Investigating Head Start Teachers' Science Teaching Attitudes and Efficacy

A Thesis

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Abstract

The purpose of this study is to explore the relation between Head Start teachers' science teaching attitudes and efficacy. A total of 150 teachers participated in the study from eight states and 22 Head Start centers. Teachers' science teaching attitudes and efficacy were measured using validated quantitative rating scales via the online survey software, Qualtrics. Teachers' attitudes toward teaching science were measured by the Preschool Teacher Attitude and Beliefs Toward Science Questionnaire (P-TABS). Teachers' science teaching efficacy was measured by the Teacher Efficacy and Attitudes toward Science, Technology, Engineering, Mathematics (T-STEM) – Science subscale. Data were analyzed using a multilevel regression approach. Results showed that Head Start teachers' perceived challenges were significantly associated with science teaching efficacy beliefs, as was teacher comfort, and child benefit beliefs. Child benefit beliefs were the only domain of science teaching attitudes that were significantly associated with science teaching outcome expectancy. This finding shows the potential in improving early childhood teachers' attitudes towards early science education by enhancing their science teaching efficacy.

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Dedication

To my grandmother. Thank you for always being my biggest supporter.

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Chapter 1: Introduction

Early science education is foundational for children's later STEM (i.e., science, technology, engineering, and mathematics) learning (Morgan et al., 2016). During the first few years of life, over a million neural connections are formed every second, making early childhood a critical period for learning (Center on the Developing Child, 2019). According to Friedman (2016), providing children with hands-on science learning experiences and teaching science concepts to young children positively contributed to school readiness and future science learning. This is particularly important for economically disadvantaged children such as children in Head Start (National Head Start Association, 2022).

Early childhood teachers have generally reported positive attitudes toward science (Erden & Sönmez, 2001; Pendergast et al., 2017; Timur, 2012), but science is often taught less frequently than other subjects possibly due to teachers' negative attitudes toward teaching science (Gerde et al., 2017; Tu, 2006). Specifically, research shows that early childhood teachers tend to perceive a low level of comfort toward teaching science (Bedel, 2015; Gerde et al., 2017), undervalue the benefit of early science education (McClure et al., 2017), and report many challenges associated with teaching science to young children (Dailey & Robinson, 2016). Consequently, children are provided with limited opportunities to have a strong foundation for future science learning (Pendergast et al., 2017). Although research on changing teachers' attitudes toward teaching science is not conclusive (Erden & Sönmez, 2001; Timur, 2012), existing literature has indicated ways to enhance teachers' science teaching efficacy (i.e., beliefs in one's ability in teaching science), such as enhancing teachers' science content and pedagogical knowledge (Bautista, 2011; Schoon & Boone, 1998; Tosun, 2000). Therefore, I sought to explore the relationship between Head Start teachers' science teaching attitudes and efficacy to elucidate possible pathways to improve early childhood teachers' attitudes toward teaching science to young children.

Purpose

The purpose of this study is to investigate the relation between early childhood teachers' science teaching attitudes and efficacy. This study specifically investigates Head Start teachers who work with children from lower socioeconomic backgrounds. The variables examined in this study include science teaching efficacy beliefs, outcome expectancy, comfort, benefits, and challenges. The findings indicate possible ways to improve early childhood teachers' science teaching attitudes and efficacy.

Theoretical Framework

The theory of planned behavior (TPB, Ajzen & Fishbein, 1980) is one of the theoretical frameworks of this study. According to TPB, perceived control refers to a person's perception of how easy or hard it is to accomplish certain behaviors. This perception reflects individuals' beliefs in their ability and motivation (Ajzen & Fishbein, 1980). Based on this theory, one's attitude includes both cognitive and affective components, which jointly determine the behavioral intentions. Applying TPB in this study, teachers' attitudes toward teaching science consist of their cognitive beliefs about the challenges and benefits of teaching science to young children and affect beliefs about their levels of comfort in teaching science. These attitude beliefs could theoretically influence teachers' inclinations of carrying out instructions (i.e., behavioral intention).

The theory of locus of control (Rotter, 1966) is the second theoretical framework of this study. According to the locus of control theory, external control is the degree to which the cause of an event is perceived to be in someone else's control or caused by chance or fate;

internal control is the degree to which the cause of an event is perceived to be by one's own action (Rotter, 1966). Applying the theory of locus of control, in the context of the present study, teachers' efficacy beliefs and outcome expectancies represent teachers' perceived internal and external locus of control, respectively. Their attitudes such as comfort, benefit beliefs, and challenges could be influenced by their perceived locus of control.

Definition of Terms

Head Start: a federally funded early childhood program serving economically disadvantaged children from birth to age five, including Native Americans, Alaskan Natives, children of migrant and seasonal workers, and pregnant women (Office of Head Start, 2022). Besides early education, Head Start also provides parental education, prenatal care, health screenings, and family support (Office of Head Start, 2022). Head Start is shown to have a lasting impact on children's future success both in school and in life (National Head Start Association, 2022).

Attitude: cognitive, affective, or behavioral inclinations (Eagly & Chaiken, 1993).

Science Teaching Attitude: Science teaching attitude includes personal or general interests in learning science subjects and professional attitudes which refer to feelings and beliefs toward teaching science, and the appropriateness of teaching science in the classroom (Asma et al., 2011; van Aalderen-Smeets et al., 2011; van Aalderen-Smeets & van der Molen, 2015). Science teaching attitude in this study is operationalized as science teaching comfort, benefit, and challenges.

Science Teaching Comfort: teachers' comfort level regarding planning and doing science activities in the classroom (Maier et al., 2010).

Science Teaching Benefit: teachers' beliefs about whether teaching science in the classroom inspires children's interests in science and whether teaching science contributes to children's school readiness (Maier et al., 2010).

Science Teaching Challenges: concerns that teachers have about teaching science, such as their discomfort, ability levels, and time needed to do science activities (Maier et al., 2010).

Efficacy: efficacy refers to individuals' beliefs about their ability in a particular domain (Bandura, 1997).

Science Teaching Efficacy: teachers' beliefs in their own instructional ability to produce desired learning outcomes (Velthuis et al., 2014). In this study, science teaching efficacy is operationalized as science teaching efficacy beliefs and outcome expectancy.

Science Teaching Efficacy Beliefs: teacher confidence and efficacy towards teaching science (Friday Institute for Educational Innovation, 2012).

Science Teaching Outcome Expectancy: how much teachers believe their science teaching impacts students' learning (Friday Institute for Educational Innovation, 2012).

Organization of the Study

Chapter 1 is the Introduction. This chapter includes four sections: Background, Purpose, the Definition of Terms, and Organization of the Study.

Chapter 2 is the Literature Review. This chapter includes six sections: Early Science Education, Attitudes, Science Teaching Efficacy, the Significance of the Study, Empirical Gaps, and Research Questions.

Chapter 3 is Methodology. This chapter includes four sections: Participants, Data Collection Procedures, Instruments, and Data Analysis Strategies.

Chapter 4 is Results. This chapter includes four sections: Background, Research Question 1, Research Question 2, and Research Question 3.

Chapter 5 is Discussion and Conclusion. This chapter includes five sections: Teachers' Perceived Comfort on Science Teaching Efficacy, Teachers' Perceived Child Benefit Beliefs on Science Teaching Efficacy, Teachers' Perceived Challenges on Science Teaching Efficacy, Limitations and Future Directions, and Conclusion.

Chapter 2: Literature Review

Early Science Education

Introducing science early in a child's life has many benefits (Curran & Kitchin, 2019; Larimore, 2020). The National Science Teachers Association (NSTA, 2014) suggests that engaging in science in the early childhood years fosters curiosity and exploration and lays the foundation for science learning not only in K-12 classrooms but throughout life. Early childhood teachers play a crucial role in early science education (Friedman, 2016). For example, Curran and Kitchin (2019) found that the amount of time spent on science instruction was related to science achievement. Early science education is not only important for later science achievement but also for the growth in other domains, such as language and literacy, executive functioning, and socio-emotional development (Larimore, 2020).

Teaching Science in the Classroom

Comparing instructional practices across different subject domains in the early childhood classroom, science teaching is often overlooked. Tu (2006) observed each of the 20 preschool classrooms for two hours per class for two consecutive days during free play time. Tu (2006) found that teachers tend to spend most of their classroom time in the art or sensory areas, but no activities were observed in the science area, and there was no unplanned science teaching throughout the observation. In a more recent study, Gerde et al. (2017) found that Head Start teachers conducted significantly fewer science activities as compared to literacy activities.

Besides the absence of teacher-led science activities, empirical evidence suggests a lack of science materials in the classroom. Research studies investigating science materials provided in the classroom indicate that early childhood teachers tend to provide lower-quality science materials (Gerde et al., 2017; Tu, 2006). Tu (2006) found that only half of the classrooms that they observed had a science area and the most common materials offered were nature-related materials like seashells, feathers, and pinecones. Tools like magnifying glasses, scales, microscopes, rulers, and measuring cups were offered less frequently in the classroom, leaving children with few ways of exploring the natural materials most classrooms offered (Tu, 2006). Similarly, Gerde et al. (2017) found less than 40% of classrooms provided nature materials and less than 25% had prisms, seeds, and fossils. Gerde et al. (2006) found that teachers who provided more science materials engaged more frequently with children in science experiences.

The National Association for the Education of Young Children (NAEYC) recommends that science education be integrated with reading and writing activities (Pentimonti et al. 2020). Pentimonti et al. (2020) found that science books were less likely than other books to be offered in the preschool classroom. They found that only four percent of books read aloud in the classroom were informational books (Pentimonti et al., 2020). Similarly, Youp and Youp (2006) found that only five percent of books read aloud in the preschool classroom were science or informational books (i.e., non-fictional books that provide scientific facts). Smolkin and Donovan (2001) investigated the types of science books that elementary teachers chose for their classrooms and found teachers were more likely to choose books with a story because they worried that informational books would be too boring. However, Donovan et al. (2000) found that children tend to choose informational books above their reading level and read in groups to learn more information.

Achievement Gap

The previous sections have gone over the importance and benefits of early science education(Curran & Kitchin, 2019; Larimore, 2020). Unfortunately, not all children are provided quality early science education wether that be from poor planning, a lack of time, or a lack of access (Asma et al., 2011; Gerde et al., 2017; Pendergast et al., 2017; Tu, 2006). This can lead to an achievement gap which is when one group outperforms another group (Anderson et. al., 2007; Jaynes, 2015; Mesroiban, 2022). Previous studies have found that the gap in achievement is often related to groups of a lower socioeconomic status and of a different racial/ethnic background which can often be attributed to the opportunities children have and necessarily their achievement (Anderson et. al., 2007; Jeynes, 2015, Mesroiban, 2022; Morgan et. al., 2016). An effective method of closing the achievement gap is high quality preschools and curriculum (Jeynes, 2015; Mesroiban, 2022; Morgan et al., 2016). When looking at gaps specifically in science achievement, a gap was already seen in Kindergarten and persisted until at least 8th grade (Morgan et al., 2016). One of the programs designed to help eliminate this gap is Head Start (Jeynes, 2015).

Head Start

The Office of Head Start (OHS, 2022) is a federally funded program that consists of over 1,600 centers around the United States and helps over 1 million pregnant women and children, many of which are below the federal poverty line. The OHS (2022) works to provide disadvantaged young children with early learning opportunities in the hope of bridging the learning gap and boosting these children's social mobility. Early learning experiences are provided in all areas of development, as well as, health screenings and access to resources such as housing, food, health care, and higher education (OHS, 2022). Head Start provides high-quality research-based curricula, that aligns with the Head Start Early Learning Outcomes framework in addition to meeting state standards, along with ongoing feedback, the ability to individualize curriculum and engaging families in children's learning

(OHS, 2022). To support teachers' effective curriculum implementation, training and professional development are provided to all Head Start teachers (OHS, 2022).

Current Standards

Currently, in the United States, there are no mandated federal standards for early science education; most states have early learning guidelines that include science (Larimore, 2020). Some states choose to use Next Generation Science Standards (NGSS) as their state standards (NGSS, 2013). The NGSS was developed in 2013 to provide researched based science standards that children should know and be able to do (NGSS, 2013). Although these standards are for K-12 education, adoption and implementation of these standards is up to the individual state (NGSS, 2013).

The OHS provides its centers with a framework for early learning outcomes, which will help teachers choose curriculum and classroom materials. There are six science-related goals, three in scientific inquiry and three related to reasoning and problem-solving. The three scientific inquiry goals are: *Child observes and describes observable phenomena (objects, materials, organisms, and events); Child engages in scientific talks; Child compares and categorizes observable phenomena.* The three goals related to reasoning and problem-solving are: *Child asks a question, gathers information, and makes predictions; Child plans and conducts investigations and experiments; Child analyzes results, draws conclusions, and communicates results.* The goals include developmental progressions and indicators that the child is reaching the goal which helps teachers monitor progress.

Attitudes

Before discussing attitudes toward science teaching, I must first define what attitude is. Egaly and Chaiken (1993) describe attitude as a psychological inclination that is formed either "on an affective, cognitive or behavioral basis" and is either favorable or disfavorable (p.2). Attitude toward science teaching includes personal attitudes and professional attitudes (Asma et al., 2011; van Aalderen-Smeets et al., 2011; van Aalderen-Smeets & van der Molen, 2015). Personal attitudes are defined as a teachers' general interest in informing themselves about science in their personal lives (Asma et al., 2011; van Aalderen-Smeets et al., 2011; van Aalderen-Smeets & van der Molen, 2015). Professional attitudes are a teacher's feelings and beliefs toward science teaching and how appropriate and important science education is for children (Asma et al., 2011; van Aalderen-Smeets et al., 2011; van Aalderen-Smeets & van der Molen, 2015).

Researchers have found that early childhood teachers and pre-service teachers generally reported positive attitudes toward science (Erden & Sönmez, 2001; Pendergast et al., 2017; Timur, 2012). Although little research has been done with young children, studies on older children have shown that teacher attitudes are correlated with student outcomes in language and math, but little research has been done on science (Mensah et al., 2013; Scrivner, 2009). In this study, teacher science teaching attitudes are operationalized as their comfort level regarding teaching science, their beliefs about child benefits as a result of teaching science, and perceived challenges related to teaching science to young children (Maier et al.,2010). These three dimensions are discussed in the following sections.

Comfort in Teaching Science

Comfort in teaching science refers to teachers' comfort levels regarding planning and conducting science activities in the classroom (Maier et al., 2010). Pendergast et al. (2017) found that teachers reported feeling comfortable planning science activities. However, Pendergast et al. (2017) questioned the quality of the lessons that teachers presented. Tu

(2006) found that planned science lessons teachers gave were often of lower quality. Although teachers in some studies reported feeling high levels of comfort teaching science and planning lessons, they did not necessarily have adequate science knowledge to prepare quality science lessons (Asma et al., 2011; Pendergast et al., 2017; Tu, 2006).

Pendergast et al. (2017) also found teachers in their study were comfortable having science centers in the classroom although they felt less comfortable using science tools. Despite reporting the importance of science centers in the classroom, science centers are often forgotten or not used to their full potential (Pendergast et al., 2017; Tu, 2006). For example, researchers reported that teachers do not regularly engage in science centers in the classroom and don't often feel comfortable with science tools such as magnifying glasses, scales, and rulers (Pendergast et al., 2017; Tu, 2006). Tu (2006) also found that 70% of classrooms had a plant and most were located on a counter but none of the teachers talked to the children about the plants nor were the children interested in the plants. Based on the previous studies, it can be concluded that science materials are widely available but not adequately used in the classroom (Pendergast et al., 2017; Tu, 2006).

Benefits and Benefit Beliefs About Teaching Science

Benefit beliefs refer to teachers' beliefs about how teaching science in the classroom creates an interest in science for children and their beliefs on the benefits of learning science to young children (Maier et al., 2010). Contrary to some teachers' beliefs that science is not developmentally appropriate for young children (Park et al., 2017), young children are capable of learning science because of their natural curiosity, especially when they are provided with the right support (Lairmore, 2020). Natural curiosity refers to children's innate need to want to build, collect, organize, and explore the world around them (Lairmore, 2020;

Sarama et al., 2018; Worth, 2010). With teachers' high-quality instructional support, children can engage in authentic and meaningful science learning (Samara et al.,2018).

Early science learning has many long-term benefits for children. Early science learning supports future learning in all subject areas, including future STEM classes, reading comprehension, writing skills, socio-emotional development, and large and small motor control (Samara et al., 2018; Worth, 2010). However, according to Lairmore (2020), unless children's science learning is actively supported and occurs on a regular basis, children are less likely to receive these benefits.

Teachers generally tend to believe that early science education is important for children (Asma et al., 2011; Park et al., 2017; Pendergast et al., 2017). However, Park et al. (2017) found that about 30 percent of teachers in their study did not believe in the appropriateness or importance of early science education, and another 12 percent did not believe that they had the knowledge to answer if science was appropriate for young children. Similarly, Asma et al. (2011) found that teachers reported that science was important for children but could not explain why. Professional development training programs that focus on early science education could potentially increase teachers' awareness of the benefits of teaching science to young children. As suggested by Asma et al. (2011), teachers who had less training often stated that science was less important than reading, writing, and math.

Challenges in Teaching Science

Many of the challenges that early childhood teachers reported regarding teaching science included a lack of time, support, knowledge, professional development, and teacher collaboration (Asma et al., 2011; Park et al., 2017, Pendergast et al., 2017). For instance, Park et al. (2017), found that teachers also had challenges meeting the needs of their students such as different cognitive abilities and special needs. Teachers in Asma et al. (2011)'s study also reported that they lacked effective strategies to teach science to young children.

The challenges perceived by early childhood teachers are also related to their attitudes toward teaching science (Asma et al., 2011; Park et al., 2017; Pendergast et al., 2017). Asma et al. (2011) found that teachers with negative attitudes toward teaching science also tend to perceive challenges related to contextual factors such as a lack of school support, time, materials, money, and knowledge. Similarly, Pendergast et al. (2017) found that teachers reported a feeling of ineptitude as science teachers due to poor experiences with science, and the lack of support, time, and materials.

Improving Attitudes

Literature is unclear about the contributing factors of science teaching attitudes, but professional development and teacher education programs are found to influence teachers' science teaching attitudes (Erden & Sönmez, 2001; Timur, 2012). Timur (2012) found that preservice teachers in teacher education programs who took science-related classes have more positive views toward science subjects and science teaching than those who did not take science-related courses. Erden & Sönmez (2001) found that teachers who have been teaching for a year or less have more positive attitudes towards science teaching, especially in developmental appropriateness, than teachers who have been teaching longer. They suggested this could be because teachers have "more enthusiasm and idealism" and "may be more willing to apply all their recent knowledge to the educational environment" (Erden & Sönmez, 2001, p. 1163). Van Aalderen-Smeets and van der Molen (2015) created a professional development course that challenged and drew awareness to teachers' attitudes toward teaching science and provided teachers with the opportunity to experience inquiry investigation to further develop their understanding. The training had a positive effect on teachers' personal and professional attitudes about science, their science teaching behavior, and their views on conducting science-related activities in their daily lives (van Aalderen-Smeets & van der Molden, 2015).

Science Teaching Attitudes and Student Outcomes

There is very little research on how teachers' attitudes toward science affect student performance, especially with young children (Mensah et al.,2013; Ravanis, 2017; Scrivner, 2009). A handful of studies exist about teachers' attitudes toward curriculum and students' achievement with older children, but their findings are mixed. Scrivner's (2009) study surveyed 136 third through sixth-grade teachers and found that teachers' attitudes toward curriculum was not associated with student math achievement, but there was a slight positive relationship with student literacy achievement. Mensah et al. (2013) also examined the relationship between teacher attitudes and math performance. Mensah et al. (2013) surveyed 100 tenth and eleventh-grade students and four math teachers; they found that there was a significant positive relation between teacher attitudes toward math and student attitudes toward math, which were both positively correlated with student performance.

Science Teaching Efficacy

According to Bandura (1997), efficacy refers to individuals' beliefs about their ability in a particular domain. The four sources of efficacy include mastery experiences, vicarious experiences, social persuasion, and physiological states (Bandura, 1997). Mastery experiences are how individuals understand their experiences: successful experiences raise one's efficacy, and failures decrease it (Woolfolk, 2019). Physiological responses are how excited or anxious one feels before/during an experience (Bandura, 1997). Vicarious experiences refer to observing others' experiences (Bandura, 1997). Social persuasion is messages received from others such as pep talks and feedback (Woolfolk, 2019). Researchers indicate that science teaching efficacy is correlated with teachers' enacted instructional practices (Sandholtz & Ringstaff, 2014), which subsequently propel children's learning (Perera & John, 2020). Science teaching efficacy includes two subdomains: efficacy beliefs and outcome expectancy, which I discuss in detail below (Friday Institute for Educational Innovation, 2012).

Efficacy Beliefs

Teachers' science teaching efficacy beliefs is defined as teachers' beliefs in their own instructional ability in teaching science subjects (Velthuis et al., 2014). Asma et al. (2011) found that the experienced teachers whom they interviewed believed that low science teaching efficacy was the reason why teachers reported being uncomfortable or hesitant to teach science. Similarly, Oppermann et al. (2019) found that teachers with higher science teaching efficacy beliefs conducted science activities more frequently. The teachers interviewed in Asma et al.'s (2011) believed that low science teaching efficacy could be raised by changing attitudes toward science teaching.

Outcome Expectancy

Teachers' science teaching outcome expectancy refers to the degree to which teachers believe that their teaching will impact students' science learning (Friday Institute for Educational Innovation, 2012). Desouza et al. (2004) found that there is a stronger correlation between middle and high school science teachers' efficacy beliefs and outcome expectancy than that of elementary school teachers. They believe that this is because elementary school teachers are more likely to be certified in this area and teach science regularly (Desouza et al., 2004).

Years of teaching experience were found to be negatively associated with outcome expectancy (Desouza et al., 2004; Hassan & Hassan, 2012). Studying Biology, Chemistry, and Physics teachers, Hassan and Hassan (2012) found that those who had been teaching for fewer years had a higher outcome expectancy than those that had been teaching longer. The authors argued that this could be because of the enthusiasm of new teachers and their unawareness of the challenges associated with teaching science subjects (Hassan & Hassan, 2012). Similarly, Desouza et al. (2004), found that teachers with less experience were more confident that their teaching would influence students' achievement. Desouza et al. (2004) argued that experienced teachers were more aware of the fact that classroom instruction is not the only impacting factor on student achievement as compared to novice teachers. Other factors include student background, organizational support, and parental support, which are not within teachers' control (Bertolini et al., 2012).

Empirical Gaps

I identified three gaps in the existing literature. First, the research on science teaching attitudes and efficacy focuses on primary and secondary education (Mensah et al.,2013; Ravanis, 2017; Scrivner, 2009). Empirical attention is needed for science education at the early childhood level (Larimore, 2020), particularly for teachers who serve economically disadvantaged populations, such as Head Start teachers (Bustamante et al., 2018). Second, although it is unclear which factors contribute to early childhood teachers' science teaching attitudes, research on enhancing science teaching efficacy has pointed out several methods of improvement (Bautista, 2011; Schoon & Boone, 1998; Tosun, 2000). Therefore, I sought to explore the relation between Head Start teachers' science teaching attitudes and efficacy to shed light on ways to improve early science education. The third gap that I found was that many studies on early childhood teaching attitudes and efficacy mostly focused on literacy or mathematics, but very few focused on science (e.g., Cakiroglu and Isiksal, 2009; Evans, 2011). Among the few studies, Asma et al. (2011) was the only study that specifically reported on both science teaching attitudes and efficacy, although only very briefly. Additionally, Asma et al. (2011) adopted a qualitative method which provided less generalizable results than quantitative studies (Polit & Beck, 2010).

Significance of the Study

This research provides new insights into the relation between science teaching attitudes and science teaching efficacy in preschool teachers. Specifically, the present study could potentially benefit disadvantaged children’s learning by investigating Head Start teachers’ science teaching attitudes and efficacy. Moreover, this study provides empirical evidence regarding the relation between teaching attitudes and efficacy, which is lacking in the existing literature. Lastly, results from this study have implications for teacher preparation and professional development programs that aim to improve the quality of early science education.

Research Questions

1. Is teachers’ perceived science teaching challenge associated with their science teaching efficacy beliefs (controlling for teachers’ experience and degree)?
2. Is teachers’ perceived science teaching comfort associated with their science teaching efficacy beliefs (controlling for teachers’ experience and degree)?

3. Is teachers’ perceived science teaching benefit associated with their science teaching efficacy beliefs (controlling for teachers’ experience and degree)?

Chapter 3: Methodology

Research Design

This survey study utilized existing data that were collected for a larger study. The original survey included teachers' demographic questionnaires, science teaching efficacy, attitudes, metacognitive awareness, and teaching thinking skills rating scales. Additionally, seven teachers were randomly selected among participants to be interviewed by researchers. The present study focuses on quantitative measures of teachers' demographics, science teaching efficacy, and attitudes. The study is approved by the Institutional Review Board (IRB) at the University of Idaho (IRB number: 19-257).

Participants

A total of 153 participants completed the online survey. After examining boxplots, one outlier was found and removed from the dataset. Another participant was excluded from the analysis because the information was identical to another participant, therefore it was assumed that the two data points were duplicates. The third participant was excluded from the analysis because this participant only completed the demographic information. The final sample size was 150 participants (Table 1). Participants' highest education level included GED, High School Diploma, Associate degree, BA/BS degree, and MS/MA degree. Participants' major in their highest degree included Early Childhood Education, Education, and other majors (e.g., Arabic language, history, and secondary education). Participants also disclosed if they participated in STEM-related professional development programs in the past 12 months.

Table 1

Descriptive Statistics

	N	M/percentage	*SD*	Min.	Max.
Race		2.21	1.36	1	8
Black/African	18	12.00			
White	122	81.33			
Pacific Native	1	.67			
Native American/ Alaskan Native	1	.67			
Multiracial	3	2.00			
Other	5	3.33			
Ethnicity		1.88	.33	1	2
Hispanic/Latino	18	12.00			
Not Hispanic/Latino	132	88.00			
Gender		1.99	.08	1	2
Female	147	98.00			
Male	1	.67			
Age (yrs.)		39.82	11.40	21	68
Experience		10.88	8.47	0	40
Degree		3.29	.96	1	5
GED	3	2.00			
High School Diploma	30	20.00			
Associate degree	52	34.67			
BA/BS Degree	51	34.00			
MS/MA Degree	14	9.33			
Major		1.69	.89	1	3
Early Childhood	74	49.33			
Education	15	10.00			
Other	35	23.33			
CDA					
Yes	107	71.33			
No	43	28.67			
PD					
Yes	61	40.67			
No	89	59.33			
Challenges	150	.02	4.69	-11.70	12.71
Comfort	150	.10	6.88	-18.18	17.60
Benefit	150	.11	4.22	-10.93	8.28
STEB	150	.05	6.19	-16.69	16.50
STOE	150	.05	4.23	-11.75	13.31

Note. GED = General Educational Development; CDA = Child Development Associate; PD = Professional Development; STEB = Science Teaching Efficacy and Beliefs; STOE = Science Teaching Outcome Expectancy. STEB and STOE scores were centered within clusters.

Data Collection Procedure

Data were collected from June to November 2020, from 21 centers in eight different states: Alabama, Arkansas, Idaho Florida, Kansas, Montana, Washington, and Georgia. Upon IRB approval, the researchers contacted 227 regional Head Start directors to ask their permission for data collection. Participating directors then distributed the online survey link to Head Start teachers via email. Three monthly reminders were sent to the Head Start directors and teachers. Participants completed a quantitative online survey designed to measure teachers' science teaching attitudes and efficacy. Each teacher participant received a small digital gift card as a thank you for participating.

Instruments

Preschool Teachers' Attitudes and Beliefs Toward Science Questionnaire

The Preschool Teacher Attitude and Beliefs Toward Science Questionnaire (P-TABS), is a self-reported questionnaire, measuring preschool teachers' attitudes and beliefs toward science teaching. P-TABS is a five-point Likert scale ranging from Strongly Disagree to Strongly Agree. The P-TABS questionnaire (α = .91), has three subscales. The first subscale is Teacher Comfort (α = .89), consisting of 14 items such as: *Get ideas from what kids do, say, ask; Discuss ideas, issues with other teachers; Comfortable doing science activities* (Maier et al., 2010). Maier et al. (2010) define teacher comfort as teachers' comfort level regarding planning and doing science activities in the classroom. The second subscale is Child Benefit (α = .85), consisting of 10 items, for example: *Science improves approaches to learning; Young children are curious about science; Science activities too difficult for children* (Maier et al., 2010). Child benefit is defined as teachers' beliefs about how teaching science in the classroom creates an interest in science for children and their beliefs on if science improves their school readiness (Maier et al., 2010). The third subscale is Challenges (α = .71), consisting of 7 items, such as: *Don't have enough knowledge to teach sci; Uncomfortable talking about sci method; Plan/demonstrating science is hard; Don't have enough materials to do science* (Maier et al., 2010). Teacher challenge is defined as negative attitudes and beliefs toward science such as their discomfort, ability levels, and time needed to do science activities (Maier et al., 2010).

Teacher Efficacy and Attitudes Toward STEM – Elementary Teachers Survey

Teachers' science teaching efficacy is measured by the science subscales in the Teacher Efficacy and Attitudes Toward STEM – Elementary Teachers survey (T-STEM-E; Friday Institute for Educational Innovation, 2012). The two scales measuring science teaching efficacy are Teacher Efficacy and Attitudes Toward STEM – science (T-STEM-S). The Science Teaching Efficacy and Beliefs (STEB) scale measures teacher confidence and efficacy toward teaching science (Friday Institute for Educational Innovation, 2012). The STEB questionnaire (α = .91) consists of 11 items on a five-point Likert scale, ranging from Strongly Disagree to Strongly Agree. Some items on this scale include: *I am confident that I can explain to students why science experiments work; I am confident that I can answer students' science questions; I know what to do to increase student interest in science* (Friday Institute for Educational Innovation, 2012).

The Science Teaching Outcome Expectancy (STOE) scale measures how much teachers believe their science teaching impacts student learning (Friday Institute for Educational Innovation, 2012). The STOE questionnaire (α = .81), consists of nine items and is rated on a five-point Likert scale from Strongly Disagree to Strongly Agree. Example items on this scale are: *The inadequacy of a student's science background can be overcome* *by good teaching; Students' learning in science is directly related to their teacher's effectiveness in science teaching; Minimal student learning in science can generally be attributed to their teachers* (Friday Institute for Educational Innovation, 2012).

Data Analysis Strategies

The data used in this study has a nested structure with teachers clustered within Head Start centers. According to Peugh (2010), data with a nested structure violate the independence assumption needed for regular regression modeling, causing an increase in Type I errors. Therefore, a multilevel model approach was used to account for common variance shared at the center level. In the multilevel regression model, teachers were at level 1 and centers were at level 2. The software R was used for data analysis. R is an open-source programing language and environment for statistical computing and graphics (R Core Team, 2022). R package "lme4" (Bates et al., 2015) was used to handle multilevel regression.

The data were centered within the cluster at the Head Start center level (i.e., center within the cluster, CWC) to enhance the interpretability of the results. A multilevel model approach was used. In this study, I am interested in analyzing teacher-level associations, therefore centering within the cluster is recommended to reduce between-cluster variation, allowing a better estimate of the regression coefficient β (Enders & Tofighi, 2007).

Fully unconditional models were fitted first with STEB and STOE as outcomes, respectively. Intraclass correlation (ICC) was calculated (ICC_{STEB} = .01; ICC_{STOE}=.04). Although some researchers argued that there is no need to use multilevel analysis when the ICC values are small (e.g., Aarts et al., 2014; Garson, 2013), I followed the advice offered by Pornprasertmanit et al. (2014), who reasoned that the common variances shared at the group level should be properly modelled using a multilevel approach regardless of the size of ICCs.

Chapter 4: Results and Findings

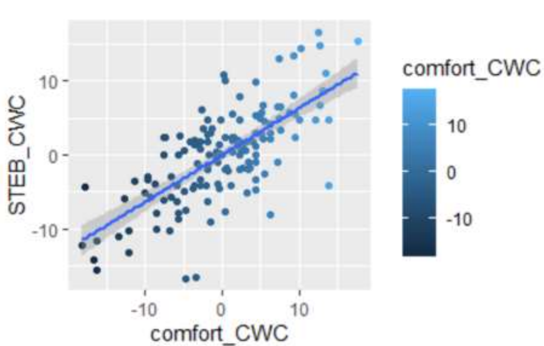
A total of 150 teachers were included in the analysis. All participants completed the demographics questionnaire, P-TABS questionnaire, STEB and STOE subscales. Multilevel regression results were discussed in the section below and shown in Table 1.

Research Question 1

To answer the question*, "Is teachers' perceived science teaching comfort associated with their science teaching efficacy beliefs (controlling for teachers' experience and degree)?"* I found that teachers' perceived level of comfort in science teaching was significantly and positively associated with STEB (β = .64, $p < .001$). As the average teacher-perceived comfort increased by one unit, the average STEB increased by .64 units. In other words, teachers who felt more comfortable teaching science had a higher science teaching efficacy than those who felt less comfortable. Additionally, the model explained half of the variance in STEB (R^2 = .50). An R^2 of .50 suggested that the model has good explanatory power (Marquez, 2018). However, there is no significant correlation between teachers' perceived comfort and STOE (β = .05, p = .31). As Figure 1 indicates, there is a strong positive correlation between STEB and Comfort.

Figure 1

Science Teaching Efficacy as a Function of Teacher's Perceived Comfort



Note. Head Start teachers' attitudes were significantly associated with science teaching efficacy beliefs (STEB). Comfort and STEB were centered within the cluster at the center level and a multilevel analysis was run. CWC= variable was centered within the cluster (e.g., comfort_CWC, STEB_CWC).

Table 2

Two-level Regression

	Model R^2	*Predictors*	*β*	*se*	*t*	*ρ*
STEB	.14	Challenge	-.50**	.10	-4.93	<.001
	.50	Comfort	.64***	.05	12.16	<.001
	.08	Benefit	.42***	.12	3.55	.001
STOE	.01	Challenge	.04	.07	.57	.57
	.01	Comfort	.05	.05	1.02	.31
	.03	Benefit	.17*	.08	2.02	.05

Note. *$p < .05$, **$p < .01$, ***$p < .001$. STEB = Science Teaching Efficacy and Beliefs; STOE = Science Teaching Outcome Expectancy

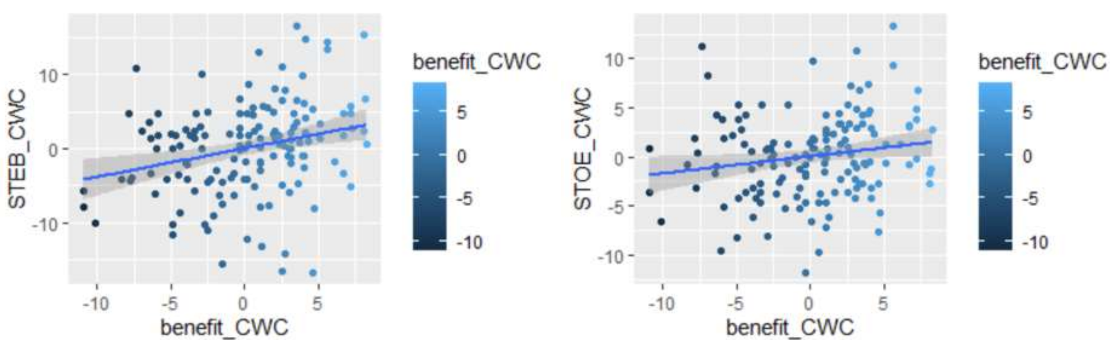
Research Question 2

To answer the question, *"Is teachers' perceived science teaching benefit associated with their science teaching efficacy beliefs (controlling for teachers' experience and degree)?"* Results indicated that teachers' perceived benefit beliefs of teaching science to young children were significantly and positively associated with STEB (β = .42, $p < .001$, R^2 = .08). Thus, as teachers perceived child benefits increased by one unit, STEB increased by .42 units, meaning that teachers who believed that science was important for young children have higher science teaching efficacy. Moreover, there was a significant positive relationship between teachers' child benefit beliefs and STOE (β = .17, p = .05, R^2 = .03).

As teachers' perceived child benefit beliefs increased by one unit, teachers' perceived STOE increased by .17 units. Teachers who believed that science teaching was beneficial to children also perceived that their science teaching was effective. As Figure 2 indicates, there is a positive correlation between STEB and Benefit and a positive correlation between STOE and Benefit.

Figure 2

Science Teaching Efficacy as a Function of Teachers' Perceived Child Benefit



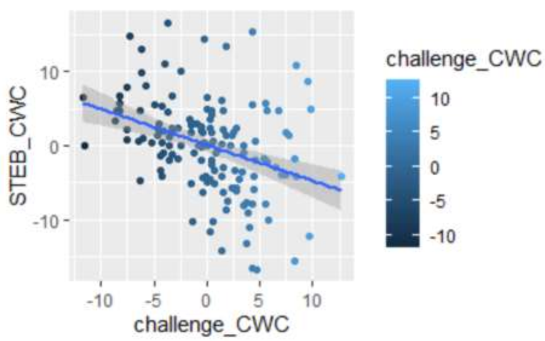
Note. Head Start teachers' child benefit was significantly associated with science teaching efficacy beliefs (STEB). Child benefit was associated with teachers' science teaching outcome expectancy (STOE). Benefit, STEB, and STOE were centered within the cluster at the center level and a multilevel analysis was run. CWC= variable was centered within the cluster (e.g., benefit_CWC, STEB_CWC, STOE_CWC).

Research Question 3

To answer the question, "*Is teachers' perceived science teaching challenge associated with their science teaching efficacy beliefs (controlling for teachers' experience and degree)?"* I found that teachers' perceived challenges were significantly and negatively associated with STEB (β = -.50, p < .001, R^2 = .14) indicating that as teachers perceived challenges decreased by one unit, STEB increased by .50 units, meaning that teachers who perceived fewer challenges tended to have a higher science teaching efficacy and vice versa. However, when looking at STOE, I did not find any significant relationship between teachers' perceived challenges and STOE (β = .04, p = .57). As Figure 1 indicates, there is a strong negative correlation between STEB and Challenge.

Figure 3

Science Teaching Efficacy as a Function of Teachers' Perceived Challenges



Note. Head Start teachers' challenges were significantly associated with science teaching efficacy beliefs (STEB). Challenge and STEB were centered within the cluster at the center level and a multilevel analysis was run. CWC= variable was centered within the cluster (e.g., challegnge_CWC, STEB_CWC).

Chapter 5: Discussion, Limitations, Future Direction, and Conclusions

The current study aims to explore the relation between Head Start teachers' attitudes toward teaching science and their science teaching efficacy. Data analysis suggested that all three domains of Head Start teachers’ science teaching attitudes (i.e., comfort, child benefits, challenges) were strongly correlated with science teaching efficacy beliefs. However, only child benefit was related to science teaching outcome expectancy. Results from this study suggest that teachers may have more positive attitudes toward science teaching when they feel efficacious about teaching science. Research on efficacy clearly pointed out ways to improve efficacy (Bautista, 2011; Schoon & Boone, 1998; Tosun, 2000; Tschannen-Moran & McMaster, 2009), which could potentially be used to elevate early childhood teachers’ attitudes toward science teaching. In this section, I discuss the interpretation and implication of my research findings.

Teachers’ Perceived Comfort and Science Teaching Efficacy

Results from the present study indicate that Head Start teachers’ comfort with science teaching was strongly and positively related to their science teaching efficacy beliefs. Previous research has found that teachers who reported feeling comfortable with teaching science in the classroom tended to have a higher science teaching efficacy (van Aalderen-Smeets & van der Monlden, 2015). Similarly, Oppermann et al. (2019) found that teachers with a higher science teaching efficacy taught science more frequently in the classroom. They concluded that when teachers’ science teaching efficacy was increased, teachers might feel more comfortable teaching science and offer science activities more frequently (Oppermann et al., 2019).

According to Bautista (2011) and Tosun (2000), mastery experiences and vicarious experiences, such as providing teachers with hands-on science teaching experiences, developmentally appropriate science content and pedagogical knowledge, and instructional support (e.g., science instruction coaching and modeling) in professional development programs, are effective ways to increase efficacy. Science related professional development programs have been shown to increase teachers' science teaching efficacy beliefs (Bautista, 2011; Schoon & Boone, 1998; Tosun, 2000; Tschannen-Moran & McMaster, 2009). Therefore, to increase early childhood teachers' comfort level with teaching science, policymakers and early childhood organization leaders should support teachers' professional development that targets teachers' science teaching efficacy through mastery and vicarious experiences, such as observing successful science lessons and giving science lessons with instructional support.

In the present study, teacher comfort with teaching science was not related to teachers' outcome expectancy – the other dimension of science teaching efficacy. It is possible that teachers believed that children's outcomes were related to a multitude of factors that are more related to contextual elements (e.g., student background, organizational support, and parental support) than their teaching practices (Bertolini et al., 2012). Asma et al. (2011) found that many teachers in their study ascribed contextual factors such as the lack of time, materials, support, and resources to their ineffective science teaching. It is possible that teachers in the present study attributed children's science learning outcomes to elements that were beyond their innate science teaching efficacy, which is in line with our theoretical framework – locus of control. Specifically, if teachers attribute children's science learning outcomes to contextual factors, such as resource support and children's baseline academic achievements, they may perceive more external locus of control, therefore may expect less favorable children's learning outcomes (Rotter, 1966).

In line with previous research (Schoon & Boone, 1998; Tosun, 2000), I found that teachers' science teaching attitudes were related to efficacy beliefs but not to science teaching outcome expectancy, indicating the need to improve teachers' ability to manage contextual factors related to science teaching. Bautista (2011) provided teachers with a science course that included both mastery experiences and vicarious experiences (e.g., interviews with children, experiences observing, coaching, and providing lessons to both children and peers). He found that these experiences increased both efficacy beliefs and outcome expectancy. Bautista (2011) suggested that giving teachers the opportunities to apply their knowledge in instructional practices through immersive professional development programs or college courses allows them to gain experience coping with contextual challenges, which could subsequently increase outcome expectancy (Bautista, 2011).

Head Start provides teachers with trainings to increase the knowledge and skills to successfully implement the curriculum (OHS, 2022). All of their teachers are required to complete 15 hours of training (OHS, 2022). If teachers were prodived with science related self-efficacy based professional development as a part of their required training, it could increase science teaching self-efficacy and outcome expactancy which would allow Head Start teachers to feel more comfortable teaching science.

Teachers' Perceived Child Benefit Beliefs on Science Teaching Efficacy

Child benefit beliefs were associated with Head Start teachers' science teaching efficacy in this study. In other words, teachers who are confident about teaching science may be more aware of the benefits of teaching science to young children. Asma et. al (2011) found that teachers who believed their untrained colleagues were less likely to teach science because of low science teaching efficacy. Based on the theory of planned behavior, teachers' beliefs about the benefits of teaching science to young children could influence their inclinations to carry out science activities (Ajzen & Fishbein, 1980). Therefore, Head Start could provide professional development training that explicitly outlines the benefit of teaching science to young children could potentially increase teachers' science teaching efficacy beliefs and their likelihood of conducting science activities in the classroom (Asma et al., 2011; Oppermann et al., 2019).

In this study, child benefit beliefs were the only domain in science teaching attitudes that were associated with teachers' science teaching outcome expectancy. In other words, teachers who are more knowledgeable about the benefits of teaching science to young children might perceive their teaching as more impactful. Asma et al. (2011) found that teachers with more training and experience were able to explain why science was important for children. This study showed that Head Start teachers who are more aware of the benefit of teaching science to young children may also have a clearer understanding of the connection between their instruction and children's outcomes (Asma et al., 2011).

Teachers' Perceived Challenges about Science Teaching

Data analysis results suggested that teacher-perceived challenges in teaching science in the classroom were negatively related to teachers' science teaching efficacy beliefs. The challenge subscale in the P-TABS Questionnaire included items about challenges regarding the lack of time, resources, knowledge, and pedagogy (Maier et al., 2010). Results indicated that teachers with a lower science teaching efficacy tended to perceive more challenges. Professional development training would allow teachers to raise their science teaching efficacy and overcome more challenges. For instance, van Aalderen-Smeets and van der Molden (2015) found that, after an attitude-focused professional development course, teachers reported higher levels of efficacy in addition to feeling less likely to be hindered by contextual challenges. This would be in line with our theoretical framework, locus of control, as Head Start teachers feel more confident in their science teaching, they might have a higher internal locus of control because they feel less hindered by contextual factors (Rotter, 1966). Moreover, Head Start, along with other early childhood organizations and policymakers should consider remediating certain early science education challenges by providing funding, training, and source support (Larimore, 2020).

Teachers' science teaching challenges were not related to teachers’ science teaching outcome expectancy. This could be because STOE asks teachers to access the degree to which children’s outcomes are direct results of their teaching (Friday Institute for Educational Innovation, 2012). However, the challenges scale tapped into elements beyond teachers’ instruction, for example, time, resources, and knowledge they perceived as challenges. Therefore, regardless of how beneficial they believe their science teaching might be, teachers might perceive that the science teaching challenges are dictated by elements beyond their control (i.e., external locus of control). According to the locus of control theory, individuals who perceive a large degree of external locus of control may perceive themselves as less capable of changing the outcomes (Rotter, 1966). For example, some childcare programs might have a required curriculum (Oliver & Klugman, 2006), which could leave teachers with little time to teach science. Therefore, teachers may feel, because of external factors, their teaching has very little impact on student outcomes.

Limitations and Future Directions

There are a few limitations to this study. First, this study used a survey study design and self-reported data, which could potentially lead to subject bias (Grimm, 2010; van de Mortel, 2008). According to Grimm (2010) and van de Mortel (2008), participants may respond with the socially desired answers on self-reported questionnaires. There is also the possibility that participants interpreted the questions differently than what the questionnaire intended (Wyatt, 1982). Future researchers should consider using different data collection methods or a combination of several methods such as interviews, observations, or experimentation. Further research could also directly measure children's science learning outcomes and examine their relationship with teachers' science teaching attitudes and efficacy (Mensah et al.,2013; Scrivner, 2009).

The second limitation is the scope of this study. The survey data only showed teachers' perceptions of their attitudes and efficacy toward teaching science. This study did not include data regarding teachers' self-reported or observed instructional practices in the classroom. Teachers may have reported positive attitudes toward and a high-level of efficacy in science teaching, which may not reflect their enacted instructional practice (Pendergast et al., 2017; Tu, 2006). Future researchers could include classroom practices as a part of the survey data. Moreover, the study could be improved by collecting classroom observation data, for example, the frequency, duration, and quality of science teaching in early childhood classrooms (Cabell et al., 2013; Fuhs et al., 2013; Tu, 2006).

Third, this study has limited generalizability. Participants in this study were from Head Start centers in eight states across the U.S., however, they were not representative of all early childhood teachers (Polit & Beck, 2010). Further research could include data collected from more states to increase the generalizability of the study. This study also only included Head Start teachers; future researchers could expand the population by including private preschools to investigate the differences in teacher attitudes and efficacy between different types of childcare centers (e.g., Espen, 1999). Additionally, future researchers could conduct a longitudinal study by following up with preservice teachers in the first few years of their jobs to investigate the long-term impact of teacher education (e.g., Swars et al., 2009; Zhang & Zeller, 2016).

Conclusion

The present study bridged the empirical gaps regarding the limited understanding of preschool teachers' science teaching attitudes and efficacy. The results showed that there was a connection between all three dimensions of science teaching attitudes and efficacy beliefs. However, only the child benefits dimension of science teaching attitudes was related to outcome expectancy, indicating that positive attitudes toward teaching science are necessary but not sufficient for high-level science teaching efficacy. Results of this study suggest that it is possible to improve teachers' attitudes toward science teaching by boosting their science teaching efficacy through ways such as professional development. Specifically, Head Start teachers may benefit from professional development programs that enhance teachers' science teaching content and pedagogical knowledge, directly teach the benefit of early science education, and mitigate the challenges associated with teaching science subjects in early childhood settings (e.g., Bautista; 2011; Schoon & Boone, 1998; Tosun, 2000; van Aalderen, S. & Walma van der Molen, J.,2015). Moreover, teacher preparation programs and professional development programs could foster mastery and vicarious experiences, the two main sources of efficacy (Bandura, 1997), through coaching, modeling, and creating inquiry-based lessons (e.g. Luft, 2010; Thijs & van den Berg, 2002). Head Start provides and requires teachers to attend professional development training, some of that training could include science related, self-efficacy based professional development training to increase science teaching attitudes which could increase the amount of science offered in the classroom (Opperman et al., 2019).

References

Aarts, E., Dolan, C., Verhage, M., & Sluis, S. (2015). Multilevel analysis quantifies variation in the experimental effect while optimizing power and preventing false positives. *BMC Neuroscience, 16*(1). https://doi.org/10.1186/s12868-015-0228-5

Anderson, S., Medrich, E., & Fowler, D. (2007). Which achievement gap? *Phi Delta Kappan, 88*(7), 547-550. https://doi.org/10.1177.003172170708800716

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Prentice-Hall.

Asma, L., van der Molen, J. & van Aalderen, S. (2011). Primary teachers' attitudes towards science and technology. *Professional Development for Primary Teachers in Science and Technology, 9*(1), 89-105. https://doi.org/10.1007/978-94-6091-7134_8

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman & Company.

Bates, D., Maechler, M., Bolker, B. & Walker, S. (2015). lme4: Mixed-effects models in R (Version 1.1-30) [Computer software]. https://github.com/lme4/lme4/

Bautista, N. (2011). Investigating the use of vicarious and mastery experiences in influencing early childhood education majors' self-efficacy beliefs. *Journal of Science Teacher Education*, *22*(4), 333-349. https://doi.org/10.1007/s10972-011-9232-5

Bedel, E. F. (2015). Exploring academic motivation, academic self-efficacy and attitudes toward teaching in pre-service early childhood education teachers. *Journal of Education and Training Studies*, *4*(1), 142-149. https://doi.org/10.11114/jets.v4i1.561

Bertolini, K., Stremmel, A.J., & Thorngren, J.T. (2012). Student achievement factors. (n.p.).

Bustamante, A. S., White, L. J., & Greenfield, D. B. (2018). Approaches to learning and science education in Head Start: Examining bidirectionality. *Early Childhood Research Quarterly*, *44*(1), 34-42. https://doi.org/10.1016/j.ecresq.2018.02.013

Cabell, S., DeCoster, J., LoCasale-Crouch, J., Hamre, B., & Pianta, R. (2013). Variation in the effectiveness of instructional interactions across preschool classroom settings and learning activities. *Early Childhood Research Quarterly*, *28*(4)*,* 820–830. https://doi.org/10.1016/j.ecresq.2013.07.007

Cakiroglu, E. & Isiksal, M. (2009). Pre-service elementary teachers' attitudes and self-efficacy beliefs toward mathematics. *Education and Science*, *34* (151), 132-139. https://www.researchgate.net/publication/289771649_Preservice_elementary_teachers'_attitudes_and_self-efficacy_beliefs_toward_mathematics

Center on the Developing Child. (2019) *Brain architecture*. Center on the Developing Child at Harvard University. https://developingchild.harvard.edu/science/key-concepts/brain-architecture/

Curran, F. C., & Kitchin, J. (2019). Early elementary science instruction: Does more time on science or science topics/skills predict science achievement in the early grades? *American Education Research Association Open*, *5*(3), https://doi.org/10.1177/2332858419861081

Dailey, D., & Robinson, A. (2016). Elementary teachers: Concerns about implementing a science program. *School Science and Mathematics*, *116*(3), 139-147. https://doi.org/10.1111/ssm.12162

Desouza, J.M.S., Boone, W.J. and Yilmaz, O. (2004), A study of science teaching self-efficacy and outcome expectancy beliefs of teachers in India. *Science Education*, *88*(6), 837-854. https://doi.org/10.1002/sce.20001

Donovan, C. A., Smolkin, L. B., & Lomax, R. G. (2000). Beyond the independent-level text: Considering the reader? Text match in first graders' self-selections during recreational reading. *Reading Psychology, 21*(4), 309-333. https://doi.org/10.1080/027027100750061949

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes.* Harcourt Brace Jovanovich College Publishers.

Enders, C. K., & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: A new look at an old issue. *Psychological Methods*, *12*(2), 121-138. https://doi.org/10.1037/1082-989X.12.2.121

Erden, F. T. & Sönmez, S. (2011). Study of Turkish preschool teachers' attitudes toward science teaching. *International Journal of Science Education*, *33*(8), 1149-1168. https://doi.org/10.1080/09500693.2010.511295

Epstein, A. S. (1999) Pathways to quality in head start, public school, and private nonprofit early childhood programs, *Journal of Research in Childhood Education*, *13*(2), 101-119, https://doi.org/10.1080/02568549909594732

Evans, B.R. (2011). Content knowledge, attitudes, and self-efficacy in the mathematics New York City Teaching Fellows (NYCTF) Program. *School Science and Mathematics*, *111*(5), 225-235. https://doi.org/10.1111/j.1949-8594.2011.00081.x

Friday Institute for Educational Innovation (2012). *Teacher efficacy and attitudes toward STEM survey-elementary teachers*. Authors.

Friedman, S. (2016, May 10). *Stem starts early!* National Association for the Education of Young Children. https://www.naeyc.org/resources/blog/stem-starts-early

Fuhs, M.W., Farran, D., & Nesbitt, K.T. (2013). Preschool classroom processes as predictors of children's cognitive self-regulation skills development. School Psychology Quarterly, *28*(4), 347-359. https://doi.org/10.1037/spq0000031

Garson, G. D. (2013). *Hierarchical linear modeling: Guide and applications.* SAGE Publications, Inc., https://dx.doi.org/10.4135/9781483384450

Gerde, H. K., Pierce, S. J., Lee, K., & Van Egeren, L. A. (2018). Early childhood teachers' self-efficacy in science, math, and literacy instruction and science practice in the classroom. *Early Education and Development*, *29*(1), 70-90. https://doi.org/10.1080/10409289.2017.1360127

Grimm, P. (2010). Social desirability bias. In J. Sheth, & N. Malhotra (Eds.), *Wiley International Encyclopedia of Marketing.* John Wiley & Sons. https://doi.org/10.1002/9781444316568.wiem02057

Hassan, A. & Hassan, T. (2012). Science teaching self-efficacy and outcome expectancy beliefs of secondary school teachers in UAE. *International Journal for Research in Education*, *32*, 1-22. https://www.semanticscholar.org/paper/Science-Teaching-Self-Efficacy-and-Outcome-Beliefs-Hassan-Tairab/61ff7d2b9ab71e72380ea3be25f6f2675ebd1bb0

Jeynes, W. H. (2015). A meta-analysis on the factors that best reduce the achievement gap. *Education and Urban Society, 47*(5), 523-554. https://doi.org/10.1177/0013124514529155

Larimore, R. A. (2020). Preschool science education: A vision for the future. *Early Childhood Education Journal*, *48*(1), 703-714. https://doi.org/10.1007/s10643-020-01033-9

Lee, S. A. (1993). Family structure effects on student outcomes. In B. Schneider & James S. Coleman (Eds.), *Parents, Their Children, and Schools*. Routledge.

Luft, J. A. (2001) Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education*, *23*(5), 517-534, https://doi.org/10.1080/09500690121307

Maier, M. F., Greenfield, D. B., & Bulotsky-Shearer, R. J. (2013). Development and validation of a preschool teachers' attitudes and beliefs toward science teaching questionnaire. *Early Childhood Research Quarterly*, *28*(2), 366-378. https://doi.org/10.1016/j.ecresq.2012.09.003

Marquez, M. (2018). *What's an acceptable value for R-squared?* Marketing Science Macky. http://www.marketingsciencemacky.com/2018/01/17/whats-an-acceptable-r-squared-value-for-data-models/

McClure, E. R., Guernsey, L., Clements, D. H., Bales, S. N., Nichols, J., Kendall-Taylor, N., & Levine, M. H. (2017). *STEM starts early: Grounding science, technology, engineering, and math education in early childhood.* The Joan Ganz Cooney Center at Sesame Workshop. https://files.eric.ed.gov/fulltext/ED574402.pdf

Mensahh, J. K., Okyere, M., & Kuranchie, A. (2013). Student attitude towards mathematics and performance: Does the teacher attitude matter? *Journal of Education and Practice, 4*, 132-139. https://www.researchgate.net/publication/334122369_Student_attitude_towards_Mathematics_and_performance_Does_the_teacher_attitude_matter#:~:text=The%20study%20unveiled%20a%20significant%20relationship%20between%20teacher,develop%20positive%20attitude%20towards%20the%20learning%20of%20Mathematics.

Mesrobian, C. (2022). *What is the achievement gap (and can quality pre-K help?).* Rasmussen University. https://www.rasmussen.edu/degrees/education/blog/what-is-the-achievement-gap/

Morgan, P. L., Farkas, G., Hillemeier, M. M., & Maczuga, S. (2016). Science achievement gaps begin very early, persist, and are largely explained by modifiable factors. *Educational Researcher, 45*(1), 18–35. https://doi.org/10.3102/0013189X16633182

National Head Start Association. (2022). *About NHSA*. National Head Start Association. https://nhsa.org/about-nhsa/

Next Generation Science Standards. (2013). *Frequently Asked Questions.* Next Generation Science Standards. https://www.nextgenscience.org/faqs

Nezlek, J. B. (2012). Multilevel Modeling for Psychologists. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology, Vol. 3. Data analysis and research publication* (pp. 219–241). American Psychological Association. https://doi.org/10.1037/13621-011

Office of Head Start. (2022). *Curriculum fidelity.* Early Childhood Learning and Knowledge Center. https://eclkc.ohs.acf.hhs.gov/browse/tag/curriculum-fidelity

Office of Head Start. (2022). *About the office of head start*. Early Childhood Learning and Knowledge Center. https://eclkc.ohs.acf.hhs.gov/about-us/article/about-office-head-start

Office of Head Start. (2022). *Head Start services*. The Administration for Children and Families. https://www.acf.hhs.gov/ohs/about/head-start

Oliver, S. J., & Klugman, E. (2006). Play and standards-driven curricula: Can they work together in preschool? *Exchange Magazine*, 12-14. https://www.researchgate.net/publication/242231918_Play_and_Standards-Driven_Curricula_Can_They_Work_Together_in_Preschool

Oppermann, E. & Brunner, M. & Anders, Y. (2019). The interplay between preschool teachers' science self-efficacy beliefs, their teaching practices, and girls' and boys' early science motivation. *Learning and Individual Differences*, *70*, 86-99. https://doi.org/10.1016/j.lindif.2019.01.006

Park, M. H., Dimitrov, D. M., Patterson, L. G., & Park, D. Y. (2017). Early childhood teachers’ beliefs about readiness for teaching science, technology, engineering, and mathematics. *Journal of Early Childhood Research*, *15*(3), 275-291. https://doi.org/10.1177/1476718X15614040

Pendergast, E. & Lieberman, R. & Vail, C. (2017). Attitudes and beliefs of prekindergarten teachers toward teaching science to young children. *Early Childhood Education Journal, 45*(1), 43-52. https://doi.org/10.1007/s10643-015-0761-y

Pentimonti, J. M., Gerde, H. K., & Pikus, A. E. (2020). *Finding time for science: Using informational texts to increase children's engagement, knowledge, and literacy.* National Association for the Education of Young Children. https://www.naeyc.org/resources/pubs/yc/sept2020/finding-time-for-science

Perera, H. N., & John, J. E. (2020). Teachers' Self-efficacy beliefs for teaching math: relations with teacher and student outcomes. *Contemporary Educational Psychology, 61*(1), 101-142. https://doi.org/10.1016/j.cedpsych.2020.101842

Perren, S., Herrmann, S., Iljuschin, I., Frei, D., Körner, C., & Sticca, F. (2017). Child-centered educational practice in different early education settings: Associations with professionals' attitudes, self-efficacy, and professional background. *Early Childhood Research Quarterly*, *38*(1), 137-148. https://doi.org/10.1016/j.ecresq.2016.07.001

Peugh J. L. (2010). A practical guide to multilevel modeling. *Journal of School Psychology*, *48*(1), 85-112. https://doi.org/10.1016/j.jsp.2009.09.002

Polit, D. F., & Beck, C. T. (2010). Generalization in quantitative and qualitative research: Myths and strategies. *International Journal of Nursing Studies*, *47*(11), 1451-1458. https://doi.org/10.1016/j.ijnurstu.2010.06.004

Pornprasertmanit, S., Lee, J., & Preacher, K. J. (2014). Ignoring clustering in confirmatory factor analysis: Some consequences for model fit and standardized parameter estimates. *Multivariate Behavioral Research, 49*(6), 518-543. https://doi.org/10.1080/00273171.2014.933762

Ravanis, K. (2017). Early childhood science education: State of the art and perspectives. *Journal of Baltic Science Education*, *16*(3), 284-288. https://www.researchgate.net/publication/317784579_Ravanis_K_2017_Early_Childhood_Science_Education_state_of_the_art_and_perspectives_Journal_of_Baltic_Science_Education_163_284-288

R Core Team (2022). R: A language and environment for statistical computing. (Version 4.2.1) [Computer software] R Foundation for Statistical Computing. https://www.R-project.org/

Rotter, J. B. (1966). Generalized Expectancies for Internal Versus External Control of Reinforcement. *Psychological Monographs*: *General and Applied*, *80*(1), 1–28. https://doi.org/10.1037/h0092976

Sandholtz, J.H., & Ringstaff, C. (2013). Assessing the impact of teacher professional development on science instruction in the early elementary grades in rural US schools. *Professional Development in Education, 39*(5), 678 - 697. https://doi.org/10.1080/19415257.2012.751044

Sarama, J., Clements, D., Nielsen, N., Blanton, M., Romance, N., Hoover, M., Staudt, C., Baroody, A., McWayne, C., and McCulloch, C., (2018). *Considerations for STEM education from PreK through grade 3.* Community for Advancing Discover Research in Education. http://cadrek12.org/resources/considerationsstem-education-prek-through-grade-3.

Schoon, K.J. and Boone, W.J. (1998), Self-efficacy and alternative conceptions of science of preservice elementary teachers. *Science Education*, *82*(1), 553-

568. https://doi.org/10.1002/(SICI)1098-237X(199809)82:5<553::AID-SCE2>3.0.CO;2-8

Scrivner, C. (2009). *The relationship between student achievement and teacher attitude: A correlational study* (Publication No. 3351416) [Doctoral Dissertation, Northcentral University]. ProQuest Dissertations Publishing. https://www.proquest.com/openview/9e8a9b96cd3c3278b952025b6d5f3bbc/1?pq-origsite=gscholar&cbl=18750.

Smolkin, L. B., & Donovan, C. A. (2001). The contexts of comprehension: The information book read aloud, comprehension acquisition, and comprehension instruction in a first-grade classroom. *The Elementary School Journal*, *102*(2), 97–122. https://doi.org/10.1086/499695

Swars S. L., Smith S. Z., Smith M. E., & Hart L. C. (2009). A longitudinal study of effects of a developmental teacher preparation program on elementary prospective teachers' mathematics beliefs. *Journal of Mathematics Teacher Education*, *12*(1), 47–66. https://doi.org/10.1007/s10857-008-9092-x

Thijs, A. & van den Berg, E. (2002). Peer coaching as part of a professional development program for science teachers in Botswana. *International Journal of Educational Development, 22*(1), 55-68. https://doi.org/10.1016/S0738-0593(00)00078-X

Timur, B. (2012). Determination of factors affecting preschool teacher candidates' attitudes towards science teaching. *Educational Sciences: Theory and Practice*, *12*(4), 2997-3009. https://eric.ed.gov/?id=EJ1002995

Tosun, Tark. (2000). The impact of prior science course experience and achievement on the science teaching self-efficacy of preservice elementary teachers. *Journal of Elementary Science Education. 12*(2), 21-31. https://doi.org/10.1007/BF03173597

Tschannen-Moran, M., and McMaster, P. (2009). Sources of self-efficacy: four professional development formats and their relationship to self-efficacy and implementation of a new teaching strategy. *Elementary School Journal*, *110*(2), 228-245. https://doi.org/10.1086/605771

Tu, T. (2006). Preschool science environment: What is available in a preschool classroom? *Early Childhood Education Journal, 33*(4), 245-251. https://doi.org/10.1007/s10643-005-0049-8

van Aalderen, S. & Walma van der Molen, J. (2015). Improving primary teachers' attitudes toward science by attitude-focused professional development. *Journal of Research in Science Teaching, 52*(5), 710-734. https://doi.org/10.1002/tea.21218

van Aalderen-Smeets, S. I., & Walma van der Molen, J. H., & Asma, L. J. F. (2011). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education*, *96*(1), 158-182. https://doi.org/10.1002/sce.20467

van de Mortel, T.F. (2008) Faking it: Social desirability response bias in self-report research. *Australian Journal of Advanced Nursing*, *25*(4), 40-48. https://www.researchgate.net/publication/46574012_Faking_it_Social_desirability_response_bias_in_self-report_research

Velthuis, C., Fisser, P., & Pieters, J. (2014). Teacher training and pre-service primary teachers' self-efficacy for science teaching. *Journal of Science Teacher Education*, *25*(4), 445-464. https://doi.org/10.1007/s10972-013-9363-y

Wyatt, R. (1982). Questionnaires without tears, *Urban Policy and Research*, *1*(1), 8-12. https://doi.org/10.1080/08111148208522668

Woolfolk, A. (2019). *Educational psychology* (14th ed.). Pearson.

Worth, K. (2010). *Science in early childhood classrooms: Content and process*. Early Childhood Research and Practice - Beyond This Issue. https://ecrp.illinois.edu/beyond/seed/worth.html

Yopp, R. H., & Yopp, H. K. (2006). Informational texts as read-alouds at school and home. *Journal of Literacy Research*, *38*(1), 37–51. https://doi.org/10.1207/s15548430jlr3801_2

Zhang, G., & Zeller, N. (2016). A longitudinal investigation of the relationship between teacher preparation and teacher retention. *Teacher Education Quarterly, 43*(2), 73-92. https://files.eric.ed.gov/fulltext/EJ1100322.pdf

Appendix A

Teachers' Demographic Questionnaire

Teacher Demographics

Gender: M __ F __ Date of Birth (MM/YYYY)______

Race: White__ African American/Black__ Asian__

American Indian__ Other ________________________

Hispanic/Latino: Yes__ No__

Highest education level completed:

____GED ____High school diploma

____Associates' Degree

____BA/BS Degree

____ MS/MA Degree

Major in highest degree if applicable _____________________

Completion of CDA or equivalent: Yes__ No__

Have you completed credit-earning course content on teaching science to young children?

Yes__ No__ If YES, was this: __A separate course __Part of a course

When teaching **science** to young children, what are some of your challenge(s)?

When teaching **thinking skills** (e.g., inquiry and scientific thinking skills) to young children, what are some of your challenge(s)?

You school is in: Rural_____ Urban______ Suburban______ Other________

Certified teacher (ID, WA, FL or other state): Yes__ No__

Check all options that match the sites in which you have worked:

Public school prekindergarten__ Head Start program__

Private preschool (for profit) __ Private preschool (nonprofit) __

Including the current school year, how many years of experience do you have as a teacher/aide in classrooms serving 3-7-year-old children? _________

Do you follow any science teaching standard? Yes____ No____

If so, what's the name of the science standard? __________

Appendix B

Preschool Teachers' Attitudes and Beliefs Toward Science Questionnaire

Preschool Teacher Attitudes and Beliefs Toward Science Questionnaire (P-TABS)

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters: **strongly disagree** (**SD**), **mildly disagree** (**MD**), **neutral** (**N**), **mildly agree** (**MA**), or **strongly agree** (**SA**)

1. Preschool science activities help foster children's interest in science in later grades.
2. I feel comfortable planning and demonstrating classroom activities related to physical and energy

science topics (e.g., force of gravity; gas, liquids, solids).

3. More science should be taught in the early childhood classroom.
4. It is important for my classroom to have a science area that can be freely explored by children.
5. Given other demands, there is not enough time in a day to teach science.
6. Experimenting hands-on with materials and objects is how young children learn best.
7. Science-related activities help improve preschoolers' approaches to learning.
8. I discuss ideas and issues of science teaching with other teachers.
9. I use all kinds of classroom materials (e.g., blocks, toys, boxes) for science activities.
10. Preparation for science teaching takes more time than other subject areas.
11. I use resource books to get ideas about science activities for young children.
12. I feel comfortable doing science activities in my early childhood classroom.
13. I feel comfortable planning and demonstrating classroom activities related to life science topics

(e.g., living things, plants, animals).

14. Science-related activities help improve preschoolers' math skills.
15. It is not appropriate to introduce science to children at an early age.
16. Science-related activities help improve preschoolers' language skills.
17. I do not have enough scientific knowledge to teach science to young children.
18. I feel uncomfortable using scientific tools such as scales, rulers, and magnifying glasses when

teaching science lessons.

19. I feel uncomfortable talking with young children about the scientific method (e.g., making
hypotheses, predicting, experimenting).
20. I use the internet to get ideas about science activities for young children.
21. Young children cannot learn science until they are able to read.
22. I get ideas for hands-on activities from what my preschoolers do, say, and ask.
23. Science-related activities are too difficult for young children.
24. I include some books about science during storytime.
25. Science-related activities help improve preschoolers' social skills.
26. I enjoy doing science activities with my preschool children.
27. I am afraid that children may ask me a question about scientific principles or phenomena that I
cannot answer.
28. I demonstrate experimental procedures (e.g., comparing objects to see if they will sink or float) in
my classroom.
29. I do not mind the messiness created when doing hands-on science in my classroom.
30. Planning and demonstrating hands-on science activities is a difficult task.
31. Young children are curious about scientific concepts and phenomena.
32. I do not have enough materials to do science activities.
33. I make an effort to include some science activities throughout the week.
34. I feel comfortable planning and demonstrating classroom activities related to earth science topics
(e.g., sun, moon, stars, weather).
35. I collect materials and objects to use in my science teaching.

Appendix C

Teacher Efficacy and Attitudes Toward STEM-Science Questionnaire

Teacher Efficacy and Attitudes Toward STEM-Science (T-STEM-S)

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Science teaching beliefs					
1. I am continually improving my science teaching practice.	○	○	○	○	○
2. I know the steps necessary to teach science effectively.	○	○	○	○	○
3. I am confident that I can explain to students why science experiments work.	○	○	○	○	○
4. I am confident that I can teach science effectively.	○	○	○	○	○
5. I wonder if I have the necessary skills to teach science.	○	○	○	○	○
6. I understand science concepts well enough to be effective in teaching science.	○	○	○	○	○
7. Given a choice, I would invite a colleague to evaluate my science teaching.	○	○	○	○	○

8. I am confident that I can answer students' science questions.	○	○	○	○	○
9. When a student has difficulty understanding a science concept, I am confident that I know how to help the student understand it better.	○	○	○	○	○
10. When teaching science, I am confident enough to welcome student questions.	○	○	○	○	○
11. I know what to do to increase student interest in science.	○	○	○	○	○

Science Teaching Outcome Expectancy (STOE)

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	○	○	○	○	○
2. The inadequacy of a student's science background can be overcome by good teaching.	○	○	○	○	○
3. When a student's learning in science is greater than expected, it is most often due to their teacher having found a more effective teaching approach.	○	○	○	○	○

4. The teacher is generally responsible for students' learning in science.	○	○	○	○	○
5. If students' learning in science is less than expected, it is most likely due to ineffective science teaching.	○	○	○	○	○
6. Students' learning in science is directly related to their teacher's effectiveness in science teaching.	○	○	○	○	○
7. When a low achieving child progresses more than expected in science, it is usually due to the extra attention given by the teacher.	○	○	○	○	○
8. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	○	○	○	○	○
9. Minimal student learning in science can generally be attributed to their teachers.	○	○	○	○	○