

**HEAD START TEACHERS' BELIEFS AND PRACTICES IN EARLY
SCIENCE EDUCATION**

By

Varsha Venugopal

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ABSTRACT

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Due to the increased attention to early childhood science education, this study sought to explain the known lack of science in preschool by examining Head Start teachers' beliefs about and practices for science. This qualitative study with collateral quantitative analyses of data of 124 Head Start teachers identified a range of science beliefs and practices and investigated this range in terms of several teacher background variables including teachers' education, experience, and role within the classroom. Results revealed that teachers in this study reported broad and general definitions of science for early childhood education. All practices reported by teachers can be categorized as developmentally appropriate practices. My study revealed that teachers' characteristics such as their educational background, their experience or their role in the classroom do not relate to their beliefs about early science or practices they employ to teach science to young children. Lastly, my findings also revealed that teachers' beliefs about science were not significantly related to their science practices.

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LITERATURE REVIEW

Introduction

Years of research on educational reforms aimed at reducing the achievement gaps between U.S. students and students in other countries show that children in the United States perform significantly poorer in science when compared to children from some other countries (National Center for Education Statistics, 2005). Gaps in achievement are also evident between the majority students and the economically disadvantaged, as well as to the non-Asian minority students (National Center for Education Statistics, 2005). Research indicates that these achievement gaps are a result of lack of science resources, insufficient teacher training and general inequities in science education (Duschl, Schweingruber, & Shouse, 2006; Brenneman et al., 2009; Nayfeld et al., 2011).

These overwhelmingly poor outcomes have resulted in increased attention to science education in early childhood. For example, prior to 2010 most states integrated science standards into the “general knowledge” sections of early learning standards (Greenfield, 2009). However, today, most schools highlight preschool science as its own readiness domain and emphasize specific learning expectations for science (Greenfield et al., 2009). On a national level, programs such as Head Start now include in their learning standards domain elements of “scientific skills and method” and “conceptual knowledge of the natural and physical world” (Office of Head Start, 2010). These changes to learning standards at a state and national levels are a reflection of administration’s recent press for improving science outcomes. However, the field remains uninformed regarding the value that early childhood educators have in the development of science skills and knowledge in the early years. Thus, the present study adds to the literature in a meaningful way by examining early childhood teachers’ beliefs about early science education.

Importance of Early Childhood Science Education

Greenfield and his colleagues (2009) identified that children often enter kindergarten with significantly lower readiness scores in science than in any other domain, including creative arts, math, language & literacy, motor development, socioemotional development and physical health. Children's poor performance in science in elementary school seems to be rooted in the ineffective introduction of science at the preschool level (Casserly, 2003). Interestingly, at the beginning of preschool, children possess similarly low skills across several domains, including language and literacy, math, and science. However, at the end of preschool, children show greater gains in language, literacy, and math domains than in their science knowledge (Greenfield et al., 2009). Clearly teachers are attending to science differently than they are to language, literacy, and math. In spite of many states and programs recognizing and highlighting the importance of preschool science readiness (e.g., Office of Head Start, 2010), and numerous cognitive researchers suggesting that preschoolers have the capacity to engage in complex scientific thinking (Duschl et al., 2006; Brenneman et al., 2009; Gleman & Brenneman, 2004; Conezio & French, 2002), it seems as though teachers of young children may not emphasize science.

Besides being a part of our everyday lives, science, when encouraged and integrated into classroom activities, helps build on children's natural curiosity (Morris et al., 2012). This lays the foundation for the complexity of knowledge they will learn when they reach elementary school and higher grades (Tu, 2006; Hong & Diamond, 2012). Moreover, engaging in science activities in early childhood results in better understanding of scientific concepts later in life (Eshach & Fried, 2005). By conducting their own investigations and asking questions, children learn to guide their own behaviors, which in turn promotes self-confidence in science and other

areas (Anderson & Gullberg, 2014). Furthermore, engaging in science related activities in preschool contributes to the development of children's core science process skills like observing, discovering, analyzing, commenting, and arguing differences and similarities, which they will come to rely on heavily in later school years (Ayvaci & Devecioglu, 2010; Lind, 1998).

Young children are capable of both abstract as well as concrete thinking (Schulz & Bonawitz, 2007). They have a reasonably rich understanding of how the world around them works and tend to seek out answers when confronted with confounding situations (Brenneman et al., 2009; Duschl et al., 2006). Preschoolers are capable of understanding concepts such as cause-and-effect as well as distinguishing between living and non-living things (Brenneman et al., 2009). These abilities develop from experience (Gleaman & Brenneman, 2004). Taking into account individual differences in maturity and experiences, research indicates that children have a predisposition to engage in science, are self-motivated to explore the world around them and may even go so far as to develop theories about how and why things work based on the evidence they can observe (Conezio & French, 2002). Studies indicate that the development of cognitive, sensory, psycho-motor skills, scientific process skills and scientific literacy of children is contingent on their exposure to science during the early childhood years (Ayvaci et al., 2002).

Providing children with opportunities for scientific exploration during the early years increases their interest in and positive attitudes about science (Zimmerman, 2007). Research also indicates that children tend to start preschool with a positive attitude towards science and can develop similar long-term attitudes, provided they find early science-related experiences engaging (Brenneman et al., 2009). Although, children are capable of learning science concepts and skills early on, and there seems to be evidence that early childhood science promotes positive attitudes and skills, both now and later (Zimmerman, 2007), limited science is occurring

in early childhood classrooms (Tu, 2006; Greenfield et al., 2009). This begs the question of what teachers believe about early childhood science education and how they promote science in their classrooms.

Theoretical Support for Early Childhood Science Education

Researchers have explored existing theories related to children's ability to generate and comprehend science knowledge in early years. In his attempt to understand the development of higher cognitive functions in children, Lev Vygotsky (1934) proposed a theory that viewed reasoning as emerging through practical activity in a social environment. He was a constructionist who advocated that individual learners should discover information for themselves (Thomas, 2005). Vygotsky specifically stressed the social aspects of learning, emphasizing cooperative learning, stating that children build or construct their own learning through collaborative experiences with adults and more competent peers. Furthermore, Vygotsky not only recognizes individual differences in children's learning but also recognizes the need to scaffold or structure instruction to meet children's individual needs (Vygotsky, 1978).

Vygotsky views the role of the teacher as imperative in identifying what the child already knows and where the child is in the learning cycle, to then be able to tailor their instruction to fit these needs accordingly. He introduced terms such as the Zone of Proximal Development (ZDP), which he defined as - the area between the actual developmental level determined by individual problem solving and the level of development as determined through problem solving under guidance of an adult or in collaboration with more capable peers - which have long influenced developmentally appropriate education by helping educators develop curricula and tailor their instruction to suit children's social, emotional and cognitive needs at a given age (Vygotsky,

1978). This work supports teachers' beliefs, knowledge, and practice as critical components of children's development.

This theoretical framework has led both cognitive developmental and educational researchers to further explore how children's learning can be supported by teachers' explicit instruction, educational environment of the classroom and/or feedback teachers provide to children. Following the constructivist approaches, Duschl and his colleagues (2009) state that children's learning within the classroom setting is largely contingent on providing developmentally appropriate opportunities to learn. By understanding children's development and their learning trajectories, teachers are able to keep in mind what the child already knows, and hence plan and construct their teaching approaches to further this development (Brenneman et al., 2009).

Early Childhood Science and Developing Skills

Research exploring science-related experiences and science activities in preschool settings argue that active experiences in which children engage in enrich the educational experience (Bati et al., 2010; Siry, 2013). Piaget believed that knowledge construction came from action (Thomas, 2004) – or what has come to be known as 'learning by doing' in science education (Haefner & Zembal-Saul, 2004). For nearly 20 years we have had the idea that teaching science means encouraging children to 'do science', which involves teaching them to question, observe, classify, communicate, measure, predict, infer, experiment, and construct models, as opposed to merely learning facts, concepts, and theories someone else has determined (National Research Council, 1996). Siry and colleagues (2012) further demonstrate that children

who actually “*do science*” gain experiences that continue to have a positive impact on their learning.

Recognizing that science is not just memorizing or learning facts, recent approaches in science education emphasize the importance of teaching children science process skills (Bati et al., 2010). Science process skills are the skills children use to engage in inquiry, conduct research and discover (Bentley et al., 2000). Programs such as Head Start now include in their readiness domains “Science Knowledge & Skills” which covers elements of scientific skills and methods as well as conceptual knowledge of the natural and physical world (Office of Head Start, 2010). In light of these reforms, and to align with developmentally appropriate practice, early educators are being encouraged to facilitate children’s development of specific skills which permit children to evoke their own curiosity, ask questions, and explore, thereby enabling them to gain new insights about their surroundings. Yoon and Onchwari (2006) recognize that traditional lesson plans adopted by most teachers provide them with limited opportunities to help children develop these skills. The Next Generation Science Standards (NGSS), based on the “Framework K–12 Science Education” created by the National Research Council, expect children to not just learn science content but to understand the methods of scientists and engineers (NGSS, 2015). They further indicate that this is achieved when children go beyond just observing and exploring, and when teachers adopt reform-based practices that encourage children to engage in testing, analyzing, collecting and using data, explaining, communicating and discussing ideas and questions (NGSS, 2015).

In order to help teachers provide children with skills needed to explore the world around them, the Biological Sciences Curriculum Study (1989) proposed the 5E model of instruction. This inquiry-based model includes five phases – Engagement, Exploration, Explanation,

Elaboration and Evaluation. Unlike traditional expository approaches, this model enables teachers to encourage children to explore specific concepts and questions, develop problem-solving skills and learn about the natural world in a step-by-step fashion, just as adult scientists do. Similarly, Greenfield and his colleagues (2009) have identified eight primary processing skills – observing, predicting, describing, experimenting, comparing, reflecting, questioning, and cooperating – that teachers need to promote to children so they can develop some basic science inquiry skills. While these skills were suggested for grades K through 12, they are also receiving attention in the Pre-K settings.

Preschool Science Instruction

Andersson and Gullberg (2014) indicate that preschool science instruction that primarily focuses on defining concepts and explaining why certain phenomenon occur is insufficient. They state that teachers should be motivated to “study these phenomena in a playful and creative way that can generate experiences and knowledge for the children to build on” (Andersson & Gullberg, 2014, p. 286). The process of incorporating developmentally appropriate and simple experiments in play is a useful technique in supporting the gradual formation of science concepts (Abrahams & Millar, 2008). Trnova and Trna (2015) developed simple science experiments which they implemented into preschoolers’ play and games, and found that it supported early science learning. Children learned concepts associated with the characteristics of substances and natural laws with little resistance (Trnova & Trna, 2015). Other research investigating the importance of play in early science education has found that teachers who support play through intentional planning of activities are often more capable of creating opportunities for young children to expand their understandings of scientific concepts than teachers who do not support play (Hamil & Wisneski, 2012).

While preschool education places strong emphasis on exploration (Ritz, 2007; Peterson & French, 2008), early science education research has shown that promoting children to identify patterns, draw inferences, and generally make sense of the world around them from an early age (National Research Council, 2008) is what drive learning. Therefore, activities in preschool that allow for children to move beyond simple exploration to meaningfully utilize these skills to make comparisons of everyday experiences provide them with the opportunity to develop a deeper understanding of rudimentary ideas (Roychoudhary, 2012). Zimmerman and his colleagues (2000) stress the importance of understanding how children’s everyday interactions with their environment can help children generate science knowledge. Dunst (2000) argues that in order to explain naturally occurring phenomena, contextualization needs to take priority. For example, he found that providing children with examples from their everyday surroundings offers all children equal and easy access to knowledge (Dunst et al., 2000).

Teachers are often able to enhance children’s learning and development when science activities are integrated into other curricular areas such as math, music, literature or art (Harlan & Rivkin, 2000). French and Peterson (2008) suggest that the comprehensive integration of science into preschool curriculum results in significant gains in children’s vocabulary and use of explanatory language. They further found that repeating certain question–answer formats (“what happened?”, “What do you think is going to happen?”) provided children with a typical linguistic format that further helped to scaffold their production of explanations (French & Peterson, 2008). Researchers have found that children are most likely to develop language and literacy skills when they have opportunities to use these skills constantly and in unique situations, such as those associated with scientific inquiry (Conezio & French, 2002).

Science Environments in Early Childhood

The selection of and access to materials are critical to early science education (Tu, 2006). Research on availability and use of science materials in the classroom suggests that teachers play a vital role in prompting children to actively and effectively use the material (Tu, 2006). In order to enhance children's nascent scientific thinking within the classroom, teachers need to promote a supportive learning environment, equipped with the appropriate materials that allow teachers to take advantage of teachable moments and provide assistance when required (Tu, 2006). Previous work has found that many early childhood classrooms, including Head Start, have a range of science-related materials available for young children (Nayfield et al., 2011; Tu, 2006). The availability and use of materials within the classroom should be open ended in order to allow children to focus on important aspects of a particular phenomenon and should not dictate what children do and think (Worth, 2010).

Although children are naturally curious about their surroundings, they are likely to gain a deeper understanding of the construct with assistance from adults (National Research Council, 2008). The language input provided by adults and teachers during the preschool years helps children acquire the receptive and expressive linguistic ability to represent their experientially learned mental representations (French, 2004). Research further indicates that teachers who share the scientific experience with children and engage in high-quality interaction either by asking open ended questions or commenting on what they are jointly observing with the child are often capable of promoting science inquiry within the classroom (Hamil & Wisneski, 2012). Since learning science is largely based on inquiry, questioning remains one of the most effective teaching strategies employed by teachers (Rakow & Bell, 1998; Yoon & Onchwari, 2006). When looking for answers to questions asked by teachers or by children themselves, children make

discoveries using their higher cognitive processing skills and engage in tasks such as analyzing, synthesizing and evaluating information (Rakow & Bell, 1998).

Current Preschool Practice

Combined, these practices suggest that teachers play a major role in early childhood science education. Teachers are responsible for providing children with appropriate instructions and a supportive learning environment in which children have an extensive range of opportunities to engage with science materials as they conduct scientific exploration using science process skills. However, despite the recent emphasis on improving science-related learning standards, instructional practices and science curricula in early childhood classrooms (Gelman & Brenneman, 2004), preschool teachers tend to engage in science practices less often in comparison to language and literacy, social studies, arts, and math (Tu, 2006). These findings seem to be especially prominent in Head Start classrooms, where the majority (86.8%) of classroom activities are not science related (Tu, 2006). Although teachers provide many science-related materials to children, they often fail to demonstrate their intended use for scientific investigations (Fleer, 2009; Greenfield et al., 2009; Nayfield et al., 2011), resulting in children's lack of understanding of these materials and perceiving them as toys rather than tools or ignoring them completely. Teachers spend little time engaging in either planned or spontaneous science-related activities (Tu, 2006). Furthermore the science center of the classroom is one of the least likely areas to be visited by the teacher or children during free choice (Hanley et al., 2009; Nayfield et al., 2011). One of the reasons for the lack of necessary and appropriate engagement in science activities could be teachers' beliefs and their attitudes towards science practice.

The Importance of Teacher Beliefs

Teachers' beliefs is a term often used to refer to teachers' pedagogic beliefs, or those beliefs which are of relevance to an individual's teaching (Borg, 1998). More broadly stated, beliefs include what educators assume to be the goal or outcome of their lesson plan. Irrespective of the academic domain, teachers' beliefs and attitudes towards teaching have been found to play a crucial role in determining what classroom practices they choose to engage in, specifically influencing the frequency and quality of classroom instruction (Ball & Cohen, 1996; Charlesworth et al., 1993; Stipek & Byler, 1997).

For the content area of science, research indicates that teachers' own attitudes and beliefs have been found to be predictive of not only why they think it is important to teach science in the classroom (van Aalderen-Smeets & Walma van der Molen, 2013) but also predictive of their general classroom instructional practices (Hanley et al., 1996). Other research exploring teachers' beliefs have reported similar findings. For example, researchers Solomon, Battistich, and Hom (1996) in an attempt to understand whether teacher beliefs were related to practices, examined the attitudes, beliefs, perceptions, and classroom practices of teachers in 24 urban and suburban elementary schools. They identified that teachers' beliefs were generally consistent with the practices they employed, even when school poverty level and students' mean achievement levels were statistically controlled. However, they further found that teachers' expectations of their students exerted a powerful influence on teachers' attitudes and behavior. Even when students' achievement was controlled, teachers saw children from high poverty schools as less capable and engaged in practices that did not emphasize meaning and understanding or even provide opportunities for children to interact with each other (Solomon et al., 1996).

Similarly, Hanley and his colleagues (2002) examined the relationship between elementary teachers' personal agency beliefs about teaching science and their ability to effectively implement science instruction, and found that the teachers who possessed positive beliefs tend to engage in more effective practices when teaching science domains (Hanley et al., 2002). Specifically, these teachers were more likely to carefully plan and execute lessons that conveyed science content accurately and in a developmentally appropriate manner. In contrast, they found that teachers with low efficacy and generally negative beliefs seemed to struggle with regard to many aspects of effectively teaching science content, such as planning lessons that incorporated inquiry, or even utilizing appropriate and available resources (Hanley et al., 2002). In order to explore how teachers' attitudes about science affect their behavior, van Aalderen-Smeets et al. (2012) devised a framework that distinguishes teachers' professional attitudes or attitude towards teaching science, from their personal attitude or attitudes towards science in general. This framework, resulting from extensive review of existing concept definitions and psychological attitude theories, identified three components that influence behavioral intention and further drive behavior. These include teachers' cognitive beliefs (i.e., beliefs related to the relevance of science education, beliefs about the relative difficulty of teaching science and gender stereotypical beliefs about science teaching), affective states (i.e., enjoying teaching science or the perceived anxiety related to teaching science) and perceived control (i.e., self-efficacy and the extent to which they feel dependent on external factors to teach science, such as the availability of materials or time or other resources) (van Aalderen-Smeets et al., 2012).

In a later study, van Aalderen-Smeets and Walma van der Molen (2015), incorporated a framework (see Figure 1) in a pretest-posttest control group study to investigate the effect of an attitude-focused professional development intervention on primary teachers' personal attitudes

toward science, attitudes toward teaching science and their science teaching behavior. The researchers hoped to stimulate teachers' attitudes toward science by challenging teachers existing attitudes toward science and teaching science and their knowledge and skill about science (van Aalderen-Smeets & Walma van der Molen, 2015). They found that teachers in the intervention group reported that they enjoyed teaching science and felt less dependent on contextual factors. They also reported that they were more engaged in science teaching and in science-related daily activities. These improvements were further supported by the increased percentage of teachers that showed a positive attitude toward science and conducted more science-related activities in their classroom (van Aalderen-Smeets & Walma van der Molen, 2015)

Studies, such as the ones discussed above, investigating the relationship between teachers' attitudes and beliefs, and their teaching behavior, predominantly focus on teachers teaching at the elementary level. There appears to be a dearth of studies focusing on the attitude of teachers toward science teaching in preschool settings. Given the significance of early childhood science education and the critical role teachers' beliefs play in the science practices of elementary teachers, it is imperative to examine the beliefs preschool teachers' hold with regard to 'how to teach' and 'what to teach' in early science education.

Preschool Teachers' Beliefs about Science

Teachers seem to hold some opposing views regarding teaching science to young children. For example, some argue that the formal and abstract thought involved in science is too difficult for young children (Erden & Sonmez, 2010), while others argue that science is an exciting way to help children explore the world they live in (Butzow & Butzow, 2000). However, the majority of research in this area seems to suggest that teachers are mostly

uncomfortable with science teaching (Greenfield et al., 2009) and are reluctant to engage children in either formal or informal science activities (Nayfield et al., 2011).

The body of research exploring why preschool teachers may feel uncomfortable with science has identified several barriers that teachers might face in implementing science instruction. For example, Owens (1999) identified that some early childhood educators are uncomfortable with the level of their own knowledge of science and hence tend to limit the number of science activities in the classroom. Hanley (1997) found that teachers' confidence in teaching science was often determined by their understanding of scientific concepts. In a multi focus group study, Greenfield and his colleagues (2009) report that many teachers indicated low self-efficacy with respect to teaching science. Conezio and French (2002) found that the teachers' own personal unpleasant science education experiences may leave them hesitant about introducing science in their classrooms. Early childhood teachers struggled to integrate science into the classroom, reporting concerns about the amount of time that teaching science consumes, stating that the short, busy schedule of the preschool day makes it challenging to incorporate all readiness domains, including science, especially taking into account the amount of time needed for setting up equipment (Cho et al., 2003; Greenfield et al., 2009). Teachers also reported that they did not feel confident using the science related materials that they were provided (Greenfield et al., 2009). Thus, teachers' educational background and experience seem to play a critical role in shaping teachers' beliefs about early childhood science education.

While the current body of research on teachers' attitudes largely suggests that teachers tend to hold negative and pessimistic views regarding early childhood science education (French, 2004; Greenfield et al, 2009; Nayfield et al., 2011) a few studies report the contrary. For example, Erden & Sönmez (2012) identified that early childhood teachers do in fact have fairly

positive attitudes towards science teaching, and Maier and his colleagues (2013) found that teachers hold a relatively positive view when it came to the planning and execution of scientific activities. These incongruent findings further bring into question the potential determinants of teachers' attitudes and beliefs.

Determinants of Teacher Beliefs

Educational preparation and experience. Teachers' beliefs may vary based on the teachers' educational background (Sosinsky & Gilliam, 2011), years of experience (Erden & Sönmez, 2012; Klassen & Chiu, 2010) their own comfort level, knowledge, or confidence with the content (Klassen & Chiu, 2010), and the general views they hold on how children learn (Peterson, 2009). Amongst all of these teacher characteristics, teachers' educational background and their years of experience seem to be particularly salient factors in influencing teachers' beliefs. Klassen and Chiu (2010), as a part of a larger study examined the patterns of self-efficacy beliefs (defined as teachers' beliefs about their capabilities) of 1,430 kindergarten teachers with varying years of experience. They found a non-linear relationship between teachers' self-efficacy and years of experience, reporting that teachers' efficacy was higher for teachers in the early and mid-career stage while it was lower for teachers in the late career stages (Kassen & Chiu, 2010). Dowdy, (2005) found that teachers who had taken a greater number of science-related courses during a two-year college program had more favorable impressions of science in comparison to teachers who had not taken science courses in college. Comparably, in an attempt to find a link between teachers' educational level, years of experience, and their beliefs, Erden and Sönmez (2012) found that teachers with less than one year of experience held more positive attitudes towards science, especially with regard to the perceived 'developmental appropriateness' of early childhood science education when compared to teachers with more

years of experience. Educational level was found to have a significant effect on the frequency and delivery of science-related activities. Teachers with higher educational levels tend to undertake science activities more frequently, employing different methods (Erden & Sönmez, 2012).

It seems, however, that teachers' background may influence their beliefs differently depending on the type of program in which they teach. For example, teachers' educational level and experience had negligible effects on beliefs when compared to the type of school. That is, teachers teaching in private schools had more favorable attitudes towards science than teachers in public school (Erden & Sönmez, 2012). These findings indicate that it might be of special interest to study teachers from Head Start, a public school program, serving children living in poverty. Further, these programs hire a teaching staff with a range of educational backgrounds and experiences. Nearly 50% of teachers do not have an advanced degree in Early Childhood Education or a baccalaureate or advanced degree in any subject (Office of Head Start, 2010). Due to the range in formal education and experience demonstrated by Head Start teachers, this variation may allow researchers to examine the relation between background characteristics and teachers' beliefs about science.

Teachers' role. Research indicates that it might be important to consider differences in the beliefs of lead and assistant teachers. Teachers' characteristics and preparation have been shown to be related to teacher-child interactions and child outcomes (Burchinal et al., 2002). While there is a considerable amount of research investigating how lead teachers' education and training might impact child outcomes, fewer studies have investigated how assistant teacher characteristics might differ from lead teachers and how this difference might matter for prekindergarten classroom quality or child outcomes. Moreover, while assistant teachers' main

role in an elementary classroom is aimed at providing support to children of low ability or difficult behavior rather than providing general support and working with the class on the whole (Russell et al., 2005), the role of the assistant teacher within the preschool setting remains unclear. Sosinsky and Gilliam (2011) report that due to the different associations between programs, classroom characteristics and the ways in which lead teachers run their classrooms, it might be difficult to identify the exact duties of the assistant teacher in preschool classroom. This may make it difficult to identify their influential reach throughout the classroom. In support of this finding, Shim et al. (2004) identified that lead teachers in a prekindergarten classroom set in a public school may be more likely to assume more responsibility for teaching the children than lead teachers in the more collaborative setting such as a Head Start classroom, in which the roles are probably shared more equally. In terms of teachers' education, Sosinsky and Gilliam (2011) state that teachers' individual credentials may not be as important as the combination of credentials of the lead and assistant teachers in influencing how important the assistant can be for teaching and planning duties. However, lead teachers with a higher level of education may not depend as much on assistant teachers with only a high school diploma for teaching duties (Sosinsky & Gilliam, 2011). Recognizing the diversity in background characteristics and identified roles as well as their shared physical space (i.e., teaching in the same classroom) and teaching collaboration (e.g., planning lessons together, making decisions about supporting individual children together), it is important to consider how lead and assistant teachers might differ in their beliefs about an academic content area such as science.

Measuring Teachers' Beliefs

Teachers' beliefs have been measured in various ways. Some work has focused on developing quantitative measures of teachers' beliefs. Cho and her colleagues, (2003) designed a scale to measure early childhood teachers' attitudes toward science teaching. They based this measure upon a pre-existing scale that measures elementary teachers' attitudes toward science. This new measure included constructs such as preschool teacher's comfort-discomfort, desire for teaching science and the importance of teaching it, teachers' concerns about time needed for science, and familiarity with which they use science materials in a developmentally appropriate manner. Similarly, Maier and colleagues (2013) conducted a study to validate the Preschool Teacher Attitudes and Beliefs toward Science Teaching (P-TABS). They found that in contrast to the negative attitudes reported by elementary school teachers toward science teaching, the preschool teachers in their study scored high on teacher comfort items and reported that they felt comfortable conducting science activities in their classroom (Maier et al., 2013). While these measures have evidence of reliability and validity, they seem to constrain teacher beliefs to researchers' preconceived conceptualization of beliefs. Such closed ended, forced-choice, researcher generated responses offer participants only a finite number of responses to choose from and therefore, fail to capture the range of participant beliefs and potentially misunderstand or misinterpret teachers' responses. Open-ended questions, on the other hand are exploratory, less leading, and permit a comprehensive response from the participant (Corbin & Strauss, 1990; Creswell, 2013). One study utilizing open-ended questions, conducted semi-structured interviews with three primary school teachers and through in-depth, qualitative coding identified that the teachers' main concerns with teaching science involved the need for appropriate resources, time to use resources effectively, physical space to engage the children, and lastly the need to not only believe that they had sufficient knowledge but also the need to develop a confidence in the

knowledge they possessed (Fitzgerald & Schneider, 2013). While this study provides meaningful insight into teachers' ideas about teaching, the sample size is extremely small, and the study targeted primary teachers vs. preschool teachers. Further, due to the semi-structured nature of the interviews, the questions were more focused on needs rather than beliefs.

Asking preschool teachers open-ended questions such as why they think science is important and how they would teach science to young children will facilitate our understanding of how early childhood teachers perceive their role in providing children with appropriate learning environments and opportunities to explore, represent, and share their discoveries. These questions will enable researchers to capture a range of potential responses from teachers, casting a wider net on teachers' beliefs. Therefore, the purpose of the current study is to investigate Head Start teachers' beliefs about science and how teacher characteristics such as educational background, teaching experience, and teaching role may relate to their beliefs and practices for science.

RESEARCH QUESTIONS

This study used a survey design to examine Head Start teachers' beliefs about science and how it should be taught to young children. The study specifically addressed the following four research questions:

1. What are Head Start teachers' beliefs about science and how science should be taught to young children?
2. Do teachers' beliefs vary depending on teachers' educational preparation and experience?
3. Do lead and assistant teachers differ in their beliefs about early science education?

4. Are Head Start teachers' beliefs related to their practices - in terms of the science materials that they provide to children and the regularity of science activities in the classroom?

METHODS

Research Design

For this study I utilized a qualitative design with collateral quantitative analyses of data. All data collected and used in this study came from a larger intervention study designed to examine the effects of a science curriculum on teachers' practice and children's outcomes for low-income children. The qualitative data collected included teachers' responses to two open ended questions and the quantitative data collected included observers' recording of data via checklists and teacher report of the frequency of engagement in science in their classroom.

Participants

The participants included 124 Head Start teachers (62 lead teachers, 62 assistant teachers) recruited from eight different Head Start programs from across Michigan. Each classroom had one lead and one assistant teacher recognizing the nestedness of these teachers within the same teaching environment. For classrooms with co-teachers, I identified one as lead and one as assistant for the purposes of the project. For lead teachers of known ethnicity, 13% (19) were African American, 73% (105) were Caucasian, 9% (13) were Hispanic, and .01% (2) categorized themselves as other. The majority of the lead teachers, 42.7% (61) had a bachelor's degree; however, 28% (40) had a two-year associate's degree, 20.3% (29) had a high school diploma and 0.7% (6) had a master's degree. Fifty-three percent (76) of teachers reported a major in early

childhood education/development or a related field. On an average, teachers had 10.6 years of experience teaching preschool-age children (ages 3-5 years) ($SD = 7.5$, Range 1-40 years).

For assistant teachers of known ethnicity, 7% (10) were African American, 31.5% (45) were Caucasian, 7.7% (11) were Hispanic, and .07% (1) categorized themselves as other. Nineteen percent of the assistant teachers (28) had a bachelor's degree; 16.8% (24) had a two-year associate's degree, 7.7% (11) had a high school diploma and 0.7% (1) had a master's degree. On an average, teachers had 9.46 years of experience teaching preschool-age children (ages 3-5 years) ($SD = 7.5$, Range 1-40 years).

Procedures

Teachers were recruited from those who volunteered to participate in a science related professional development program. It should be kept in mind that all data are from the pre-test time point of the larger study and thus, reflect the teachers' beliefs and practices prior to receiving any intervention. Initial data was collected by a team of trained researchers who adopted a survey methodology which is a technique often used to collect statistically valid information from a large number of respondents regarding their behavior, needs or opinions (Guthrie, 2010). Teachers completed a structured questionnaire which also included provisions for researchers to collect demographic information.

In addition, the trained team of researchers also observed in teachers' classrooms at the beginning of the school year. Observations were scheduled with teachers in advance to be sure the observation took place on a typical day without field trips or special guests. Thus, teachers were aware of the observation. Observers were trained to use the observational checklist by

completing the checklists in non-project Head Start classrooms. Following the practice session, all data collected through observation were reviewed by a lead researcher and any questions that the data collectors had were clarified.

Once all the data was collected and compiled by the research team, I developed a codebook, trained a secondary coder, and lead the analysis of the data.

Measures

Science Environment. The *Preschool Classroom Science Materials Checklist* (adapted from Tu, 2006) was used to record the presence of science materials and equipment in the preschool classroom. The original checklist contained four categories: science materials (21 items), science equipment (26 items), natural equipment (10 items) and others, a category where teachers recorded materials that were not science related. The checklist used in this study consisted of only three categories: science materials (21 items), science equipment (26 items) and natural materials (10 items). Observers were trained to select the items if they were available and accessible to the children in the classroom. Reliability for this measure was .92. Each item was scored as either (1) present or (0) absent if the observers identified the item in the classroom on the observation day. Teachers could receive a minimum score of 0 and a maximum score of 57.

Structured Questionnaire. Teachers completed a structured questionnaire, which also included provisions for researchers to collect demographic information. As a part of the survey teachers were asked the following two open-ended questions:

- 1) What is your definition of science for young children?

2) How should science be taught to young children?

As well as the following question:

How often do you engage in science activities in your classroom?

- 3-4 times/week
- 2 times/week
- 1 time/week
- 2 times/month
- 1 time/month

Data Coding & Analysis

Following the collection of data, I used thematic analysis to identify different categories, properties and dimensions within the data that allowed for the researchers to generate themes to express teachers' opinions (Braun & Clarke, 2006, 2013). All responses were coded for multiple ideas. I developed a codebook which was then used by a trained secondary coder to independently code all teacher responses for both questions. Adhering to the process of thematic analysis, to create the codebook, I first familiarized myself with what the data entails by reading and re-reading the data, paying special attention to the patterns that occurred in teachers' responses. Once I was familiar with the data, I created initial codes (Braun & Clark, 2006, 2013) by documenting where and how patterns occurred in teachers' responses. At this stage I collapsed data into labels in order to create categories for more efficient analysis. Following the creation of initial codes, I combined codes into overarching themes that accurately depicted the data (Braun & Clark, 2006, 2013). Once the codes were reviewed and clearly defined, I trained

the secondary coder who then independently coded all teacher responses. Following this we reviewed our independent analysis and established reliability. I then created a thematic map to illustrate the themes that were associated with each individual question as well as the interconnection between the themes across the two questions. During the process of mapping the codes, I recognized that some categories gave rise to subcategories, while other codes became more meaningful when combined.

Trustworthiness and Reliability

Established reliability with second coder. Reliability between my coding and that of the trained second coder was determined using kappa-coefficient (K). Inter-rater reliability for both open-ended questions were found to be 0.95. Disagreements were resolved through discussion and consensus. For instance, both the secondary coder and myself disagreed on the code ‘living and non-living’ as being established as its own theme. After discussion and analysis of several responses with similar ideas, we decided to embed this code within a code ‘topics’.

During the process of coding, I identified that some codes could be combined to describe broader practices and ideas. For example, the code for ‘hands on activities’ and the code for ‘using the five senses’ were combined under the broader code ‘teaching practices’ as these initial codes suggested different forms of teacher practices. Similarly, the code for ‘living-non-living’ in teachers’ responses for the second question, seemed to suggest that science was taught by addressing specific subject matter. Therefore, this code was combined into the code for ‘topics’ which described the different topics or foci.

Audit Trail. In order to ensure trustworthiness of the data, I compiled an audit trail of research decisions. I maintained a list of all codes created from the initial stages of analysis along with documented reasons for combining, expanding or eliminating codes. For example, my list

of original codes included separate codes for all the science process skills, after reviewing research on science process skills and the role they play in children's learning of science, I decided to combine all these skills and created a new code labeled 'science process skills'. An audit trail in qualitative research consists of a thorough collection of documentation regarding all aspects of the research (Lincoln & Guba, 1985). Since qualitative inquiry typically adopts a design that changes through the iterative processes of data collection and analysis and further requires the researcher to make frequent decisions that can alter the course of the study, a record of study processes can be critical in later providing justification of these actions (Creswell & Miller, 2000).

Thick Description. As another form of trustworthiness I have included direct quotes from teachers' responses to the two open-ended questions to illustrate my findings, providing a thick description of the data that was collected. These illustrative quotes were used as evidence for each code that was created in the initial coding and the code combinations during the thematic mapping processes. Thick descriptions provide a detailed account of teachers' beliefs which allows the researcher to makes explicit the patterns of ideas and puts them in context (Lincoln & Guba, 1985).

RESULTS

Definition of Science for Young Children

Teachers varied widely in their response to the question "What is your definition of science for young children?" I identified nine different thematic categories (see Figure 2) that encompassed teachers' general ideas of what they thought the definition of science is for young children. Notably, teachers' responses did not fit into one category, rather, teachers' responses

included multiple themes, such that each teacher is not coded into a theme, but results indicate the number of teachers who included each theme in their response.

A theme that was supported by a number of responses ($n = 57$) seemed to indicate that science for young children involves exploration of the world around them. The majority of the responses which fit this description seem to hold the view that everything in the child's surroundings can be considered as science. For example, one teacher said, "*Science is exploring and learning about a lot of things in our world.*" While another teacher said "[*Science is*] *exploring and experimenting with the world around them.*" Other teachers who defined science as children exploring their surroundings seemed to suggest that science learning came from experiences. For instance, one teacher defined science as "[...] *experiencing the world and seeing how and why things work the way they do.*"

A number of teachers ($n = 53$) described science for young children in terms of skills that children may require to carry out scientific activities. Science process skills are the skills children use to engage in inquiry, conduct research and discover (Bentley et al., 2000). As shown in Figure 3 teachers who defined science in this manner identified some form of scientific process skill. Teachers varied in the types, number and the complexity of the skills they described. A popular skill that was described by teachers ($n = 22$) was 'questioning'. For instance, one teacher reported that "*Science is those 'why questions' kids ask their grown-ups. For instance, 'why does this magnet stick to our refrigerator? How can an ant carry so much weight? – Science.*" Fewer teachers ($n = 5$) described skills that involved a higher degree of process (more complex skills/silks that were more scientific in nature), for example, one teacher reported "*I feel that science is an opportunity to explore the unknown, investigate questions that we may ponder, evaluate, research, provide theory while analyzing various experiments. It*

provides answers to cause and effect, changes that may occur in our environment.” While another teacher stated, “*science is all about discovery or curiosity and answering the ‘I wonder’ questions – gathering information, making predictions, observations, asking questions, forming conclusions... it’s a ‘let’s find out’ center – where children collect data and use procedures.* It might be noteworthy that all scientific process skills reported by teachers beyond ‘testing’ were collectively reported by 5 teachers.

Thirty-six teachers defined science for young children in terms of the practices that they use in their classroom to promote science. Teachers identified practices including engaging in ‘hands-on activities’, ‘learning through the 5 senses’ or play. For example, when asked to define science, one teacher stated that “*Young children should be able to see and physically experience sounds, sights and how things feel and smell.*” Another teacher said, “*My definition of science is hands on experiments for young children.*” Interestingly, just three teachers specifically identified play as a practice used.

A number of teachers ($n = 24$) defined science as children learning about nature. Teachers seemed to suggest that science involved exploring nature and observing things that appeared in nature. For example, one teacher stated, “*Science to me is exploring nature, and process of nature around us.*”

Some teachers ($n = 19$) defined science for young children in terms of the topics that they may discuss in their classroom. Teachers, when asked to define science, often listed out a number of activities that they may engage children in. For instance, one teacher said “[...] *mixing colors – painting and watching the plant grow, blowing bubbles, and adding food coloring to it. Taking pictures and watching it develop, sand table.*” Another teacher reported

that, *“Science for young children involves discovery and observation. It includes weather, seasons, nature and animals.”*

A number of teachers ($n = 18$) reported in their definition of science that children required some form of adult or teacher guidance in order to engage in scientific inquiry. For example, one teacher stated that science was *“Exploring, observing, and hands-on experiences with adults making suggestions and asking questions to guide the children’s learning.”*

Responses from teachers who supported this view seemed to suggest that while children are capable of exploring their surroundings, their learning of science is contingent upon the input and directions that they receive from teachers. For instance, another teacher said *“My definition of science is teaching young children about how things work, also teaching children how to think about ‘what will happen if?’ through experiments.”* Or *“Allowing children to use their imagination to see how things work with the help of an adult.”*

Some teachers ($n = 15$) defined science for young children in terms of the tools and materials they use to teach science. Their responses seemed to suggest that science was defined by how children used and manipulated the tools and the materials that were made available to them in order to engage in scientific exploration. For example, one teacher said *“My personal definition of science for young children would be the use of a wide variety of materials both natural from real life experiences as well as science tools.”* Another teacher stated that *“Science for young children is teaching children about bar magnets, mirrors, color paddles, and magnifiers, etc. and how to use each item and get them familiar with the different types of science products.”* Interestingly, just three teachers identified books as a material for science.

A few teachers ($n = 7$) who defined science based on children’s interest defined science as those activities that build on children’s interests and are child initiated. For example, one

teacher defined science as *“Exploring scientific concepts at [children’s] level to develop skills necessary for life. I also think it is important to take science ideas from children so they are interested in the activities and want to learn the material.”* Another teacher reported the importance of *“[...] using children’s interests to teach within the classroom and outside the classroom”*.

A small number of teachers ($n = 5$) defined science for young children as fun. For example, one teacher when asked to define science stated *“Science for young children for me is exploring and having fun while you are learning.”* Another teacher responded *“Fun, fun, fun”* when asked to define science.

Some teachers ($n = 11$) pointed out the engineering aspect of science when asked to define science for young children. These teachers, used in their definitions phrases such as ‘learning how things work’. For instance, one teacher reported *“science for young children is an exploration of how things work in their world.”* Another teacher stated that science was *“seeing how things change, experiencing the world and seeing how and why things work the way they do.”*

It may be noteworthy that while several responses converged across multiple teachers, a few other responses seem to diverge from the larger group. For instance, only one teacher mentioned the need to incorporate children’s existing knowledge when defining science, she stated, *“[Science] allows them to incorporate what they already know and how to use it to figure out something else.”* Only one teacher pointed out that science is defined differently for different children. She also suggested that science is defined based on how children are taught, how ideas are presented to them, by whom these ideas are presented and whether or not the activities are engaging. She stated, *“The definition of science to a child will be different for each child*

depending on their experiences. It depends on who is talking to them, the subject of conversation and if they are allowed to participate in things. Science to a young child is what they are told it is.” One teacher indicated that science interactions need to occur in the home environment. Only two teachers specifically mentioned the role language plays in early childhood science in their definition and one teacher pointed out that science in the classroom can promote children’s higher level of thinking.

Teaching Science to Young Children

Teachers also varied widely in their response to the question “How should science be taught to young children?” On analyzing teachers’ responses, researchers identified nine different thematic categories (see Figure 4) that encompassed teachers’ general ideas of what they thought were some of the best practices to teach science to young children. Similar to responses to the first question, teachers’ responses to this question did not fit into one category, rather, teachers’ responses included multiple themes, such that each teacher is not coded into a theme, but results indicate the number of teachers who included each theme in their response.

A number of teachers ($n = 52$) reported the use of “hands on” activities when asked how young children should be taught science. For instance, one teacher reported that “[*Science should be taught*] with a hands on approach”. It should be noted that there was a lot of variability within this code. Some teachers simply stated “*Hands on*” when asked how science should be taught to children, while other teachers elaborated further. For instance, one teacher said, “*Children should be taught science utilizing hands-on sensory activities.*” While another teacher said, “*Science should be taught through hands-on activities, children should be allowed to explore and experiment with materials.*” Since teachers seemed to differ in how they described /what they meant by “hands on activities”, all responses with the phrase “hands on”

were coded for hands on activities as well as other practices they suggested (e.g. using materials, experimenting, using the 5 senses, etc.).

A number of teachers ($n = 34$) reported that science should be taught with the use of materials or by providing children with appropriate materials. For example, one teacher reported, *“Science should be taught through objects, manipulatives and living/non-living things that preschoolers can manipulate and observe.”* Teachers’ responses suggested that the availability of engaging materials would facilitate children’s ability to spontaneously explore, observe and ask questions, all of which they believed lead to science learning. For instance, one teacher stated, *“I also believe that many times if materials are available science will just happen.”* Another teacher reported, *“Having hands on materials available to help peak a child’s curiosity to learn more about science.”*

Teachers ($n = 32$) recognized the importance of adult guidance involved in the process of children developing scientific knowledge. For example, one teacher said, *“An adult helps [children] by asking questions and giving information to help them understand what they are observing.”* Another teacher reported, *“Children should be allowed to explore and ask questions about science while still being facilitated by their teacher.”* Teachers seemed to be cognizant of their role as a mentor or guide; they recognized that children played a big role in leading their own learning experience and constructing their own knowledge. Teachers’ responses suggested that they identified their responsibility in structuring or scaffolding the tasks and activities so as to expedite children’s learning. For instance, one teacher illustrated that *“I believe a majority of the science activities should be explored by the children themselves, but the teachers implement what the activity is about.”* While another said, *“It can be teacher directed at first but children should be allowed to observe and explore at their own rates.”*

Another response among teachers ($n = 22$) was the use of the phrase “through exploration”. Teachers seemed to be of the opinion that children learned science by exploring. For instance, one teacher said, “*Science should always be taught to young children with an open mind. Allowing them to explore their surroundings and environment. Through such explorations children will develop the ability to think more critically.*” For some teachers this exploring was limited to materials, while for other teachers, the term exploring was broader and seemed to extend to exploring their surroundings at large. One teacher said, “*Talk about the materials you have and let the children explore it.*” While another stated, “*Science should be taught to children through an active exploration of their environment.*”

Similar to this idea of exploration, teachers ($n = 19$) supported the view that children’s experience played a vital role in their learning. For instance, one teacher said, “*I think they should learn through experience rather than ‘lecture’.*” or “*They need to experience science not be told how things happen.*” Some teachers who expressed this opinion seemed to also verbalize the need for these experiences to not only be engaging but also emphasized children’s ability to relate to the experiences. One teacher said, “*I feel the children can learn best when they can relate the activities to their own world.*”

Some teachers ($n = 15$) recognized the role that children’s natural curiosity plays in science learning. They identified that science learning is often child initiated. One teacher expressed, “*Science is a discovery area - frequently it is child initiated - child are born with a natural curiosity for their world - teachers can set out items but children should be allowed to freely discover the materials.*” Teachers who expressed this idea were also often of the view that children are responsible for taking a lead in their science learning. Their responses emphasized the significance of questions children ask. For example, one teacher responded, “*Children should*

be able to ask questions about why things happen. They should explore and be able to give their opinion.” While others said, *“Let the children be leaders.”* Or *“I believe a majority of the science activities should be explored by the children themselves.”*

Similarly, teachers ($n = 10$) also seemed to recognize the need to take into consideration children’s interest in teaching science. Their responses suggest that science is taught by identifying children’s interests and then tailoring classroom instruction to expand on those interests. For example, one teacher said, *“Science should be taught by asking children some of their interests first. Expand on these interests with books, materials to explore and conversations that promote problem solving.”* While another teacher responded, *“...take cues from children and develop their interests further.”*

Some teachers ($n = 12$) suggested in their responses that children learn science by engaging their five senses. For instance, one teacher said, *“They should be allowed to see, touch, smell, and feel. Sometimes tasting items as well.”* Teachers stated the need to allow children to have sensory experiences in order to learn, stating that children had to be taught science *“In a way that they touch and feel. They need to experience science not be told how things happen.”*

When asked to define science for young children, a number of teachers identified that nature played a big role in science, however when asked to describe practices to teach science only 3 teachers mentioned nature. For example, one teacher said, *“[Science should be taught] with real objects from nature.”*

On the whole teachers seem to be positive about teaching science, when asked how science should be taught to young children one teacher reported, *“Enthusiastically, with a sense of wonder.”* While a majority of the responses were positive, it should be noted that only three teachers reported that science education should be fun and only three teachers talked about

implementing science into play, stating “*Science needs to be introduced to children in a fun motivational manner. Children learn best through play.*” Surprisingly, only two teachers mentioned that science could be integrated into other classroom domains. For example, one of the teachers said, “*Just like literacy and math, science should be incorporated in all daily activities.*”

During the process of analyzing responses and generating themes, coders were able to identify a number of similarities and a certain degree of consistency in teachers’ responses, not only within questions but also across questions. In order to illustrate interconnections between ideas and repeated concepts that emerged during coding, researchers created a thematic map (Braun & Clark, 2006, 2013). The thematic map (see Figure 5) visually represents the themes that arose for each question individually as well as the relationship between ideas. Orange arrows signify common themes while the green arrows signify a common idea behind themes. Researchers were further able to relate the themes that emerged in this study to a broader conceptual framework of developmentally appropriate practices. How themes are related to this framework is examined in the discussion of the findings.

Teachers’ Beliefs, Background Characteristics, and Practices

Greenfield and his colleagues (2009) have identified eight primary processing skills – observing, predicting, describing, experimenting, comparing, reflecting, questioning, and cooperating – that teachers need to promote to children so they can develop some basic science inquiry skills. In line with this, The Next Generation Science Standards (NGSS), created by the National Research Council (2014) set the stage for high-quality science education through which students will develop an in-depth understanding of content and develop key skills such as communication, collaboration, inquiry, problem solving, and flexibility, among others, that will

serve them throughout their educational and professional lives (NRC, 2014). The NGSS expect children to not just learn science content but to understand the methods of scientists and engineers (NRC, 2014). Moreover, they indicate that this is achieved when children go beyond just observing and exploring, and when teachers adopt reform-based practices that encourage children to engage in testing, analyzing, collecting and using data, explaining, communicating and discussing ideas and questions (NRC, 2014). Since teachers in our study reported a wide range of science process skills, all of which overlap with those identified in the NGSS; for research questions 2-4, I compared teachers who reported these specific science process skills with those teachers who did not report these skills.

To answer research question 2, “*Do teachers’ beliefs vary due to teachers’ educational preparation and experience,*” I examined the mean years of experience of teachers who reported science process skills with teacher who did not report these skills. I also examined the highest level of education for lead teachers in these two groups. T-test indicates that there was no significant difference in the average years of experience for teachers who reported science process skills ($M = 12.00, SD = 7.67$) and teachers who did not report these skills ($M = 9.71, SD = 7.33$), $t_{(131)} = 1.73, p = .18$. Table 1 displays education for lead teachers who reported science process skills and lead teachers who did not report these skills, identifying similar distribution of educational backgrounds.

To answer research question 3, “*Do lead and assistant teachers differ in their beliefs about early science education,*” I identified whether an assistant teacher was likely to report a process skill if the lead teacher did. Our analysis revealed that of the 53 teachers (both leads and assistants) who identified science process skills in their responses, only 11 pairs (22 teachers) of

leads and assistants both reported science process skills. These findings identify that less than half of the group showed similar responses between leads and assistants.

To answer research question 4, “*Are Head Start teachers’ beliefs related to their practices in terms of the materials that they provide to young children and the regularity of science activities in the classroom,*” I compared teachers who reported process skills with teachers who did not regarding the number of materials observed in their classrooms and frequency of science activities in the classroom. T-test indicates that there was no significant difference in the availability of materials in the classroom for teachers who reported science process skills ($M = 23.83$, $SD = 11.35$) and teachers who did not report these skills ($M = 19.02$, $SD = 9.71$), $t_{(70)} = 1.92$, $p = .068$, $d = 0.45$. Figure 6 identifies the distribution of how often teachers reported engaging in science for these two groups of teachers. Since we want teachers to engage in science activities as frequently as possible, I used X^2 to examine teachers who reported engaging in science most frequently for both groups. X^2 test indicated that there was no significant relationship between the frequency of science activities and teachers’ beliefs, $X^2(1, N = 124) = 3.56$, $p = .058$, Cramer’s $V = .158$.

DISCUSSION

Interestingly when asked to define science for young children, teachers defined science in terms of the practices they employ to teach children science. Their responses suggest that early educators believe that young children are capable of learning science. The findings also reveal that teachers’ responses seemed to capture the sense of discovery and exploration involved in science learning. Their responses indicate that teachers are aware that learning science within the early education setting needs to be made relevant for young children, capitalizing on their natural curiosity. These findings are consistent with previous research that indicates the need to

recognize that early science education is not achieved by merely teaching children facts, concepts, and established theories (National Research Council, 1996) but rather enriched when children are allowed to engage in spontaneous scientific exploration (Bati et al., 2010; Siry, 2013).

Moreover, teacher responses in this study seem to align with the developmentally appropriate practices identified by the National Association for the Education of Young Children (2009) which states that young children construct their own knowledge and understanding of the world in the course of their own experiences. Developmentally appropriate practice is a framework that was developed to promote optimal learning and development in young children, which is grounded in the research on what is known about effective early education classroom instruction and how young children develop and learn (Copple & Bredekamp, 2009). They state that children are capable of integrating the knowledge they accumulate as they actively engage with their surroundings to work out their own understanding and hypotheses about the world (Copple & Bredekamp, 2009). On examining teachers' responses to both questions, researchers identified that all responses in this study fall within this framework. Figure 7 shows how responses were broadly categorized based on the ways in which children learn, the content or domain knowledge that teachers hope to cover during the school year, and teachers' recognition of the role they play in children's learning.

How Children Learn

A vast majority of the teachers articulated developmentally appropriate practices when asked to identify how science should be taught to young children. Some of the practices reported by teachers involved providing and engaging children with appropriate materials, identifying children's interests in choosing activities, allowing children to initiate science learning,

providing opportunities for sensory engagement, hands on activities, asking children open-ended questions, providing children with support and guidance while they explore, and incorporating lessons in play. Experts in the field of early education have identified these practices as best practices for teaching young children (Kostelnik et al., 2014). Furthermore, these recommended strategies suggest favorable child learning outcomes and lay the foundation of widely used curriculum in early education, the Developmentally Appropriate Curriculum (DAC) (Kostelnik et al., 2014). For instance, the DAC (Kostelnik et al., 2014) states that in order to identify what to teach children, it might be meaningful to explore areas in which children express curiosity and then provide them with significant experiences to support those interests and expand children's knowledge and skills. The DAC also states that children's learning begins with perception (Kostelnik et al., 2014) and the most effective means of sensory engagement is providing children with first hand experiences, meaning teachers must consider ways to give children direct contact with real objects so that they can see, touch, and feel it (Kostelnik et al., 2014).

It may be worth noting that teachers in this study also stated very broad definitions without specifically defining the actual content of science education, suggesting that they are unfamiliar with this this domain of knowledge. While research indicates that teachers who have studied how children learn and develop and have received sufficient training in identifying effective ways of teaching children are more likely to have specialized knowledge about how children learn (Copple & Bredekamp, 2009), it seems that in light of the absence of specific training in science (Greenfield et al., 2009) teachers in our study are leveraging what they know about developmentally appropriate practices, which are not domain specific, and child development in general, to this unfamiliar domain.

While teachers seemed to recognize and articulate the importance of teaching children science process skills, teachers seem to have a narrow view of these skills. The most reported skill was questioning ($n = 22$), while other skills, such as predicting, analyzing, hypothesizing, and collecting, using and reporting data were collectively noted by only 5 teachers. One might reasonably argue that the reason teachers may struggle to articulate these processes might be a result of teachers' lack of science domain knowledge (Conezio & French, 2002; Owens, 1999) or feeling unprepared on account of receiving insufficient training with regard to identifying and teaching children appropriate skills (Greenfield et al., 2009).

Research further indicates that the development of these process skills enables children to not only construct meaning from what they observe, and develop an understanding of the world around them (Wilson, 2008), but also enhances critical thinking which facilitates science learning at higher grades (Conezio & French, 2002). Moreover, early childhood learning environments that foster scientific thinking provide children with the space and opportunity to practice science, therefore allowing them to exercise their natural curiosity and engage in rich scientific inquiry (Worth, 2010). Findings from this study indicate that while some teachers may recognize the benefits of cultivating scientific process skills in young children, a vast majority of those teachers seem to identify and promote only general process skills. They seem to fall short of providing children with adequate opportunities to develop more advanced skills.

Teacher's Role in Science Education

Teachers' in this study recognized the role they play in identifying children's interests and building upon those interests by asking them open-ended questions. These findings are supported by research which has identified that these practices not only engage children more actively in learning than other practices but also enable them to develop their cognitive abilities,

acquire general reasoning skills and expand their perceptual abilities (Kostelnik et al., 2014). Brenneman and her colleagues (2009) have identified that by understanding children's development and interests, teachers are better prepared to not only identify teachable moments when science learning is taking place, but also assess what a child knows or needs to know and further plan for subsequent instruction.

Teachers' responses seem to suggest that they recognize the role adults/teachers play in facilitating children's learning and development by providing them with adequate guidance and support when appropriate. Teachers' responses in this study align with the findings of the National Research Council (2008) which suggest that although children are naturally curious about their surroundings, they are likely to gain a deeper understanding of the construct with assistance from adults. Teachers in this study seem to value the role they play in modeling, demonstrating and not only providing children with meaningful experiences but also participating in those experiences with the children. These findings are also supported by research which signifies that teachers who share the scientific experience with children and engage in high-quality interaction either by asking open-ended questions or commenting on what they are jointly observing with the child are often capable of promoting science inquiry within the classroom (Hamil & Wisneski, 2012).

However, it should also be noted that while teachers recognized that they played a significant role in children's learning, they also identified that their role should be limited, as illustrated by one teacher's quote, "*Teacher instruction holds importance to an extent but should be limited.*" It is evident that they see the importance in allowing children to take the lead. These practices might suggest that teachers understand the value not only in scaffolding activities in order to enhance learning but also in identifying that each child learns differently and will

require different kinds of support. These findings are supported by a number of early childhood curricula that support the idea that effective teaching strategies arise by integrating implicit opportunities and explicit teaching (e.g., Tools of the Mind, Creative Curriculum, and Project Approach) (Kostelnik et al., 2014). In other words, these curricula emphasize the need for a balance between child directed and teacher supported learning opportunities in order to enhance learning (Vygotsky, 1978).

One may also argue that the reason teachers acknowledge the strong need to provide children with assistance and support when dealing with science content could be because early childhood educators are able to distinguish science from other readiness domains and further identify that children might be unfamiliar with this novel domain and could benefit from further assistance in the course of their learning. This is also supported by research which has identified that teachers recognize that science concepts can be difficult for children to grasp at an early age (Erden & Sonmez, 2010).

What Children Learn

When it comes to science domain knowledge, teachers in this study articulated a broad range of activities that seemed to cover only some aspects of science content. While teachers suggested traditional preschool activities such as mixing paint, differentiating between living and non-living objects, taking pictures and playing with materials at a sensory table, teachers didn't seem to articulate what science content children were learning from these activities. Teachers' responses did not capture specific science domains such as earth science, physical science and life science. In fact, besides the mention of nature, teachers did not seem to touch upon any of these specific domains. However, while a significant number of teachers defined science as exploring nature or learning about nature, only three teachers mentioned nature or incorporating

materials from nature when asked how they think science should be taught to young children. As stated earlier, most of the developmentally appropriate practices reported by teachers were not specific to the science domain, rather they reported general practices that can effectively be used in teaching any area of content knowledge to children. Only 15 teachers identified practices and activities that were specific to the science domain (e.g. “*exploring living and non-living things*”, “*answering questions like ‘why do the leaves change color? Why does the magnet stick to the refrigerator?’*”).

These findings might not be surprising as indicated by previous research which states that teachers are not only largely apprehensive about teaching early childhood science (Conezio & French, 2002) but also report low self-efficacy in teaching science (Greenfield et al., 2001). Furthermore, research indicates that preschool teachers have not been prepared to teach domain-specific knowledge, aside from literacy to young children (Isenberg, 2000). Other research in support of these findings suggest that teachers’ confidence in teaching science was often determined by their understanding of scientific concepts (Hanley, 1997) and teachers often reported that they felt underprepared to engage children in either formal or informal science activities (Nayfield et al., 2011). Research also indicates that teachers do not feel confident using the science related materials that they were provided with (Greenfield et al., 2009).

Determinants of Teachers’ Beliefs

This study identified that there was no association between teachers’ characteristics such as years of experience or educational background and their beliefs about science education for young children or the practices they adopted in their classrooms. These findings are contrary to research which has identified that teachers with higher educational degrees and teachers fewer years of experience tend to have more positive beliefs about early science (Erden & Sönmez,

2012). However, research has also revealed that there exists some level of incongruence between teacher beliefs and the instructional methods used in the classroom (Stipek & Byler, 1997).

These incongruences may be a result of outside pressure from parents who are apprehensive about their children's academic achievement as well as from administrators and policy makers who stress on the curriculum requirements aimed at enhancing test scores (Stipek & Byler, 1997). For example, with the majority of the states (46 states) adopting the Common Core State Standards (CCSS) for Language Arts (National Governors Association Center for Best Practices [NGA Center] & Council of Chief State School Officers [CCSSO], 2010), classroom instruction seems to focus less on developing domain knowledge in areas such as social studies and science, shifting teachers' attention to high-stakes testing focused specifically on reading and math. This shift at the k-2 level may result in pressures from kindergarten teachers, preschool administrators and families to focus on reading and math over science. Moreover, factors such as parents' education level as well as the socio-economic status also influence what teachers are forced to teach at school. Parents with less formal education and a lower socioeconomic status tend to insist on children acquiring basic skills rather than on learning specific content knowledge (West, Hausken, & Collins, 1993). Thus, family pressures may support Head Start teachers in particular to focus on literacy and math rather than science. Teachers' beliefs were also not related to the materials available in their classrooms. One might argue that teachers may not be in control of the materials they are provided with. Therefore, even if their beliefs support the use of materials to promote science process skills, they may not have the capacity to alter the materials provided to them to promote science learning in young children.

Teachers' role within the classroom also did not explain their beliefs. There was little similarity in the responses of lead and assistant teachers. These findings may be a reflection of

previous research which has identified that due to the different associations between programs, classroom characteristics and the ways in which lead teachers run their classrooms, it might be difficult to identify the exact role of the assistant and lead teacher in preschool classroom (Sosinsky & Gilliam 2011). This may mean that leads and assistants do less collaborative thinking and planning than previously thought, resulting in diverging beliefs.

LIMITATIONS AND FUTURE DIRECTIONS

All teachers in this study were recruited from those who volunteered to participate in a science related intervention study. Although these responses were collected pre-intervention from both control as well as intervention group teachers, one possible limitation for this study is that teachers volunteered to participate in a science intervention. Although no professional development in science had been provided prior to this data collection, teachers may have been primed differently for answering such questions about science than a group of teachers who have not volunteered to participate in a science intervention. This seems unlikely, because so few teachers provided responses specific to science.

Although the survey method is an appropriate and rigorous method for gathering data from a large number of participants, limitations to this method exist. This survey method did not provide researchers with the opportunity to ask teachers to elaborate or explain their responses, which may have resulted in less detailed responses than would have been derived from an interview. Further, the survey relied on teachers typing their responses which, depending on their skill and motivation for typing, may have reduced the detail they provided in responses. However, many teachers did provide details about the types of practices they use.

Although my decision to target the teachers who reported science process skills when examining research questions 2-4 is both theoretically and empirically supported, it is possible that there may be other beliefs that drive teachers' classroom practices.

Keeping these limitations in mind, future research may want to use interviews to ask teachers more targeted questions about their early science beliefs and practices and include follow up questions to permit teachers to elaborate on these responses. This might enable researchers to understand more about teachers' beliefs and approaches to science. Professional development aimed at improving teachers' early science practices and teacher training in general should take teachers' beliefs into consideration while designing programs to equip teachers with content knowledge on science as well as prepare them to use developmentally appropriate practices to teach domain-specific knowledge.

CONCLUSIONS

Early childhood educators seem to be of the opinion that young children are capable of learning science at a young age. While teachers stated broad definitions of science for young children, they did articulate a range of instructional strategies, which align with developmentally appropriate practices that are recommend for early childhood education. Unfortunately, less than half of teachers articulated practices which aligned with the Next Generation Science Standards, recognizing an important area for professional development.

APPENDIX

Level of Education	Teachers who reported science process skills	Other Teachers
High School Diploma	0	2.2%
Associates Degree	25%	22.2%
Bachelor's Degree	68.8%	66.7%
Master's Degree	6.3%	6.7%

Table 1. Teachers' highest level of education (in percentage) for teachers who reported science process skills and teachers who did not

Attitude towards teaching science

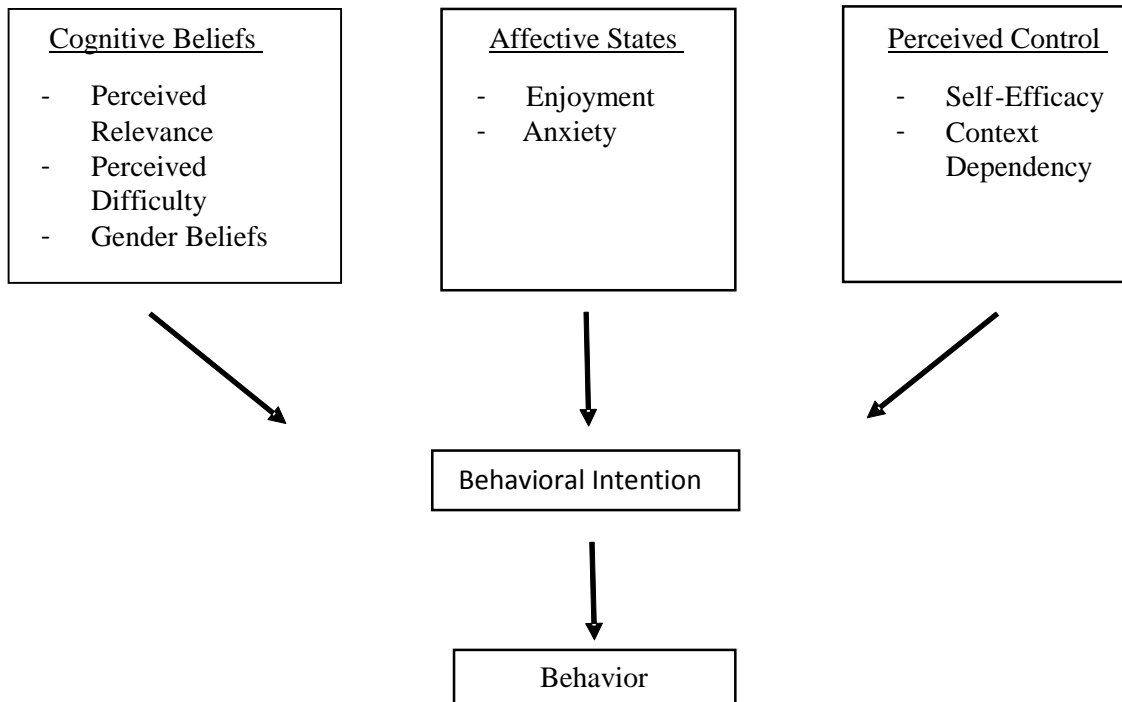


Figure 1. Theoretical Framework for the construct of primary teachers' attitude towards (the teaching of) science.

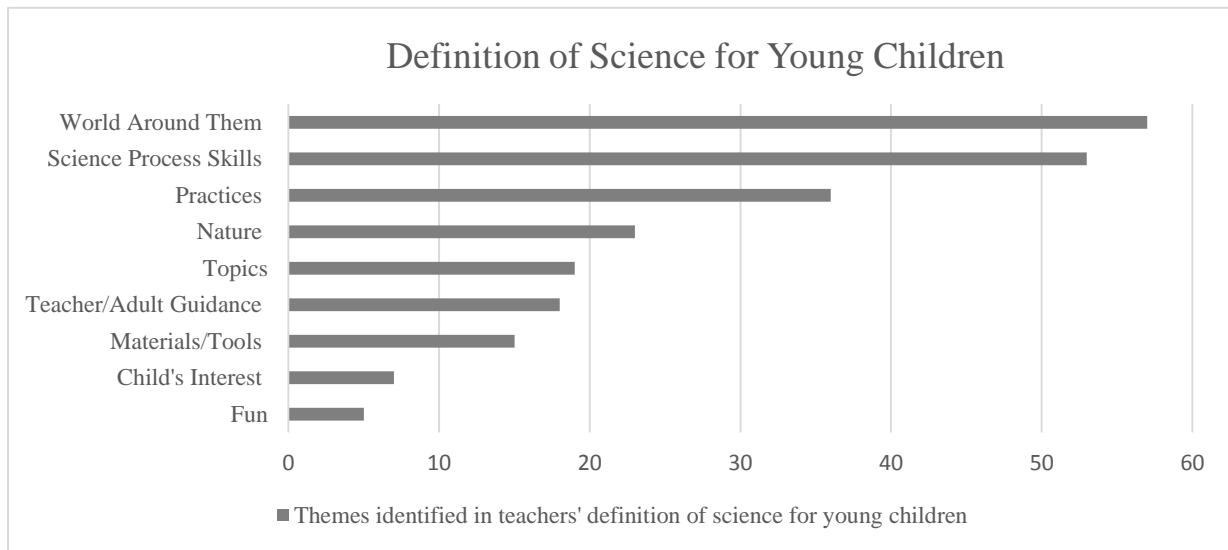


Figure 2. Frequency of themes identified in teachers' definition of science for young children

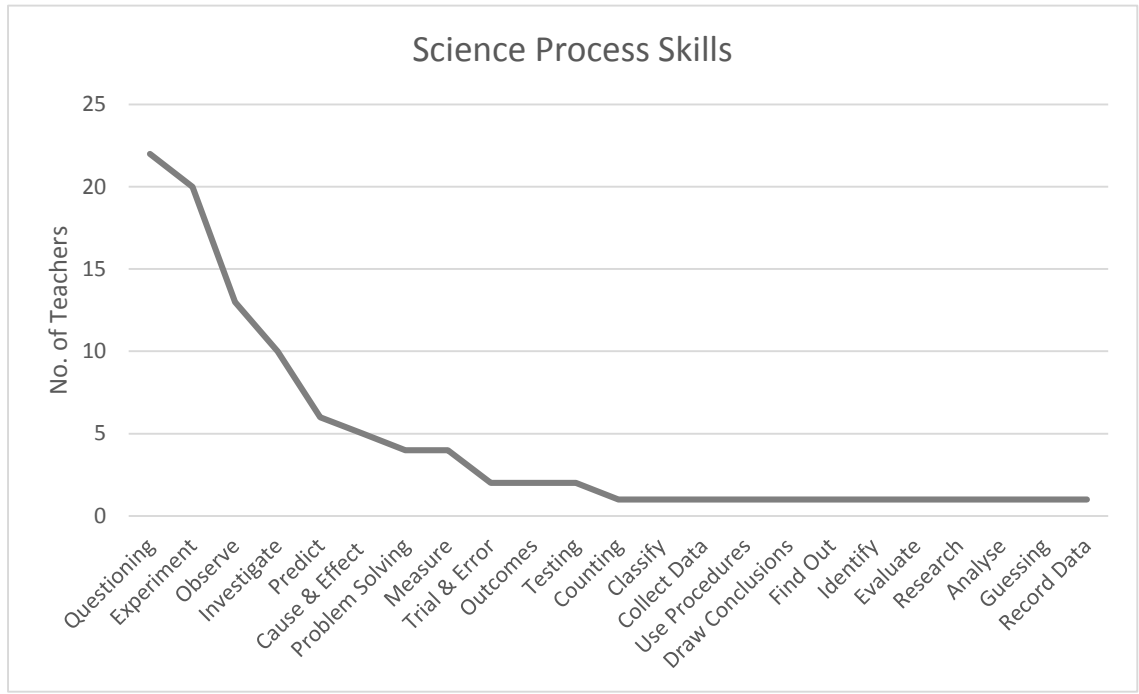


Figure 3. Frequency of science process skills identified by teachers

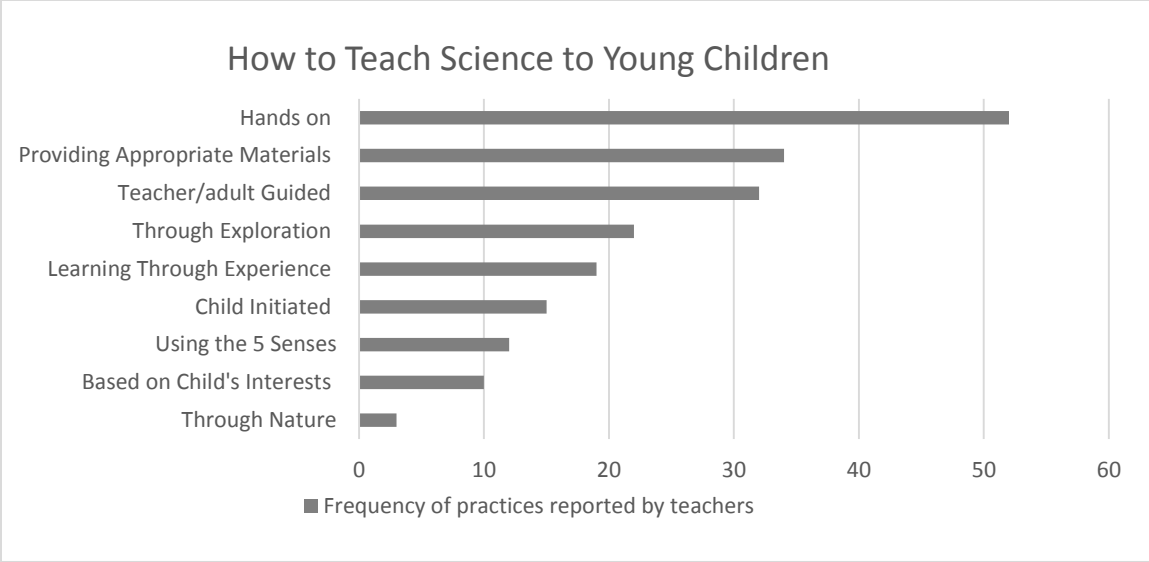


Figure 4. Frequency of themes identified in teachers' science practices

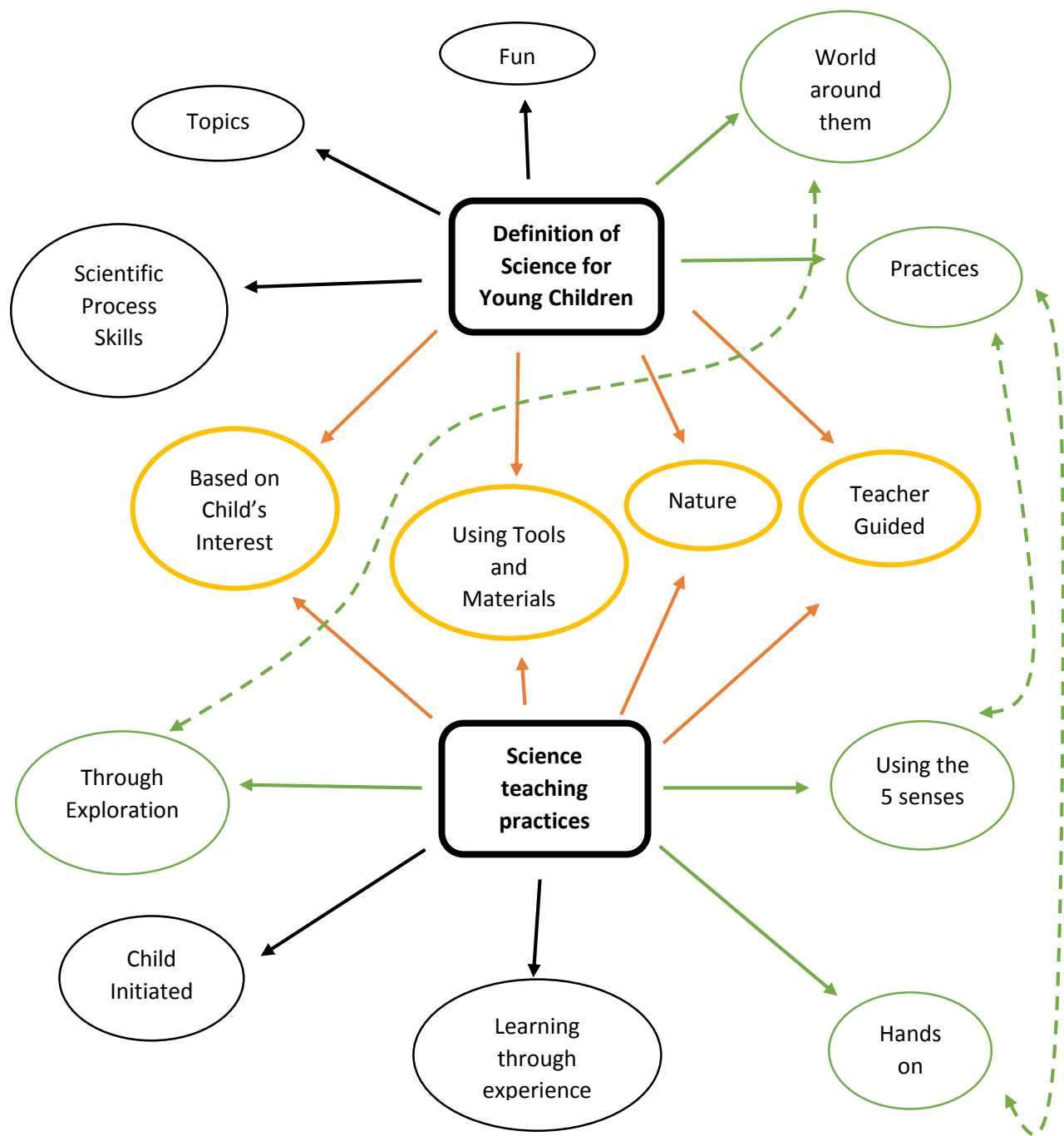


Figure 5. Thematic map illustrating relationships between the codes for the two questions

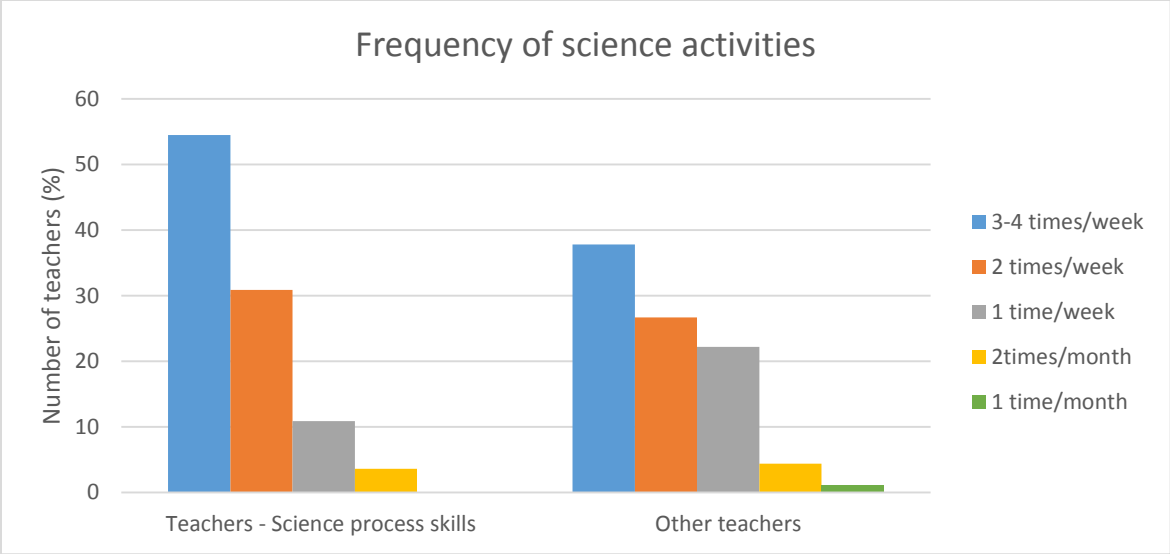


Figure 6. Frequency of science activities (in percentage) for teachers who reported science process skills and teachers who did not

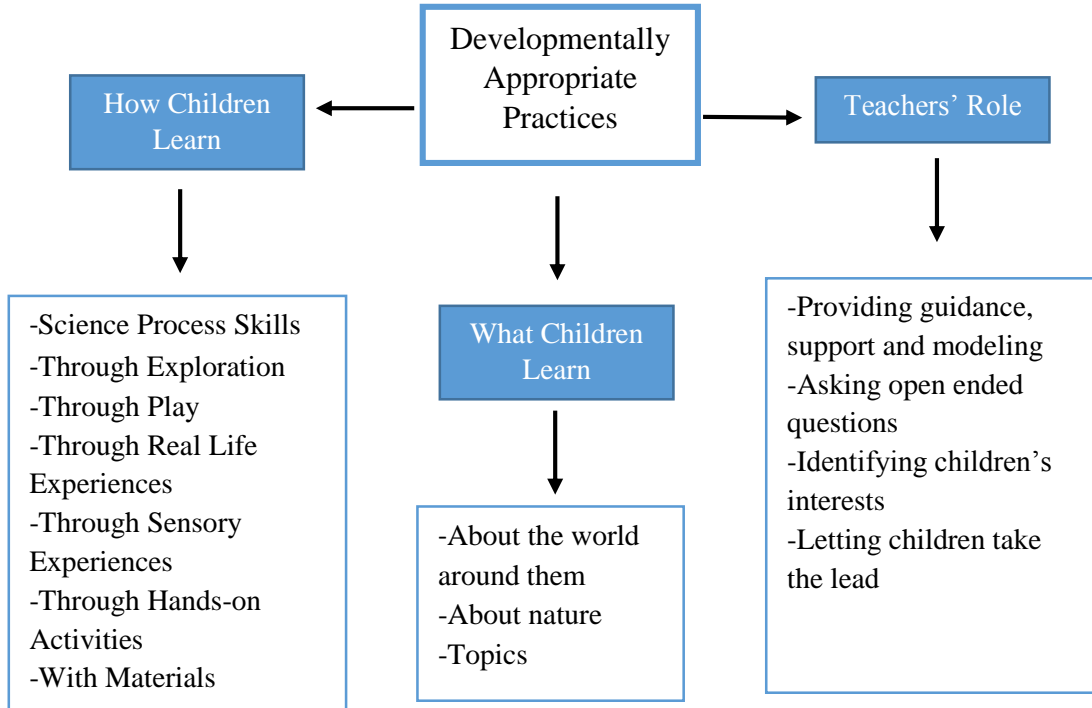


Figure 7. Model of how teachers' responses are categorized as developmentally appropriate practices

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