community college campus. Given that many university CDL teachers are hired to teach future preschool teachers the best developmentally appropriate practices, holding more advanced degrees is not surprising. Furthermore, my results show that Head Start programs had the highest percentage of children who qualified for free and reduced lunch and the most concentrated number of teachers with CDA's or bachelor's degrees, which is reflective of the nationally mandated policies in place for that organization. Head Start's purpose as a federal program is to make early care and education available to low-income families, and the organization holds a high standard for teachers' levels of education. Head Start's lead teachers are required to hold or be working toward bachelor's degrees, so the results are expected in that regard.

It was also estimated that the majority of the preschool teachers in this sample would be female and would report low levels of comfort, high levels of anxiety, and minimal time teaching science. Nearly all teachers reported having high levels of comfort and low anxiety levels, which was contrary to my hypothesis. Within the Preschool Teacher Attitudes and Beliefs Toward Science Teaching Questionnaire (PTABS), the measure of comfort can be analyzed into specific items about general comfort, comfort with scientific tools, comfort with different science topics and where teachers typically access science resources. Teachers reported that they were comfortable planning all types of science activities and scientific tools, enjoyed engaging children in science, and accessed resource ideas from a variety of sources.

In support of my hypothesis, teachers did report minimal time teaching science on the Dimensions of Attitude toward Science (DAS). Teachers reported science activities to occur "1-3 times a month," which is fairly disappointing given that previous studies have found that science is already being taught less than other subjects (Connor et al., 2006; Piasta et al., 2014). My results on teacher attitudes support the research of Pendergast et al. (2017), indicating that preschool teachers report that they enjoy science teaching. This finding is in contrast to previous research indicating more negative attitudes related to teaching science (see Brenneman et al., 2009; Edwards & Loveridge, 2011; and Greenfield et al., 2009). These differences may be due to measurement methods as this study and the study done by Pendergast et al. (2017) used the PTABS, while other studies used classroom observations or qualitative approaches (Edwards & Loveridge, 2011; Greenfield et al., 2009). The relatively low reported amount of time spent on science taken together with the high comfort teachers report is difficult to interpret as actual classrooms were not observed. The qualitative questions contribute additional insight to this discrepancy, with many teachers describing several challenges to teaching science accompanied by several ways to overcome those barriers. It is possible that although teachers understand the importance of teaching science and feel comfortable with it, there are still barriers that prevent them from teaching as often as their attitudes and perceptions would suggest. The differences may also be in teachers' ineffectiveness or lack of knowledge about how to integrate science into other subjects as well. This would be unfortunate as it may be that teachers are missing the potentially endless opportunities to integrate simple science concepts throughout the day, such as in areas of art, language arts, or mathematics. Qualitative results provides further evidence of this; when asked to describe their more recent science activities most teachers described very specific large group experiments such as baking soda and vinegar reactions or mixing colors. These activities, while wonderful in themselves, may not accurately capture the possibility to recognize science as being in everything that occurs. A mental shift on the part of the teachers would be needed to realize that mixing colors may also occur during art time, or bug exploration and classification also occurs during outside time, not just at times designated for science.

Teachers were asked about the amount of time they spent teaching science in two different formats in the current study which generated two very different responses. The majority of teachers reported a range of one to thirty minutes when asked about the amount of time they spent each day in formal science instruction. In contrast, the average report of science instruction from the Dimensions of Attitude toward Science (DAS) questionnaire was one to three times per month. How the questions about time teaching science were asked may have contributed to this difference in responses. The qualitative question was open to interpretation of what "formal" science meant to the teacher, whereas the DAS measure articulated more specific items such as how often they "let their students test or analyze an existing or personally designed product on its technical aspects" (van Aalderen-Smeets & Walma van der Molen, 2013). Piasta et al. (2014), who used observational methods to assess their sample, also expressed difficulty in accurately quantifying time spent on science, since the subject is so versatile and often deliberately interwoven into children's play. Formal science for some teachers was reported as circle time where everyone watches an experiment or a field trip where children are actively listening for bird songs. The children's experiences are different for each scenario but equally vital for learning opportunities, so it is beneficial to have both ways to help us understand the time spent on science.

Associations Among Teacher and Classroom Characteristics

Several teacher and classroom characteristics were correlated with time spent teaching science. It was predicted that teachers with high levels of education and more years of experience would report greater comfort, more positive attitudes and more science time than teachers with less education and experience, which was partially reflected in the results. Teachers reporting higher levels of education reported spending more time spent on science with fewer reported challenges. However, level of education and years of experience were not specifically associated with comfort with science or any other teacher attitudes. It may be that teachers who experience higher levels of education may be better equipped to handle negative situations that may arise during teaching because they have been prepared with experiences in pre-service. Although Pendergast et al. (2017) found that newly graduated teachers still feel unprepared or apprehensive, Erden and Sonmez (2011) discovered that while the level of education is not related to comfort level, it is related to better science delivery methods. Perfecting science delivery methods was a theme that arose in this study's qualitative results when teachers were asked how they overcome barriers, reinforcing the results from Erden and Sonmez (2011).

It is important to note that time spent on science was correlated with the level of education as well as each of the six attitudes measured (comfort, benefit, challenges, anxiety, difficulty, and contextual factors). A recent study by Gerde et al. (2018) found that education was not associated with self-efficacy, but that feelings of self-efficacy and time spent on science were related. The results from the current study provide additional support for the association between teacher self-efficacy and time spent on science. Teachers in the current study who reported high levels of self-efficacy (measured by comfort) and who believed children benefitted from science also reported more time spent on teaching science than those teachers reporting less comfort and fewer benefits of science to children. Challenges, anxiety, difficulty, and challenging contextual factors negatively influenced time spent on science, further reinforcing the need for teachers to feel comfortable in their teaching. Contextual factors emerged within qualitative answers as well, with several teachers expressing a desire for their programs to have more science directed curriculum, or to have more of a supportive community of ideas between peers. Furthermore, Zinsser et al. (2016) found that the more comfortable teachers were, the better quality and technique skills they used to teach science. Many teachers reported understanding the importance of science for preschoolers, and perceived children to enjoy science activities very much. Teachers reported enjoying seeing the children light up when the children were discovering something or watching an experiment, further reinforcing the teachers' own excitement about science.   It is unsurprising then, that teachers who are more aware of the benefits of science are more likely to have increased time spent on science.

Bandura' Social Cognitive Theory proposed that individuals with high levels of self-efficacy are also more likely to repeat an activity, which is evident in the correlations between teachers' comfort and time spent on science in the present study. Bandura (2018) proposed that self-efficacy beliefs remain relatively stable, which may explain why other factors such as age or years of experience were not associated with the comfort level.

Furthermore, Bandura's triadic codetermination process of causation can be broken into a triangle of personal, behavioral and environmental factors (2018). Teacher attitudes fit into the personal factor side of the triangle. For example, in my results, teachers who are comfortable with science report being more willing to teach science. Teachers' levels of education were influential for time spent on science, and studies have shown it to have behavioral implications (see Zinsser et al., 2016), which matches the behavioral factor in the triangle. The third side of the triangle, environmental factors, is not as clearly supported by the quantitative results of this study. Preschool type, contextual factors, and the percentage of students receiving free and reduced lunch were not related to the amount of time teachers spent on science, which is contrary to the finding that the average classroom socioeconomic status (measured by maternal education level) was correlated with science learning opportunities in minutes (Piasta et al., 2014). This may be due, in part, to the different means of measurement, as this study attempted to assess the classroom socioeconomic status by the percentage of children who qualify for free and reduced lunch. Even still, environmental factors were evident to be influential in the qualitative results for some teachers. A few teachers reported that factors such as not having supportive administration, not enough time or money for science, and having unconstructive curriculum were barriers that impeded teachers' ability to include science teaching. Taking these experiences into account, all three sides of Bandura's triadic codetermination of the process of causation can be seen to be supported.

The last tenet of Bandura's Social Learning Theory was observational learning which includes: attentional processes, retention processes, motor production processes, and reinforcement/motivational processes (Bandura, 2018). One way this observational learning can be seen by the data is that several teachers reported the desire to have increased professional development directed to improve their science teaching. Having targeted professional development may allow teachers to receive hands-on instruction to later implement in their classrooms. Having professional development incentives, or spotlighting science being taught through newsletters or shout outs, may be ideas for motivation to support these processes as well.

Contributions Above and Beyond Demographics

The results of the hierarchical linear regression provided additional evidence of the association between time spent on science and comfort teaching science, as comfort level was predictive of more time spent on science above and beyond the teacher or classroom demographics. While the level of education was also a significant predictor, comfort teaching science was the only teacher attitude that contributed to time spent on science. More educated teachers, who are comfortable with science, may be better equipped to handle difficult situations (such as short attention spans and misunderstanding science vocabulary) as they may have more experience with a variety of science delivery methods. Teachers who are more comfortable teaching preschool may be able to form better teacher-child relationships (Zinsser et al., 2016). Additionally, the level of education and comfort may help teachers appraise stressors more mindfully, such that children's difficult behaviors during teaching can be viewed in a more positive light (Becker, Gallagher, & Whitaker, 2017). For example, the qualitative themes for challenges were mainly that of barriers before and during teaching science, which may provide greater insight into why the level of education and comfort level were significant predictors on the amount of time teachers spent teaching science. Teachers who have the ability to create better delivery methods (as expressed in the responses to the qualitative question about how to overcome barriers), may also be more comfortable with science teaching. This study provides support for previous research indicating an association among education level, comfort and time spent with science (Erden & Sonmez, 2011; Gerde et al., 2018; Klassen & Chiu, 2010; Zinsser et al., 2016). More time spent on preschool science is needed, as science helps children develop the school readiness skills they need to succeed. When teachers are able to incorporate the scientific method, children learn process skills of observing, describing, comparing, questioning, predicting, experimenting, reflecting, and cooperating (Greenfield et al., 2009). Teachers who teach effectively also are able to incorporate science into many other subject areas such as literacy or even art (Clements & Sarama, 2016). Children are the clear beneficiaries of teachers who are able to competently teach preschool science.

Limitations

There are some measurement limitations of this study that should be noted. Foremost, the addition of factors such as maternal education level, curriculum types, or other measures of science quality may help account for more science variance. Including factors beyond program type and the percentage of students eligible for free and reduced lunch may also give a more thorough indication of classroom characteristics. Maternal education level has been well documented to be a valid predictor of socioeconomic status (Hosokawa & Katsura, 2018; Rafferty & Griffin, 2010), which may be a more reliable indicator of the classroom's SES than the percentage of children who qualify for the free and reduced lunch programs. Curriculum type may also be an important variable to consider as existing research is meager in connection with preschool science, but researchers are calling for this area to be explored (Savinskaya, 2017). Fitzpatrick et al. (2014) found that progressive curricula, in contrast to traditional curricula, had more emphasis placed on active learning, negotiating and debating skills, creative problem solving, and independent exploration. These types of skills could benefit science activities as they demonstrate some of the same learning skills children need to understand preschool science such as observing, questioning, experimenting, and cooperating (Greenfield et al., 2009). Kinzie, Whittaker, Mcguire, Lee, and Kilday (2015) found that strong curriculum has elements of a balance between teacher-led and child-led activities, intentional teaching with anchored science investigations, support for high-quality teacher-child interactions, and time for reflection about the science activities done. Since some curricula are written to be more general, Aldemir and Kermani (2017) found that children's scores for math and science concepts were significantly higher in the intervention group that had targeted efforts with math and science instruction (Aldemir & Kermani, 2017). While these elements would be difficult to measure without physical classroom observations, an understanding of the required curricula type for teachers could account for more of the variance missing from my model.

Our research provides new insight into the predictors of science time spent in preschool classrooms, but stronger claims could be made through observational methods. As noted earlier, several studies of teachers' attitudes have found that comfort levels and other attitudes have important impacts on time spent on science, and combining self-reports with observational methods could bolster confidence in the measurement. All surveys of behaviors and attitudes are subject to a measurement bias (Schwarz, 1999). For example, teachers who reported lower levels of science time may perceive their science activities to be of poor quality, while an impartial observer might report differently. Similarly, observers would be able to rate the quality of the formal and informal science activities within the classroom, much like the research done by Piasta et al. (2014).

Several data limitations hamper the generalizability of my results. Data collection for demographic questions was done in categories, where age and years of experience could have been more precise with continuous data where the respondents reported their actual age and years of experience. Large percentages of participants reported being on the older end of the age scale, and, therefore, the results on age should be interpreted more cautiously than if the data was approximately even within each age category. Furthermore, while this data represents a diverse sample of teachers from different types of preschools in the state of Utah, the results may not be generalizable to all preschool types or early childhood programs.

This study is also limited by the relatively low response rate of 25%. Although this was adequate for conducting my analyses, the response rate could introduce bias if non-participating teachers differed in some way from participants. Participants may have been more interested in science than non-participants, or they may have had greater comfort with teaching science. Therefore, these results should be interpreted with caution. Despite these limitations, there are multiple ways this study can contribute to future research and policy.

Implications and Future Directions

An important aspect of this study is understanding the association between teachers' comfort levels and time spent on preschool science. Despite a multitude of various challenges reported, teachers did not report that challenges or difficulties were significantly associated with the amount of time they spent on science. This may show that difficulties do not hold back teachers who are comfortable with science from continually trying to have science experiences. To prevent these challenges from decreasing teachers' comfort levels over time, barriers such as feelings of inadequacy, inability to find engaging activity ideas, time and money to prepare science activities beforehand, and time to understand scientific explanations should be addressed in early care and education programs. Individual programs could provide professional development opportunities focused on science to encourage teacher's own learning, and to give teachers the overhead support they need to feel successful. While these reported challenges may act as a guide for where to begin, it also may be of worth for program directors, professional development trainings, and intervention programs to focus on strengthening teachers' overall science comfort levels than to try and address every challenging issue. Good science teaching practices have been associated with increasing executive functioning, and consequently school readiness (Fitzpatrick et al., 2014), thus more support for teachers to address their barriers is strongly recommended.

This exploratory study also suggests that increasing teacher education may also contribute to increased teacher comfort with science. Increasing educational levels may be more complicated to implement than raising comfort levels. However, several teachers reported the desire to participate in science-related professional development to learn techniques, delivery methods, or to simply gain resources. The association between time spent teaching science and level of education further implies that trainings of this sort have the potential to make a difference for teachers. Examining resources such as Utah's Early Childhood Core Standards, "Approaches To Learning And Science" for preschool (Utah Office of Education, 2013, available at https://www.schools.utah.gov/file/867f3f1b-c233-497a-bd45-e31dc4581327) may give teachers developmentally appropriate strategies and activity ideas to use immediately. Kindergarten standards outlined in Utah's Science Common Core (Utah Education Network, 2018; available at https://www.uen.org/core/core.do?courseNum = 3110#strands) or Next Generation Science Standards (2019; available at https://www.nextgenscience.org), may give also teachers ideas of what standards their preschool children should be ready to meet in the coming years. Additionally, pre-service education that supports positive attitudes towards science and ensures positive experiences related to science activities are needed to help early childhood teachers feel comfortable teaching science. Professional development or pre-service programs could provide teachers with an arsenal of tried and true resources through practicum or field experiences that may also encourage all teachers to go forward with confidence in themselves and their science teaching abilities. Furthermore, giving teachers the ability to recognize the integral role science can play in all areas of the classroom can make them aware of greater opportunities to engage students in enriched and expanded learning. Making Utah teachers aware of these resources to help implement science teaching could help encourage their students to foster a love of learning and science. With Utah technological business booming, it seems more important than ever to give these children the foundations of interest in the STEM fields (Hanewicz, & Thackeray, 2019).

Social Learning Theory explains that the comfort levels of teachers are critical to the internal interpretation of how teachers feel their attempts at science are received. Since teachers are observational learners themselves, they are interpreting feedback from their students, their own feelings and from peers. The personal, behavioral, and environmental factors influence each teacher to select how much time they spend on any aspect of their teaching. When attitudes of comfort, supportive environments, and teachers' unique skills combine, that is when science time may be the most enjoyable for teachers leading to potentially positive cycles of more and more science time. This triadic codetermination process of causation is impacted first and foremost by teacher comfort levels, also evident in Bandura's tenants of self-efficacy.

Finally, future research could explore the possibility of additional variables that may influence the amount of time spent in science such as the impact of different measures of SES, curriculum types, and formal versus informal science activities. Observational methods would be needed to accurately capture the intricacies of daily science activities that may be constantly occurring. Future research that evaluates the impact of professional development intervention programs based on creating positive impacts on teachers' comfort levels with science is also needed.

In sum, the findings of this study contain important contributions to the field of preschool science research. Understanding the predictors of levels of education and comfort level with time spent on science is important for researchers and professionals alike. Considering the influence of teachers' attitudes on behaviors will not only benefit teachers themselves, but also the students they teach. Preschool science is a pivotal learning opportunity for young children as it helps explain the world around them and gets them excited about the process of learning. The benefits of science at this age are profound, and it is essential that teachers are comfortable enough with this subject area to effectively engage children in science activities, not just in Utah but nationally and globally as well. These exploratory findings can help guide future research, current and future teachers, and most importantly, the next generation of learners.

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