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ABSTRACT

Early science learning is a part of preschool curriculum that can have positive outcomes for children's scientific knowledge and interest. Head Start teachers are well positioned to implement quality science lessons. Through an in-depth needs assessment survey, the current study examined North Carolina preschool Head Start teachers' responses on needs, resources, experiences with professional development, and personal priority levels for science education. Our analysis revealed that Head Start teachers mostly utilized informal teaching methods and used curricular and organizational resources, but utilizing mealtimes for teaching science had mixed responses. Teachers reported their access to resources and connections to community partnerships. Teachers preferred asynchronous or online PD formats and were motivated by compensation and continuing education credits while accessing PD. Most teachers rated science to be a very or extremely important personal priority. Differences in teacher education, experience, and position levels also influenced the findings of the study. The implication section delineates steps that can be taken toward strengthening science education within Head Start settings along with support that can be provided to teachers.

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Science instruction focused on children's scientific thinking that supports school readiness is a priority in the early childhood classroom. Recent initiatives have called for greater attention and support for children's science learning (Areljung, 2019; Larimore, 2020; Morgan et al., 2016), highlighting the role of early childhood educators. However, not all early childhood educators may feel prepared or have an interest in implementing science lessons. While some educators may be more comfortable or have a personal interest in delivering science education and developing their science pedagogy, others may not

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(Areljung, 2019; Pendergast et al., 2017). Understanding teachers' needs in this area could inform professional development (PD) opportunities aimed at strengthening science learning.

Head Start (HS), a federally funded preschool program for children from low-resource backgrounds, aims to foster children's healthy development and well-being (Office of Head Start, n.d.). One way that HS strives to accomplish this goal is through the promotion of science and nutrition education. Head Start is positioned to support quality science learning through various means including providing healthy mealtimes through the Child and Adult Food Care Program (Office of Head Start, 2023). Because HS teachers can be facilitators in promoting science education in the classroom, it is important to know what they think about the state of science education in the HS classroom. Thus, the current study's purpose is to gain an understanding of HS teachers' needs, resources, experiences with PD and the priority placed on science education using survey data collected from North Carolina (NC) HS teachers.

Literature review

Science education and its impact in early childhood

Science education has been defined as providing educational experiences that engage children in scientific reasoning and inquiry (e.g., observing and discussing objects, materials, organisms, and events, classifying objects based on similarities, using measurement tools). Science education covers a variety of topics such as the life sciences (e.g., plants and animals), earth and space science, and health sciences (e.g., food, nutrition, and human health) (NGSS Lead States, 2013). The science domain capitalizes on the natural curiosity of preschoolers and can relate positively with other domains (Bustamante et al., 2018). Science learning involves asking questions, seeking solutions, and investigating (Bustamante et al., 2018; National Research Council, 2012). Science learning should focus on cognitively developing science knowledge and increasing motivation and identity as a scientist (Larimore, 2020). Science, as part of HS's Cognition learning domain, is a key feature of HS's learning framework (Head Start Early Learning Outcomes Framework, 2020). Most states have science learning standards in preschool, but most do not follow up-to-date guidance and guidelines from the Next-Generation Science Standards (NGSS) and *A Framework for K-12 Science Education* (Larimore, 2020; National Research Council, 2012; NGSS Lead States, 2013). The guidelines by NGSS are educational goals or standards for science competencies that all US children should be able to demonstrate at different stages (Akerson & Buck, 2023). These standards were developed for each state to use as guidance in developing their own standards (Akerson & Buck, 2023). However, recent reviews indicated that there are discrepancies between preschool teachers' practices and the recommended standards (e.g., Hoisington, 2024; Tanas & Fulmer, 2023; Tuttle et al., 2016; Won & You, 2022).

It is well accepted now that children are not only capable of learning and talking about science, but given early exposure, they also find it enjoyable (Larimore, 2020; McClure, 2017; Oppermann et al., 2018). Early exposure to science learning, or lack thereof, can have lasting impacts on children across domains. Science learning enables children to better understand the world around them (Larimore, 2020), and early interest in science contributes to interest in and understanding of science (Alexander et al., 2012; Greenfield et al., 2017). Children involved with early quality science learning demonstrated greater competence in science in kindergarten, which impacted their continued interest in science and science-related careers beyond high school (Mantzicopoulos et al., 2008). Science, Technology, Engineering, and Math (STEM) lessons in early childhood also provide enriching experiences for other developmental domains such as language development for children from all cultural and linguistic backgrounds, particularly if multimodal instruction is included (Brenneman et al., 2019; Méndez et al., 2023). Recently, higher quality instructional interaction was found during HS science and storybook reading than during math and circle time because science and storybook reading lend themselves more to a culture of inquiry and meaningful questioning (Kook & Greenfield, 2021). Integrating STEM into early childhood education may help reduce the achievement gap for ethnically and economically diverse children attending HS (Aldemir & Kermani, 2017). One study of eastern North Carolina HS classrooms found that children's scientific understanding increased by engaging in a developmentally appropriate STEM program (Aldemir & Kermani, 2017).

On the other hand, of the four academic domains (language, literacy, math, and cognition), children from low-income households perform lowest on science (Bustamante et al., 2018; Greenfield et al., 2009; Office of Head Start, n.d.). The resulting achievement gap persists into middle childhood (Gerde et al., 2021; Morgan et al., 2016). Unfortunately, the benefits of science learning cannot be realized unless children engage with science learning on a regular basis (Larimore, 2020). Therefore, quality science learning should be a requirement of preschool education (Larimore, 2020).

Types of science lessons

Science learning in the preschool setting can take many forms and utilizes various scientific materials. Lessons can be formal preplanned lessons, informal ones that occur when teachers provide science materials and then children choose to engage or not, or incidental ones that occur unexpectedly when something happens that piques children's interest and the teachers expand upon the science concepts using child-led learning (Neuman, 1972; Tu, 2006). With competing priorities in the preschool classroom and teachers' lack of time, the family-style mealtimes in HS are an excellent time for teachers to engage children in science learning (Dickinson & Tabors, 2001; Massey, 2004). Using these teachable moments and children's prior experiences to talk about science in everyday conversation at home or during childcare can spark interest and provide this early exposure to children (Andersson & Gullberg, 2014). Talking about science engages children in scientific conversation and ideation by encouraging children to have conversations about what they observe with their senses, describe, compare/contrast, question, predict, and reflect. Talking about science also supports the development of children's language skills by supporting and teaching children understanding and use of science-related concepts and words (Méndez et al., 2023). Certain aspects of inquiry may come easier to teachers; many preschool teachers reported using scientific concepts such as observing and questioning (the beginning steps of inquiry) more than predicting and evaluating evidence (Hollingsworth & Vandermaas-Peeler, 2017). Despite children's interest and the benefits of science learning, delivery of quality science lessons in preschool is infrequent, around once or twice a week or less (Gerde et al., 2018;

Oppermann et al., 2021; Tu, 2006). Few studies have examined the factors that influence the infrequency of formal, informal, and incidental science lessons in preschool (Neuman, 1972; Oppermann et al., 2021).

Science learning can occur with a range of materials. Teachers and children can make use of everyday items that classrooms already have for more open-ended exploratory play and lessons on science (DeVries & Sales, 2011; Hong et al., 2023). Some more formal or specific science lessons may require additional resources in the classroom that are more commonly considered science items (e.g., magnifying glasses, pipettes, balancing scales, and microscopes). Previous research has found that teachers expressed wanting more science-specific materials because of their association with formal science experiments (Hong et al., 2023). Regarding both general and science-specific materials, it is important to know what resources teachers have access to and use for teaching science. Tu (2006) found that only half of the preschool classrooms observed had science learning centers, despite teachers in other studies expressing the importance of having a science learning center (Pendergast et al., 2017). The existing science-related materials in the classroom, such as plants, should be used to create an engaging environment to promote science (Tu, 2006). However, not all teachers may feel confident or be trained on using science learning center materials, such as scales and microscopes (Pendergast et al., 2017). It is also important to know what resources teachers turn to in order to learn about and plan science lessons. Pendergast et al. (2017) survey of 112 pre-kindergarten teachers found that most often teachers used the Internet to plan science learning activities and least often discussed science teaching with fellow teachers. It is important to ask teachers to reflect on, critique, and justify the use and need for various science materials in the classroom (Hong et al., 2023). Reflecting on science materials may help to ensure that materials promote equal participation in science and does not promote bias (Gichuru, 2024). Having access to quality science materials allows both teachers and children to create opportunities to use these materials for science exploration (Raven & Wenner, 2023). Understanding teachers' uses and needs for science materials can inform allotment of materials and has implications for promoting the use of materials already found in the classroom.

Science as a priority for teachers

It has been well established that teachers at all levels, including in early childhood, face competing demands on teaching time. In preschool, math and literacy are often given priority over other subject areas in order to prepare children for kindergarten (La Paro et al., 2009). McWayne et al. (2022) highlight that science has not been prioritized in HS teacher preparation nor credentialing which has resulted in less effective science teaching. Buy-in and modeling valuing science from faculty in pre-service teacher education programs and from administration for in-service teachers can communicate that high-quality science is important in early childhood (Lippard et al., 2018). Teachers are better positioned to encourage children's scientific inquiry when they prioritize science themselves (Zembal-Saul et al., 2022). Even when teachers value science, teachers may feel less competent in science than other subjects which impacts their implementation (Oppermann et al., 2021; Pendergast et al., 2017). Furthermore, there have been recent initiatives to increase participation and the quality of science, technology, engineering, and mathematics across the United States at all levels in order to compete with other countries (Piasta et al., 2014; The

White House, 2010). In line with previous research and initiatives, it is important to assess teachers' prioritization of science in order to tailor science-specific professional development training opportunities and other supports.

Professional development

Professional development has been associated with improvements in teacher self-efficacy and skills (Duran et al., 2009; Oppermann et al., 2021). Professional development is a continuum of learning and support activities designed to prepare individuals to work with and on behalf of young children and their families. These opportunities lead to improvements in the knowledge, skills, practices, and dispositions of early childhood professionals (NAEYC, n.d.). Science specific PD opportunities can broaden and strengthen teachers' skills (Oppermann et al., 2021; NAEYC, n.d.). The number of HS teachers with an associate or bachelor's degree continues to increase over time due to a federal mandate, whereas educational requirements for teachers in public and private preschools vary (Bassok, 2013). However, teacher education level does not necessarily predict higher-quality classroom instruction, but having teachers with a background in early childhood education is a predictor of classroom quality (Lin & Magnuson, 2018). Professional development and mentorship can contribute to classroom quality even if teachers have fewer years of education (Lin & Magnuson, 2018; Rhodes & Huston, 2012). For example, sustained PD efforts with HS teachers on an American Indian Reservation demonstrated that teachers paid more attention to children's science learning, delivered more inquiry-based practices, and improved their attitudes toward science learning when assessed 2 years after the PD (Roehrig et al., 2011). By improving upon these skills, teachers may improve their confidence and feelings to deliver science education (Andersson & Gullberg, 2014).

Professional development can support teachers to learn how to design and integrate quality science learning into the early childhood classroom (Brenneman et al., 2019). Effective PD opportunities should be responsive to teachers' needs, empower teachers, and focus on developmentally appropriate science concepts (Blank & De las Alas, 2009; Brenneman et al., 2019; Wei et al., 2009; Zaslow et al., 2010). Professional development is critical as it may influence educators' beliefs, attitudes, and knowledge and teaching practices regarding science education (Brenneman et al., 2019). Professional development can take many forms, including workshops, individualized coaching, and professional learning communities (Brenneman et al., 2019). Conducting a targeted needs assessment may allow for more tailored PD opportunities. For example, needs assessments conducted by Larimore (2020) indicated the need for intentional support for early childhood educators with concrete ways to implement quality science learning in the classroom. Kook and Greenfield (2021) recommended high quality targeted PD opportunities that used inquiry-based approaches to increase the quality and quantity of science education in early childhood education. While teachers may not have extensive science training backgrounds, science PD may influence teachers' science practices more than their educational backgrounds (Oppermann et al., 2021). For example, kindergarten teachers participating in a five-day science PD intervention found an increase in teacher confidence, a decrease in teacher anxiety and an increase in confidence and peer collaboration after 3 and 6 months related to a science curriculum (Furtado, 2010).

Although early childhood education provides a fitting environment for early science learning, quality science lessons and science engagement are limited especially in HS for various reasons (Gerde et al., 2021; Greenfield et al., 2009). Early childhood educators often have not received formal in-depth training on quality science education for children and may lack confidence, which leads to decreased science instruction in the classroom (Brenneman et al., 2019; Larimore, 2020; Piasta et al., 2015). School investment into teacher PD in science may yield higher quality, and more frequent science learning experiences for children in the classroom (Gerde et al., 2021). An increase in science PD opportunities could in turn improve children's outcomes for science learning and school readiness (Brenneman et al., 2019; Piasta et al., 2015). For teachers, by supporting and preparing them to effectively teach science, they may express more positive attitudes about science learning and science-specific PD opportunities which may in turn improve job satisfaction (Pendergast et al., 2017; Wells, 2015).

Similar to possible variations by education and experience, teachers' position as either a lead or assistant teacher may impact their views on science education. Assistant teachers are an invaluable part of early childhood education. As a teaching team, both lead and assistant teachers are in dynamic roles and contribute to the classroom in important ways (Mowrey & Farran, 2022). However, where these teachers' roles, views, and behaviors converge and diverge has been understudied (Mowrey & Farran, 2022). While assistant teachers are often included in research of early childhood educators, analysis is not always done by position level. In early childhood, some researchers have examined the role of teachers' position in various topics such as assistant teachers' views on quality in education (e.g., Karademir et al., 2017), assistant teachers' role in classroom management and teaching (e.g., Sosinsky & Gilliam, 2011), and curriculum demands by lead or assistant position (e.g., Mowrey & Farran, 2022). There may be differences in teachers' report of their perceptions and needs for science education by lead and assistant position. Understanding both lead and assistant teachers' needs and perceptions of science education can aid in development targeting professional development supports and resources by position.

This study was informed by Bronfenbrenner's ecological systems theory (Bronfenbrenner, 1979). This theory posits that individuals and their environment are continuously interacting and influencing one another. For early childhood educators, how teachers interact within the preschool system and classroom mutually influence how they navigate different goals and subjects, and implement their teaching practices (Sheridan et al., 2011). Ecological systems theory provides a lens to understand how teachers navigate the classroom, the profession, and other structural factors. Preschool, and more specifically HS are situated in and influenced by macrolevel policy changes. Teachers also navigate micro- and meso-level factors including working with families, administrators, and community partnerships. Furthermore, critical perspectives of ecological systems theory in early childhood position teachers as agents of change and as a community of learners themselves (Dalli et al., 2012; Sheridan et al., 2011). This theoretical framing contextualizes our study and provides a basis for understanding the contexts in which teachers experience science education in the early childhood education environment.

Purpose of current study

How teachers prioritize science may impact their experiences with science education. Science-specific PD has shown promise for improving HS teachers' delivery of science education lessons. To support teachers and tailor effective science PD opportunities, it is essential to understand teachers' priorities and needs related to science education. Therefore, the purpose of our current study was to describe HS programs' needs, resources, experiences with PD, and priorities placed on science education from HS lead, assistant, and other floater teachers' viewpoints. Thus, these research questions (RQs) guided the current study:

(1) How frequently do HS teachers use formal, informal, incidental, and mealtimes for science teaching?
   a. Do HS teachers differ in their use of formal, informal, incidental, and mealtime science teaching based on their teaching experience, education, and position level?
(2) From teachers' perspectives, what science resources are available and what characteristics are important when selecting resources?
(3) What are teachers' experiences, motivations, and preferences for science related PD opportunities?
(4) What are teachers' reported priority level for science education?
   a. Do teachers' reported priority levels for science education differ based on their teaching experience, education, and position level?

Methods

Research design

We utilized a descriptive research design (Siedlecki, 2020), wherein we described the landscape of science teaching and its utility within HS settings by surveying NC HS teachers. Descriptive research designs are used to provide a comprehensive and accurate picture of groups, events, or conditions as they are (Colorafi & Evans, 2016; Siedlecki, 2020), which in our study is HS teachers and their work in the realm of preschool science education. Through the use of survey, we describe the experiences of HS teachers by reporting frequencies and analyzing trends that emerge as appropriate with descriptive research designs. We are not inferring cause-and-effect relationships in our paper (Colorafi & Evans, 2016; Siedlecki, 2020). Thus, our needs assessment survey primarily examined HS teachers' science education practices, training and PD needs, and perceptions of priority placed on science education. We obtained university Institutional Review Board approval for this study.

The larger study

The present study uses a subset of the larger state-level needs assessment study of partner HS programs to inform the development of teacher PD resources for the Preschool Education in Applied Science (PEAS) Institute for Early Childhood Teachers. PEAS is a five-year grant funded by a National Institutes of Health (NIH) National Institute of General Medical Sciences (NIGMS) Science Education Partnership Award (SEPA). The overall aim of PEAS is to create a teacher PD intervention that aims to (1) build teachers' science teaching efficacy and pedagogical knowledge and skills; and (2) improve children's science knowledge, development of scientific language, and dietary quality.

Participant eligibility, recruitment, and data collection procedures

Individuals were eligible to participate if they were currently employed as a lead, assistant, or other (floater) teacher at a HS-funded organization in NC and 18 years of age or older. To recruit teachers, we used a comprehensive list of HS-funded organizations and their affiliated centers as the sampling frame from the NC HS website (North Carolina Head Start Association, n.d.). We contacted all organizations to ensure representation by location and organization type. At the time of the study, there were 354 centers within 52 funded HS organizations in NC. Seventeen of the 52 agencies (32.7%) responded to the initial communication. We contacted each organization's education manager via phone or e-mail to obtain permission to contact the teachers. HS Program Directors were also contacted and asked to post the study's details on their internal webpage and/or Facebook page. However, HS Directors were unaware of which individuals ultimately volunteered to participate in the study. Once permitted, we contacted HS teachers by e-mail. Teachers who agreed to participate were given an electronic informed consent form and an online survey (REDCap). Participants were entered into a raffle for a $95 gift card for completing the survey. We collected our data from September 2020 to March 2021, which was during the COVID-19 pandemic. However, we asked participants to answer questions regarding normal pre-pandemic operations. We could not calculate the overall response rate as we did not know the total number of teachers (potential participants) that each center and agency had. Table 1 presents the participant demographics.

Data collection tools

Statewide teacher survey

The overall larger online survey assessed HS teachers' experiences with teaching science, implementing science talk and food experiences, training, and professional development opportunities and priorities for science education (78-items total). Most of the survey items were adapted from tools researchers had developed or utilized before (Carraway-Stage et al., 2014; Peterson et al., 2017). We also adapted Derscheid et al. (2014)'s questions about teachers' self-efficacy and knowledge of healthy nutrition practices in the classroom for science teaching practices. We did not use the full survey for this study. In this study, we focused on science education only and specifically analyzed and discussed data about teaching science. To address our research questions, this paper uses five main variables of interest (i.e., 1. teachers' reported frequency of science teaching, 2. teachers' reported available resources, 3. teachers' reported important characteristics of resources, 4. teachers' reported experiences, motivations, preferences for science education PD, 5. teachers' reported priority levels for science education) and demographic variables about themselves (e.g., self-reported age, gender, race, language (1 item each)) and their careers (i.e., years of teaching experience, highest level of education, and position at Head Start (1 item each)). Teachers' reported frequency of science teaching was three questions, one question for each type of learning experience (formal, informal, and incidental) on a 5-point Likert scale. Teachers' report of availability of resources

Table 1. Participant demographics.

Variable	*n*	%	*M(SD), Range*
Gender			
Female	155	92.3	
Male or Other*	2	1.2	
*Category of Male or Other grouped together to prevent possible re-identification of participant			
Missing	11	6.5	
Race (Mark all that apply)			
White or European American, non-Hispanic	65	38.6	
Latino(a) or Spanish	9	5.4	
Black or African American, non-Hispanic	85	50.6	
Asian or Asian-American, non-Hispanic	0	0	
American Indian or Alaskan Native, non-Hispanic	0	0	
Middle Eastern or North African	0	0	
Native Hawaiian or Pacific Islander	0	0	
Multi-ethnic	2	1.2	
Other	0	0	
Missing	7	4.2	
Speak Language Other than English			
Yes (specify)	21	12.5	
Spanish	17	10.1	
Italian	1	0.6	
Russian	1	0.6	
Sign	1	0.6	
No	140	83.3	
Missing	7	4.2	
Years Work in Head Start	150	89.3	8.57(*7.78*), 1-36
Worked in Other Preschool Setting Outside of HS	120	71.4	
Position			
Lead	105	62.5	
Assistant	41	24.4	
Other	15	8.9	
Missing	7	4.2	
Education			
Some college	12	7.1	
2-year Associate's degree	40	23.8	
4-year Bachelor's degree	85	50.6	
Some graduate coursework	9	5.4	
Master's degree or above	18	10.7	
Missing	4	2.4	
Highest degree focused in Early Childhood Education			
Yes	117	69.7	
No	39	23.2	
Missing	12	7.1	
Licensure Held (Mark all that apply)			
Birth through Kindergarten (BK)	56	33.3	
BK Add-on	6	3.6	
Pre-K Add-on	3	1.8	
Elementary	10	6.0	
Special Education	7	4.2	
NC Early Childhood Credential/CDA	41	24.4	
Early Educator Certificate	18	10.7	
No licensure	41	24.4	
Missing	1	0.6	

N = 168.

was one question with 14 response categories and important characteristics of resources was one question with eight response categories. Teachers' reported experiences (7 items), motivations (14 items), preferences for science education (8 items) were 3 questions with various response categories. Teachers' reported priority levels for science education was one question with five response categories. We provide more information with the survey question/item of analysis and the response options (italicized) in the Results where appropriate. We used standard demographic options from the US Office of Management and Budget (Díaz Rios et al., 2022; Office of Management and Budget, n.d.).

The Cronbach's alpha for the measures used in this study ranged from .73 to .89, indicating good reliability. However, Cronbach's alpha is heavily influenced by the number of items in a measure (Tavakol & Dennick, 2011; Vaske et al., 2017). Therefore, we wanted to examine reliability beyond Cronbach's alpha. To assess and improve the validity and reliability of our survey, we cognitively evaluated our final survey with experts and pilot participants. Beyond quantitative assessments of these criteria, cognitive interviews are helpful in ensuring that participants interpret and understand survey instructions and questions as researchers intend (García, 2011; Willis, 2004). Cognitive evaluations of surveys are an underused method to assess and improve reliable and valid measures (Desimone & Le Floch, 2004; García, 2011; Willis, 2004). Two experts (a Registered Dietitian and an early childhood scholar) who were familiar with our subject matter assessed our survey questions to determine if they effectively addressed our topics of interest. Additionally, we engaged two preschool teachers (who were not a part of the final sample) in cognitive interviews to evaluate the survey and provide feedback on each question. In these interviews, participants discussed their thought processes and interpretations when reading and responding to the survey (Desimone & Le Floch, 2004). We revised questions accordingly from the experts' and teachers' feedback with minor edits to wording; there were no substantive changes. The cognitive interviews indicated that we were appropriately addressing our topic of interest. We compensated the cognitive interview participants with a $10 gift card.

Data analysis

We conducted our statistical analyses (i.e., descriptive statistics, frequencies, and ANOVAs) in an IBM's SPSS (version 28.0, IBM Corp, Armonk, NY, 2021) version 28. The following results will be presented by sections: frequency of science teaching in HS (RQ 1); resources (RQ 2); teacher experiences, motivation and preferences for PD (RQ 3); and teachers' perceptions on priority placed for science education (RQ 4).

Results

In the following section, we present descriptive statistics and frequencies. We report all ANOVA results, including non-significant findings, in Table 2. We report only the most significant ANOVA findings in-text below.

Frequency of science teaching in HS

Addressing RQ 1, we asked teachers how frequently they provided formal, informal, and incidental science learning experiences within their classrooms. Teachers responded on a Likert scale of 1 to 5: very often (daily), regularly (2–4/week), sometimes (weekly), rarely (monthly) and almost never (less than monthly) or None of the above. To ensure teachers understood what we mean by formal, informal, and incidental experiences, we provided

Table 2. Means, standard deviations, and one-way analyses of variance for teaching science and priority by experience, education, and position.

		Beginning Teacher		Experienced Teacher								
	Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	Sum of Squares	*df*	Mean Square	*F*	*p*
Teaching science by experience	Formal teaching	2.26	1.10	1.99	.91			2.84	1	2.84	2.78	.10
	Informal teaching	1.48	.72	1.57	.70			.29	1	.29	.56	.45
	Incidental teaching	2.13	1.09	2.13	.91			.00	1	.00	.00	.99
	Mealtime teaching	2.07	1.08	1.78	.83			3.48	1	3.48	3.69	.05**
Priority by experience	Personal priority	3.80	.81	4.09	.62			3.50	1	3.50	6.67	.01*
		<4 Years of Education		≥4 years of Education								
Teaching science by education	Formal teaching	2.17	1.08	2.13	.99			.07	1	.07	.07	.79
	Informal teaching	1.41	.67	1.59	.74			1.17	1	1.17	2.25	.14
	Incidental teaching	2.37	1.14	2.03	.90			4.03	1	4.04	4.17	.04*
	Mealtime teaching	2.04	.99	1.88	.97			.85	1	.85	.90	.35
Priority by education	Personal priority	3.92	.87	3.95	.67			.02	1	.02	.04	.85
		Lead		Assistant		Other						
Teaching science by position	Formal teaching	2.15	.94	2.05	1.20	2.21	1.01	.43	2	.21	.20	.82
	Informal teaching	1.52	.68	1.51	.68	1.80	1.01	1.06	2	.53	1.01	.37
	Incidental teaching	2.09	.94	2.20	1.12	2.21	1.12	.47	2	.23	.23	.79
	Mealtime teaching	2.00	.98	1.88	1.01	1.60	.83	2.26	2	1.13	1.19	.31
Priority by position	Personal priority	4.00	.67	3.83	.90	3.87	.64	.98	2	.49	.92	.40

* = statistically significant at the $p < .05$ level, ** = statistically significant at the $p < .01$, *** = statistically significant at the $p < .001$.

participants with a definition of each. We defined formal experiences as those that are planned ahead of time, materials are prepared, activity is documented on the lesson plan, and children are encouraged to engage in the activity (e.g. melting/freezing activities, cooking activities, etc.). Informal experiences were those that occur when materials are made available to children, such as science centers/areas in the classroom, but the child freely chooses to engage with the materials (e.g. science center with magnifying glasses and items to view, spoons, measuring cups or spoons, etc.). Incidental experiences were not preplanned by the teacher and occurs "in the moment" when children are engaged in naturalistic experiences and then expended on by the teacher (e.g. a sudden change in weather, interest in how plants grow, etc.). As with formal experiences, informal experiences can be planned but children may have options to choose other activities such as multiple science centers/stations.

HS Teachers reported utilizing informal teaching methods *very often or regularly* to teach science (87.3%), followed by incidental teaching (63.0%) and formal structured teaching (61.2%). When asked which environments they teach science to children most frequently, they reported that most of the informal and incidental teaching of science occurred when teachers interacted with children in the learning centers, during free play time (54.2%), followed by outdoor play time (21.4%) and circle time (20.8%), and lastly mealtimes (1.2%). HS teachers also reported using mealtimes *very often or regularly* with children to talk about science (73.8%), followed by *sometimes* (20.2%), when use of mealtimes to teach children about science was posed as a separate question. Science education during mealtimes could include science talk and/or informal discussions with children about science concepts during a meal.

Differences in type of teaching based on teacher experience, education, and position

We further explored if teachers differ in their use of formal, informal, incidental, and mealtime science teaching based on their experience, education, and position within the HS setting. We conducted one-way analyses of variance (ANOVA) to examine the mean differences between the groups (see Table 2). To assess differences by teacher experience level, we placed teachers into two groups: 1) teachers with equal or fewer than 5 years (beginning) and 2) more than 5 years of teaching experience (experienced). Early career teachers have been defined at various lengths in previous research (e.g., new hires, first-year teachers, within their first few years). We used the cutoff of 5 years because many early-career teachers leave the profession within the first 5 years with some leaving before completing their first year of service (Cabell et al., 2013; Kutsyuruba et al., 2019; Zhang et al., 2019). Beginning teachers had a mean score of 2.26 ($SD = 1.09$), and experienced teachers had a mean score of 1.99 ($SD = 1.99$) for utilizing formal structured learning experiences. The ANOVAs for formal, informal, and incidental teaching by experience level were not significant. When beginning and experienced teachers were compared on mealtime teaching opportunities, beginning teachers had a mean of 2.07 ($SD = 1.08$) and experienced teachers had a mean of 1.78 ($SD = 0.83$). These mean differences were significant F (1, 158) = 3.48, $p = .05$), indicating that experienced teachers reported utilizing mealtimes *very often* (daily) to teach children science compared to beginning teachers who reported doing so on a *regular* basis (2 to 4 times a week).

To assess differences by education levels, we compared teachers with fewer than 4 years education (i.e., group 1) and equal to or more than 4 years of education (i.e., group 2) as 4 years is typically a Bachelor's degree. The one-way ANOVAs by education levels (see Table 2) were not significant for formal, informal, and mealtime teaching. For incidental teaching by education level, the mean differences between teachers in group 1 (<4 years) ($M = 2.37$, $SD = 1.14$) and those in group 2 (≥4 years) ($M = 2.03$, $SD = 0.90$) were statistically significant at $F(1, 160) = 4.04$, $p = .04$). This finding indicated that teachers with fewer years of education reported *regularly* utilizing incidental teaching to teach children science, compared to teachers with more years of education who reported utilizing it *very often* (daily) *or regularly* (2 to 4 times a week).

We aimed to assess differences in teaching by position in HS (lead, assistant, and other teachers). There were no significant differences between the means for these groups and their scores on formal, informal, incidental, and mealtime science learning opportunities (see Table 2).

Resources

Regarding RQ 2, we asked teachers what resources were available to teach science in their classrooms (options: *available, not available*, and *not applicable*), including curricula and community organizational resources. Participants indicated the availability of 12 different resources: Specific Curricular Resource, Games, Educational Posters, Books, Computer Software, Music, Videos, Materials for Center Play, Refrigerator for Perishable Items, Additional Staff Support to Help with Hands-on Activities, Funds to Support Purchasing New Sup-plies Needed for New Activities, and Funds to Support Field Trips or 2 other options (Other and None of the Above). From teachers' reports, books on science (98.1%) were the most readily available resource for teachers to teach science followed by specific materials within their centers such as plants or magnifying glasses (97.6%), music (84%), games and educational posters (83%), curricular resources on science (78.9%), videos, and computer software for science available (78.5% and 53.7% respectively). Interestingly, only 61.1% of the HS teachers reported having access to a refrigerator to keep perishable foods and products, while only 36.8% of HS teachers reported having resources available to take children on a field trip (e.g., grocery stores, and farms). Approximately 72% of the HS teachers stated they could get additional staff help with hands-on science activities.

Other curricular resources HS teachers specified were books they could get from the lending library such as Smart Start (a dedicated program within the NC Partnership for Children to provide national programs to children and families and increase the quality of early childhood education in the state) (Smart Start, n.d.) or public libraries. Teachers also mentioned using the Creative Curriculum (Teaching Strategies, n.d.) and their suggested lesson plans. Other easily available resources mentioned by teachers were free YouTube videos, donated items, and materials that they could rotate periodically within the center to keep children's interest. According to participants, the following community resources were available to them in the past year: parents and guardians (19.8%), local library (18%), physicians and nurses (16.2%), NC Partnership for Children (15.6%), and dentists (14.4%). Approximately 25% of the teachers stated that they did not have any partnerships with people within the community in their efforts to teach science.

We asked teachers to rate the importance of various characteristics when selecting an activity or curricular resource for teaching science (options: *important*, *somewhat important*, *not important*, or *I don't know*) from six different options (Cost to implement activity;

Ease of use; Structure/organization of content; Inclusive of all materials needed to implement the activity; length of activity; cultural appropriateness) and two other options (Other and None of the Above). Most teachers indicated that cultural appropriateness of an activity (98.7%), inclusion of all materials that are needed to teach science (97.5%), structure/organization of the content (96.9%), ease of use of a particular resource (95.5%), length of the activity (95.0%), and cost of the activity (85.7%) were considered *important* or *somewhat important* resource characteristics.

Teachers' experiences and views on professional development

Regarding RQ 3, we assessed teachers' experiences, motivations, and preferences for science learning PD opportunities. We asked teachers to reflect on when they were a newly hired teacher and select how their program trained them in their first year to teach children about science (mark all that apply) from seven options. The options were as follows: 1) Senior teachers verbally explain practices and strategies, 2) I was asked to review the program's written guidelines, 3) The program provided videotapes, 4) I was required to attend a workshop or training session (e.g. pre-service, in-service conference), 5) I was asked to read books or articles, 6) I collaborated with the more experienced teachers to get ideas and successful strategies, and 7) I did not receive any training on teaching children about this concept. Approximately 46% of participants reported that they attended some PD sessions on science and science education during their first year. Additionally, over half of participants (56.3%) reported collaborating with more experienced teachers to get ideas on how to approach science education and implement successful strategies during their first year as a way to prepare to teach science education. Approximately a third of participants (32%) also reported that they relied on more experienced teachers to provide a verbal explanation of practices and strategies while utilizing science in their classrooms during their first year. Less than a third of participants (29.3%) reported getting directly trained on science and teaching science concepts to young children during their first year as a teacher. Participants also mentioned being prepared to teach science by reading program guidelines (25.7%), reading suggested books and articles (10.8%), and watching program videos (6.6%) during their first year.

There was variety in teachers' motivation to participate in science related PD. Teachers could select all that apply out of 14 response options: 1) to stay updated with best practices 2) To grow and improve job performance as a professional 3) Topic was interesting, new, or different 4) Licensure or regulatory requirements (obtain continuing education units) 5) To better meet children's special needs 6) Passion for job/love of children 7) Network and meet other providers 8) Help educate children and prepare for school (kindergarten readiness) 9) Accreditation 10) Financial incentive offered for participation (e.g. gift card) 11) Resource incentive offered (e.g. classroom teaching materials) 12) Interest in promotion at job (e.g. center director) 13) Other and 14) None of the above – I do not participate in professional development. Based on teacher responses to those items, we arrived at six motivational categories for reporting purposes and readability: personal, for the children, professional, regulatory, general, and a combined reason. Teachers reported being motivated by personal reasons to participate in PD. Other choices such as staying up to date with best practices (83.2%) and to grow and improve in their job performance as a professional (92.8%) were other motivators. However, there were a few teachers (32.9%) who wanted to participate in PD for gift cards/monetary reasons as well. The next popular motivation was for children themselves. Teachers wanted to learn and know how to meet children's special needs (77.8%) and help children learn and prepare for kindergarten (79.6%). Teachers reported being motivated to participate in PD for professional reasons including specifically networking with other colleagues during PD (26.9%) and opportunities to grow in their own workplace (e.g., getting promoted as a center director) (22.2%). Teachers reported using PD to fulfill regulatory requirements such as accreditation requirements of the center (24.6%) and to maintain their own teaching license (53.9%). Other general reasons teachers reported being motivated to participate in PD were to get classroom materials (43.7%) or because the specific topic was of interest (67.1%) as stated by the teacher. Lastly and unsurprisingly, approximately 81% of teachers stated that their passion for their job and love for children was a huge driving force for involvement in PD, which is a combination of both professional and personal factors.

Teachers selected their most preferred methods to receive PD (select one) from eight options: 1) In-person training, 2) Live webinar, 3) Recorded webinar that I can view at any time 4) Ongoing mentorship/coaching, 5) Ongoing peer-to-peer with other providers, 6) Self-study (e.g. anytime learning modules), 7) Attending conferences with multiple trainings on one day, 8) None of the above. I have no professional development. Teachers most preferred recorded webinars that could be viewed anytime (73.7%), followed by live webinars with questions (69.5%), and self-study learning modules that could be utilized anytime (34.7%). In-person training (22.2%), ongoing mentorship and coaching (21.6%), and peer to peer assistance (19.8%) were less preferred as a delivery method for PD. Few teachers (~2%) reported that they had no specific preferences on PD modality.

Teachers' personal priority placed on science education

Related to RQ 4, teachers reported to what degree they prioritize science education (e.g., how important they personally perceive science education to be). Teachers were asked "Considering the many competing priorities in the early childhood setting (e.g. kindergarten readiness), from your perspective, rate the importance of science education in the preschool classroom environment." The response options were 1 = *not at all important*, 2 = *not very important*, 3 = *fairly important*, 4 = *very important*, and 5 = *extremely important*. Three-quarters of teachers considered science education to be *very* or *extremely important* to them.

Further, we explored if teachers' personal priority level for science education differed based on their experience, education, and position at HS (see Table 2). We compared the mean differences between beginning teachers (group 1) and experienced teachers (group 2) using a one-way ANOVA. Beginning teachers had a mean score of 3.80 ($SD = 0.81$) compared to experienced teachers with a mean score of 4.09 ($SD = 0.62$). This finding was statistically significant at $F(1, 156) = 6.67$, $p = .01$). Thus, beginning teachers reported perceiving teaching science as a *fairly important* personal priority compared to experienced teachers who reported considering it to be *very important*. The ANOVAs for personal priority by education and position were not significant.

Discussion

Children are naturally curious, and teaching children science at a young age is pivotal as science learning in early childhood has been shown to improve educational outcomes over time (Whittaker et al., 2020). Science education needs to be intentional and appropriately taught to children based on Developmentally Appropriate Practice principles (Cabe Trundle, 2015; Yoon & Onchwari, 2006). This study highlights the status and landscape of science education within HS settings by measuring teachers' perceptions on this topic.

HS teachers' science teaching needs and resources

Informal science was most utilized by teachers in this study to teach science within the classrooms followed by incidental and formal teaching methods. Seemingly, teachers found it easy to incorporate science during children's free and outdoor play time. Most preschool classrooms have a science center, as it is a part of the NC childcare licensing system (NC Division of Child Development and Early Education, n.d.). Thus, as children interact with science materials (e.g., magnifying glass, measuring cup) in the center, it might be an opportune time for teachers to discuss science (Gomes & Fleer, 2020; Piasta et al., 2014; Tu, 2006). Outdoor play time can lend itself to both informal and incidental science teaching (Gomes & Fleer, 2020). As children play in the sand or water play area with various measuring cups or tools outside, teachers can incorporate science talk as these activities progress. Further, discussions on weather, climate, insects, and plants as children play outside can translate into incidental science teaching episodes (Änggård, 2010). In this study, formal teaching of science seemed to be utilized the most during center time because center time can serve as an ideal learning environment to relate to real-life objects and events (Eshach, 2007).

The extant literature documents the importance and use of mealtimes to promote healthy eating and discusses science with young children (Bandy et al., 2018; Dixon et al., 2023) and its corresponding advantages in doing so. When teachers were asked specifically in which environment they teach science most frequently, mealtimes seemed to be the least popular (1.2%), compared to learning centers, circle, and outdoor times. However, when questions about "use of mealtimes as learning time" where teachers can indulge in "science talk" and hold "discussion surrounding topics such as food, how food is grown, eating healthy" were posed as separate questions, teachers reported that they *very often or regularly* (73.8%) used mealtimes to discuss "science" with the children. Perhaps, the wording of the survey questions and the context influenced how teachers perceived the questions and responded accordingly.

However, teacher experience levels might influence the use of "mealtimes" to engage children within science. There was a difference between the frequency that beginning and experienced teachers use of mealtimes to talk to children about science. Experienced teachers who have worked within the HS or early childhood settings longer, might know of strategies or techniques to engage children in informal talks during breakfast, lunch, or snack time, a skill that beginning teachers might still be developing. In a similar vein, we found that teachers with more education *very often* to *regularly* utilized incidental science teaching with children compared to teachers with less years of education. Thus, both teachers' experience and education levels seemingly explain differences within the practice of science and its implementation with the HS settings.

While having the right skill set to engage children in science is important, not having adequate science materials or resources could be a potential barrier to teaching high-quality science activities (Hannaway et al., 2019; Mahmood, 2013; Olgan, 2015; Watters et al., 2001). Overall, obtaining books related to science and having access to specific materials such as plants or magnifying glasses was not difficult for the teachers. However, close to 39% of the teachers did not report having access to a refrigerator to store perishable foods, a huge impediment for teachers who might want to use "food" as a medium to teach science education (e.g., life sciences). Nearly two-thirds (63%) of the teachers had no resources to take children on a field trip, an experiential activity that could enrich children's learning cognitively and affectively (Eshach, 2007). It is hard to gauge if the constraint to take children on a field trip was due to lack of human or monetary resources, which are common barriers (Eshach, 2007). Field trips require a great amount of preplanning and collaboration from teachers and staff to promote optimal science learning (Eshach, 2007). Additionally, the location of a center could also add to the constraint. Some HS facilities, such as those in rural areas, may not have as much access to stores, museums, and libraries compared to centers in other areas, such as large urban areas.

It was encouraging to see that teachers utilized a range of free resources such as YouTube videos and community libraries to borrow science-related books. More information is needed to investigate how these teachers selected these resources and if they felt confident finding credible, developmentally appropriate information and lessons. Previous research has found that teachers often select books that are easy to understand, have plain language from recognizable authors or publishers, and that are narrative (Bartan, 2018; Pentimonti et al., 2011). Further, local partnerships with NC Partnership for Children and Smart Start were advantageous to the teachers. Of concern, close to 25% of the teachers did not have any connections with the community resources. Facilitators and barriers to establishing and maintaining these partnerships should be investigated further in future studies.

When it comes to selecting resources or science activities for children, cost incurred for a science activity can be a barrier (Sherman et al., 2010; Tanik Onal & Ezberci Cevik, 2022). However, in this study, we found that cost of an activity is not the most important characteristic to teachers when selecting a science activity. Instead, cultural appropriateness, inclusion of all materials to execute the activity, the content, ease of use, and duration of activity are the most important. These factors are not as prevalent in the literature but are as important when considering how to make materials and resources more attractive for teachers to use and implement science. Furthermore, we speculate inclusion of all materials to execute an activity could also lead to cost savings on science materials for the teachers. Hence, even though cost of an activity was not considered the most important characteristic by the teachers, it can be indirectly implied that providing all science materials for an activity to teachers offsets the cost of supply and lends itself to easier implementation. Head Start strives to be culturally responsive and encourage family engagement, and therefore, it is important that the classroom materials and lessons reflect the cultures of the students and their families (M. Gichuru et al., 2015). On this note, it was encouraging to see that HS teachers within this study demonstrated their awareness and use of culturally appropriate science activities within their classroom.

HS teachers' experiences and views on professional development

Professional development and training have always been an important topic of discussion within science education (Barenthien et al., 2020; S. M. Sheridan et al., 2009; Van Driel et al., 2001). Teachers need quality PD exposure that can impact their self-efficacy and actual classroom practices (Birman et al., 2000; Christ & Wang, 2013). However, in this study, we specifically examined teachers training and motivations for PD. Unfortunately, only 46% of newly hired teachers had an opportunity to attend PD on science in their first year. Understanding HS policies and procedures and other classroom assessments might take precedence over science learning as the demands for HS teachers to focus on institutional goals and compliance has intensified (Bullough et al., 2014). Those who discussed getting trained in their first year alluded that only one-third of their PD was directly related to science and teaching science concepts to young children. Teachers described other avenues for science training, including talking to and getting mentored by more experienced teachers, watching videos, and reading books and articles related to science. In this study, the quality of the teachers' science training and its frequency was not assessed, which is an important parameter to include in future studies.

Teachers' motivation to participate in PD ranged across personal, professional, regulatory, general, and combined reasons (both for themselves and children). Personally, teachers wanted to stay current with the changing trends within science education and improve themselves as a professional. For teachers, monetary benefits, such as cash or gift cards, provided enough incentive to participate in PD. If we combined the monetary incentives with providing CEUs that count toward teachers' licenses, the chances of teachers attending science PD might increase. Preparing children for kindergarten or helping children with their special needs was a strong incentive for attending PD as well. Working for children was an even bigger incentive for PD, more than their own professional reasons (getting promoted or networking with colleagues). Thus, it is no surprise that teachers rated their love for job and children (81%) as the biggest incentive for attending PD sessions. Teachers have reported being intrinsically motivated to participate in PD, especially when they saw positive change in their children (Wagner & French, 2010).

Further, teachers expressed that they would like to complete PD at their own pace and time, indicating a preference for recorded PD webinars, compared to in-person training (22.2%). Additionally, for PDs that require synchronous participation from the audience, live webinars with a follow-up question and answer session might be preferred. This information can potentially change the delivery system for PD and increase audience participation.

HS teachers' priority level related to science education

Overall, science teaching and learning is a priority across all HS settings in NC. Teachers' ratings of their own perceived priority level for science were always above 50%. Interestingly, teacher experience levels did explain some of the priority-level differences. At the personal level, more experienced teachers viewed science education to be *very important* compared to beginning teachers. Some of these differences can be attributed to teacher experience levels. Experienced teachers personally prioritized science teaching for themselves. As seen earlier, experienced teachers also reported practicing more science teaching across mealtimes and engaging in informal talks related to science. This finding might have some bearing on how they rate priority levels for science and science teaching within a HS setting. In-service preschool teachers have been found to have higher self-efficacy about teaching science than pre-service teachers, indicating that more self-efficacy may come with experience (Aslan et al., 2016).

Implications

Our study has implications for understanding aspects that need to be considered when designing teacher preparation and in-service PD opportunities. Utilizing this information, we can build more valuable supports for teachers and improve the use of science strategies within the classroom more broadly.

(1) Teacher Professional Development – By understanding teachers' motivations to participate in PD, PD opportunities can be designed that draw upon teachers' passion for the profession while also providing incentives and meeting regulatory criteria. Providing PD on specific topics can improve the use of science learning in informal, incidental, and formal ways throughout HS. Ongoing PD is essential and important for teachers, particularly as it relates to science education. However, PD provided should couple robust compensation (e.g. gift cards) with continuing education credits. The modality of PD should be considered. The preference for asynchronous or online PD formats over face-to-face has implications for the design and implementation for both pre-service and in-service PD opportunities. PD facilitators may be able to reach more teachers more efficiently through these formats.
(2) Availability of Resources – This study describes differences in the availability of resources that teachers have access to and have implications for resource development. The differences in availability between centers in NC are clear, and the difference between states is likely greater.

However, HS administrators may want to assess and inventory science materials at their centers. Teaching children science often requires additional resources in the classroom (e.g. balancing scales, microscopes), so it is important to know what resources are available and what needs to be made available for teachers to engage in high-quality science teaching. Additionally, if the materials are available that aid science teaching (e.g. measuring scale and plants), its utility needs to be further assessed. If teachers do not feel confident in using those materials (Pendergast et al., 2017), support and training can be provided to meet teacher needs. Thus, inventory checks on available science materials and its utility should be conducted in a periodic fashion.

(3) Tapping into Community Resources – Community can be a great asset and partner in the realm of science education. HS center administrators need to explore and tap into these resources. For example, field trips to visit a local museum to explore science exhibits or inviting a farmer or dentist from the local community could result in a beneficial partnership. Many of these organizations already have an educational

outreach arm which HS centers can tap into. When planning out the school year, administration and teachers may wish to reserve educational time for these field trips.

(4) Modeling Priority for Science – Teachers reported on their own personal priority level for science. Most teachers reported that science is very or extremely important to them. This finding has implications for center administration and state-level HS administration. Administration may wish to model this same level of importance and priority. It may be beneficial to have frequent discussions about the priority of science as a center, which could be done at staff meetings or by forming a dedicated professional learning community focused on science learning.

(5) Tailored Science Supports in North Carolina through PEAS – More specifically, for our program called PEAS, we have used these findings to develop and revise a professional development program with evidenced-based science teaching strategies for HS teachers. HS teachers were our partners in creating these resources. From the findings of this study and our other work with teachers, we developed the program as an innovative multi-component PD program. It is not a prepackaged "one-and-done" curriculum and instead focuses on building capacities in teachers to deliver quality science, technology, engineering, and mathematics. Our program with its accompanying Teaching Guide is currently being expanded across the state of North Carolina. Our program provides teachers with the materials needed to complete specific activities in addition to using materials commonly found in the preschool classroom. Other inbuilt support such as online PD, which is accessible any time at no cost incurred by teachers, short and interactive science videos that emphasize research-based developmentally appropriate science strategies and formulation of learning communities to sustain science teaching within HS centers also lend support teachers with HS settings.

Strengths and limitations

In this study, we were able to quantify HS teachers' reported access to resources, partnerships, experiences with barriers, and training as it related to science education in early childhood, which was a strength of the study. This information assessed teachers' needs for science-specific support and resources, which will be beneficial to administrators and researchers to better serve and support teachers. The large sample size and recruitment of teachers from the different regions of NC allows for generalizability of these results. However, a similar study across different states within the US can yield more representative findings of the state of science education in the country. It can help us compare support, PD opportunities, and resources made available to teachers within the HS settings across various states. This study has limitations to consider. One limitation of this study was that data collection occurred during the pandemic. Due to the impact on early childhood centers such as shutdown and absences, we do not know the full impact of how the pandemic may have influenced teachers' participation and responses. Outside of the pandemic, we might have expected a higher response rate throughout the state. As is the nature of self-reported data, teachers' self-report of how frequently they implement science activities may be under or over reported. Further, during the pandemic, conversations with children about scientific topics may have increased due to the context. For example, scientific conversations might have been more likely because of the public health emphasis on appropriate hand washing, hygiene, mask wearing, and teaching people how to sneeze in a way to reduce transmission. Thus, the context of pandemic might have led teachers to be more conscious about the scientific topics, which could have inflated the importance teachers placed on science and subsequently leading to teachers over reporting on science activity within the survey.

Future studies may wish to add classroom observation to accurately quantify and classify the types and frequency of science teaching in the classroom.

Conclusion

Science education is receiving increased attention in early childhood education as it can improve school readiness and promote scientific thinking in children and overall support school readiness. Head Start teachers are well positioned to implement quality science education due to HS's dedication to early learning, development, health, and well-being. In this study, NC-based HS teachers shared their perceptions of science education in HS including their needs, assets, and resources regarding teaching science lessons and science PD opportunities. These findings have implications for improving science resources and PD for HS teachers across the state and country.

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References

Akerson, V. L., & Buck, G. A. (2023). US next generation science standards: Possibilities, not prescriptions for STEM teacher education. In S. M. Al-Balushi, L. Martin-Hansen &Y. Song (Eds.),*Reforming science teacher education programs in the STEM Era: International and comparative perspectives* (pp. 251–263). Springer International Publishing.

Aldemir, J., & Kermani, H. (2017). Integrated STEM curriculum: Improving educational outcomes for head start children. *Early Child Development & Care*, *187*(11), 1694–1706. https://doi.org/10.1080/03004430.2016.1185102

Alexander, J. M., Johnson, K. E., & Kelley, K. (2012). Longitudinal analysis of the relations between opportunities to learn about science and the development of interests related to science. *Science Education*, *96*(5), 763–786. https://doi.org/10.1002/sce.21018

Andersson, K., & Gullberg, A. (2014). What is science in preschool and what do teachers have to know to empower children? *Cultural Studies of Science Education*, *9*(2), 275–296. https://doi.org/10.1007/s11422-012-9439-6

Änggård, E. (2010). Making use of"nature" in an outdoor preschool: Classroom, home and fairyland. *Children, Youth and Environments*, *20*(1), 4–25. https://doi.org/10.1353/cye.2010.0032

Areljung, S. (2019). Why do teachers adopt or resist a pedagogical idea for teaching science in preschool? *International Journal of Early Years Education*, *27*(3), 238–253. https://doi.org/10.1080/09669760.2018.1481733

Aslan, D., Tas, I., & Ogul, I. G. (2016). Pre-and in-service preschool teachers' science teaching efficacy beliefs. *Educational Research & Reviews*, *11*(14), 1344–1350. https://doi.org/10.5897/ERR2016.2794

Bandy, K., Peterson, A. D., Wilkerson, K., Hegde, A., & Stage, V. C. (2018). Do North Carolina head start teachers use supportive feeding practices at mealtimes with 3-5-year-old low-resource children? *Journal of Nutrition Education and Behavior*, *50*(7), S120–S121. https://doi.org/10.1016/j.jneb.2018.04.168

Barenthien, J., Oppermann, E., Anders, Y., & Steffensky, M. (2020). Preschool teachers' learning opportunities in their initial teacher education and in-service professional development–Do they have an influence on preschool teachers' science-specific professional knowledge and motivation? *International Journal of Science Education*, *42*(5), 744–763. https://doi.org/10.1080/09500693.2020.1727586

Bartan, M. (2018). Determination of preschool teachers' preference reasons for children's books used by them in their classes. *World Journal of Education*, *8*(6), 187–195. https://doi.org/10.5430/wje.v8n6p187

Bassok, D. (2013). Raising teacher education levels in head start: Exploring programmatic changes between 1999 and 2011. *Early Childhood Research Quarterly*, *28*(4), 831–842. https://doi.org/10.1016/j.ecresq.2013.07.004

Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership*, *57*(8), 28–33.

Blank, R. K., & De las Alas, N. (2009). *The effects of teacher professional development on gains in student achievement: How meta analysis provides scientific evidence useful to education leaders*. Council of Chief State School Officers.

Brenneman, K., Lange, A., & Nayfeld, I. (2019). Integrating STEM into preschool education; designing a professional development model in diverse settings. *Early Childhood Education Journal*, *47*(1), 15–28. https://doi.org/10.1007/s10643-018-0912-z

Bronfenbrenner, U. (1979). *The ecology of human development. Experiments by nature and design*. Harvard University Press.

Bullough, R. V., Jr., Hall-Kenyon, K. M., MacKay, K. L., & Marshall, E. E. (2014). Head start and the intensification of teaching in early childhood education. *Teaching & Teacher Education*, *37*, 55–63. https://doi.org/10.1016/j.tate.2013.09.006

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*, 34–42. https://doi.org/10.1016/j.ecresq.2018.02.013

Cabell, S. Q., DeCoster, J., LoCasale-Crouch, J., Hamre, B. K., & Pianta, R. C. (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

Cabe Trundle, K. (2015). The inclusion of science in early childhood classrooms. *Research in Early Childhood Science Education*, 1–6. https://doi.org/10.1007/978-94-017-9505-0_1

Carraway-Stage, V., Henson, S. R., Dipper, A., Spangler, H., Ash, S. L., & Goodell, L. S. (2014). Understanding the state of nutrition education in the head start classroom: A qualitative approach. *American Journal of Health Education*, *45*(1), 52–62. https://doi.org/10.1080/19325037.2013.853000

Christ, T., & Wang, X. C. (2013). Exploring a community of practice model for professional development to address challenges to classroom practices in early childhood. *Journal of Early Childhood Teacher Education*, *34*(4), 350–373. https://doi.org/10.1080/10901027.2013.845630

Colorafi, K. J., & Evans, B. (2016). Qualitative descriptive methods in health science research. *HERD: Health Environments Research & Design Journal*, *9*(4), 16–25. https://doi.org/10.1177/1937586715614171

Dalli, C., Miller, L., & Urban, M. (2012). *Early childhood grows up: Towards a critical ecology of the profession: Setting the scene*. Springer Netherlands.

Derscheid, L. E., Kim, S. Y., Zittel, L. L., Umoren, J., & Henry, B. W. (2014). Teachers' self-efficacy and knowledge of healthy nutrition and physical activity practices for preschoolers: Instrument development and validation. *Journal of Research in Childhood Education*, *28*(2), 261–276. https://doi.org/10.1080/02568543.2014.884027

Desimone, L. M., & Le Floch, K. C. (2004). Are we asking the right questions? Using cognitive interviews to improve surveys in education research. *Educational Evaluation and Policy Analysis*, *26*(1), 1–22. https://doi.org/10.3102/01623737026001001

DeVries, R., & Sales, C. (2011). *Ramps and pathways: A constructivist approach to physics with young children*. National Association for the Education of Young Children.

Díaz Rios, L. K., Stage, V. C., Leak, T. M., Taylor, C. A., & Reicks, M. (2022). Collecting, using, and reporting race and ethnicity information: Implications for research in nutrition education, practice, and policy to promote health equity. *Journal of Nutrition Education and Behavior*, *54*(6), 582–593. https://doi.org/10.1016/j.jneb.2022.01.006

Dickinson, D. K., & Tabors, P. O. (2001). *Beginning literacy with language*. Paul H Brookes Publishing.

Dixon, J., Hegde, A. V., Goodell, L. S., Arnold, N. L., Swindle, T., Dev, D. A., Méndez, L. I., McMillan, V. J., Lee, T. D., & Stage, V. C. (2023). Integration of food-based learning with science in the preschool classroom: Implementation gaps and opportunities. *Journal of Nutrition Education and Behavior*, *55*(4), 266–284. https://doi.org/10.1016/j.jneb.2023.01.002

Duran, E., Ballone-Duran, L., Haney, J., & Beltyukova, S. (2009). The impact of a professional development program integrating informal science education on early childhood teachers' self-efficacy and beliefs about inquiry-based science teaching. *Journal of Elementary Science Education*, *21*(4), 53–70. https://doi.org/10.1007/BF03182357

Eshach, H. (2007). Bridging in-school and out-of-school learning: Formal, non-formal, and informal education. *Journal of Science Education and Technology*, *16*(2), 171–190. https://doi.org/10.1007/s10956-006-9027-1

Furtado, L. (2010). Kindergarten teachers' perceptions of an inquiry-based science teaching and learning professional development intervention. *New Horizons in Education*, *58*(2), 104–120.

García, A. A. (2011). Cognitive interviews to test and refine questionnaires. *Public Health Nursing*, *28*(5), 444–450. https://doi.org/10.1111/j.1525-1446.2010.00938.x

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

Gerde, H. K., Pikus, A. E., Lee, K., Van Egeren, L. A., & Quon Huber, M. S. (2021). Head start children's science experiences in the home and community. *Early Childhood Research Quarterly*, *54*(2021), 179–193. https://doi.org/10.1016/j.ecresq.2020.09.004

Gichuru, J. (2024). Enhancing STEM education through equity, diversity, inclusion and decolonization. In *Global perspectives on STEM education*. Springer. https://doi.org/10.1007/978-3-031-60676-2_3

Gichuru, M., Riley, J. G., Robertson, J., & Park, M. H. (2015). Perceptions of head start teachers about culturally relevant practice. *Multicultural Education*, *22*(2), 46–50.

Gomes, J., & Fleer, M. (2020). Is science really everywhere? teachers' perspectives on science learning possibilities in the preschool environment. *Research in Science Education*, *50*(5), 1961–1989. https://doi.org/10.1007/s11165-018-9760-5

Greenfield, D. B., Alexander, A., & Frechette, E. (2017). Unleashing the power of science in early childhood. *Zero to Three*, *37*(5), 13–21. https://www.zerotothree.org/resource/journal/vol-37-no-5-building-stem-science-technology-engineering-math-skills-from-birth/

Greenfield, D. B., Jirout, J., Dominguez, X., Greenberg, A., Maier, M., & Fuccillo, J. (2009). Science in the preschool classroom: A programmatic research agenda to improve science readiness. *Early Education & Development*, *20*(2), 238–264. https://doi.org/10.1080/10409280802595441

Hannaway, D., Govender, P., Marais, P., & Meier, C. (2019). Growing early childhood education teachers in rural areas. *Africa Education Review*, *16*(3), 36–53. https://doi.org/10.1080/18146627.2018.1445974

Head Start Early Learning Outcomes Framework. (2020). Retrieved February 25, 2021, from https://eclkc.ohs.acf.hhs.gov/school-readiness/article/head-start-early-learning-outcomes-framework

Hoisington, C. (2024). Science in preschool, part 1: Leveraging the power of the next generation science standards (NGSS) with consideration to developmentally appropriate practice (DAP). *Science and Children*, *61*(1), 6–10. https://doi.org/10.1080/00368148.2023.2292324

Hollingsworth, H. L., & Vandermaas-Peeler, M. (2017). 'Almost everything we do includes inquiry': Fostering inquiry-based teaching and learning with preschool teachers. *Early Child Development & Care*, *187*(1), 152–167. https://doi.org/10.1080/03004430.2016.1154049

Hong, S., Hamel, E., Joo, Y., & Burton, A. (2023). Enhancing preschool teachers' reflective thinking on science teaching and learning using video reflections. *Journal of Early Childhood Teacher Education*, *44*(4), 791–811. https://doi.org/10.1080/10901027.2022.2149435

IBM Corp. 2021. *IBM SPSS statistics for windows, version 28.0* https://www.ibm.com/support/pages/how-cite-ibm-spss-statistics-or-earlier-versions-spss.

Karademir, A., Cingi, M. A., Dereli, F., & Akman, B. (2017). Quality in preschool education: The views of teachers and assistant teachers. *Bayburt Eğitim Fakültesi Dergisi*, *12*(23), 7–33.

Kook, J. F., & Greenfield, D. B. (2021). Examining variation in the quality of instructional interaction across teacher-directed activities in head start classrooms. *Journal of Early Childhood Research*, *19*(2), 128–144. https://doi.org/10.1177/1476718X20942956

Kutsyuruba, B., Walker, K. D., & Godden, L. (2019). Contextual factors in early career teaching: A systematic review of international research on teacher induction and mentoring programs. *Journal of Global Education and Research*, *3*(2), 85–123. https://doi.org/10.5038/2577-509X.3.2.1057

La Paro, K. M., Hamre, B. K., Locasale-Crouch, J., Pianta, R. C., Bryant, D., Early, D. M., & Burchinal, M. (2009). Quality in kindergarten classrooms: Observational evidence for the need to increase children's learning opportunities in early education classrooms. *Early Education & Development*, *20*(4), 657–692. https://doi.org/10.1080/10409280802541965

Larimore, R. A. (2020). Preschool science education: A vision for the future. *Early Childhood Education Journal*, *48*(6), 703–714. https://doi.org/10.1007/s10643-020-01033-9

Lin, Y. C., & Magnuson, K. A. (2018). Classroom quality and children's academic skills in child care centers: Understanding the role of teacher qualifications. *Early Childhood Research Quarterly*, *42*, 215–227. https://doi.org/10.1016/j.ecresq.2017.10.003

Lippard, C. N., Tank, K., Walter, M. C., Krogh, J., & Colbert, K. (2018). Preparing early childhood preservice teachers for science teaching: Aligning across a teacher preparation program. *Journal of Early Childhood Teacher Education*, *39*(3), 193–212. https://doi.org/10.1080/10901027.2018.1457578

Mahmood, S. (2013). "Reality shock": New early childhood education teachers. *Journal of Early Childhood Teacher Education*, *34*(2), 154–170. https://doi.org/10.1080/10901027.2013.787477

Mantzicopoulos, P., Patrick, H., & Samarapungavan, A. (2008). Young children's motivational beliefs about learning science. *Early Childhood Research Quarterly*, *23*(3), 378–394. https://doi.org/10.1016/j.ecresq.2008.04.001

Massey, S. L. (2004). Teacher–child conversation in the preschool classroom. *Early Childhood Education Journal*, *31*(4), 227–231. https://doi.org/10.1023/B:ECEJ.0000024113.69141.23

McClure, E. (2017). *More than a foundation: Young children are capable STEM learners*. NAEYC. https://www.naeyc.org/resources/pubs/yc/nov2017/STEM-learners

McWayne, C. M., Zan, B., Ochoa, W., Greenfield, D., & Mistry, J. (2022). Head start teachers act their way into new ways of thinking: Science and engineering practices in preschool classrooms. *Science Education*, *106*(4), 956–979. https://doi.org/10.1002/sce.21714

Méndez, L. I., Lee, T. D., Hegde, A. V., McMillan, V. J., Dixon, J. B., Goodell, L. S., & Stage, V. C. (2023). Let's talk: Linking science and language learning in the preschool classroom. *Young Children*, *78*(2), 66–72. https://doi.org/10.17226/11625

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

Mowrey, S. C., & Farran, D. C. (2022). Teaching teams: The roles of lead teachers, teaching assistants, and curriculum demand in pre-kindergarten instruction. *Early Childhood Education Journal*, *50*(8), 1329–1341. https://doi.org/10.1007/s10643-021-01261-7

NAEYC. (n.d.). *Professional development*. https://www.naeyc.org/resources/pd

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

NC Division of Child Development and Early Education. (n.d.). *Licensing Requirements*. North Carolina Department of Health and Human Services. https://ncchildcare.ncdhhs.gov/Services/Licensing/Licensing-Requirements

Neuman, D. (1972). Sciencing for young children. In K. R. Baker (Ed.), *Ideas that work with young children* (pp. 216–225). National Association for the Education of Young Children.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. The National Academies Press.

North Carolina Head Start Association. (n.d.). *Locate a head start program*. https://headstartnc.org/head-start-center-locator/

Office of Head Start. (2023, June 30). *Head start services*. https://www.acf.hhs.gov/ohs/about/head-start

Office of Head Start. (n.d.). US department of health and human services administration for children and families. In *Head start program performance standards 45 CFR XIII current through 2015* (pp. 1–137). US Government Publishing Office.

Office of Management and Budget. (n.d.). *Standards for maintaining, collecting, and presenting federal data on race and ethnicity*. Retrieved April 13, 2024, from https://www.federalregister.gov/documents/2016/09/30/2016-23672/standards-for-maintaining-collecting-and-presenting-federal-data-on-race-and-ethnicity

Olgan, R. (2015). Influences on Turkish early childhood teachers' science teaching practices and the science content covered in the early years. *Early Child Development & Care*, *185*(6), 926–942. https://doi.org/10.1080/03004430.2014.967689

Oppermann, E., Brunner, M., Eccles, J. S., & Anders, Y. (2018). Uncovering young children's motivational beliefs about learning science. *Journal of Research in Science Teaching*, *55*(3), 399–421. https://doi.org/10.1002/tea.21424

Oppermann, E., Hummel, T., & Anders, Y. (2021). Preschool teachers' science practices: Associations with teachers qualifications and their self-efficacy beliefs in science. *Early Child Development & Care*, *191*(5), 800–814. https://doi.org/10.1080/03004430.2019.1647191

Pendergast, E., Lieberman-Betz, R. G., & Vail, C. O. (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., Zucker, T. A., & Justice, L. M. (2011). What are preschool teachers reading in their classrooms? *Reading Psychology*, *32*(3), 197–236. https://doi.org/10.1080/02702711003604484

Peterson, A. D., Goodell, L. S., Hegde, A., & Stage, V. C. (2017). Teacher perceptions of multilevel policies and the influence on nutrition education in North Carolina head start preschools. *Journal of Nutrition Education and Behavior*, *49*(5), 387–396. https://doi.org/10.1016/j.jneb.2017.01.003

Piasta, S. B., Logan, J. A. R., Yeager Pelatti, C., Capps, J. L., & Petrill, S. A. (2015). Professional development for early child educators: Efforts to improve math and science opportunities in early childhood classrooms. *Journal of Educational Psychology*, *107*(2), 407–422. https://doi.org/10.1037/2Fa0037621

Piasta, S. B., Pelatti, C. Y., & Miller, H. L. (2014). Mathematics and science learning opportunities in preschool classrooms. *Early Education & Development*, *25*(4), 445–468. https://doi.org/10.1080/10409289.2013.817753

Raven, S., & Wenner, J. A. (2023). Science at the center: Meaningful science learning in a preschool classroom. *Journal of Research in Science Teaching*, *60*(3), 484–514. https://doi.org/10.1002/tea.21807

Rhodes, H., & Huston, A. (2012). Building the workforce our youngest children deserve. Society for research in child development. Volume 26, number 1. *Social Policy Report*, *26*(1), 1–32. https://doi.org/10.1002/j.2379-3988.2012.tb00070.x

Roehrig, G. H., Dubosarsky, M., Mason, A., Carlson, S., & Murphy, B. (2011). We look more, listen more, notice more: Impact of sustained professional development on head start teachers' inquiry-based and culturally-relevant science teaching practices. *Journal of Science Education and Technology*, *20*(5), 566–578. https://doi.org/10.1007/s10956-011-9295-2

Sheridan, S. M., Edwards, C. P., Marvin, C. A., & Knoche, L. L. (2009). Professional development in early childhood programs: Process issues and research needs. *Early Education & Development*, *20*(3), 377–401. https://doi.org/10.1080/10409280802582795

Sheridan, S., Williams, P., Sandberg, A., & Vuorinen, T. (2011). Preschool teaching in Sweden–A profession in change. *Educational Research*, *53*(4), 415–437. https://doi.org/10.1080/00131881.2011.625153

Sherman, C. P., Tran, C., & Alves, Y. (2010). Elementary school classroom teacher delivered physical education: Costs, benefits and barriers. *Physical Educator*, *67*(1), 2.

Siedlecki, S. (2020). Understanding descriptive research designs and methods. *Clinical Nurse Specialist*, *34*(1), 8–12. https://doi.org/10.1097/NUR.0000000000000493

Smart Start. (n.d.). Smart start. https://www.smartstart.org

Sosinsky, L. S., & Gilliam, W. S. (2011). Assistant teachers in prekindergarten programs: What roles do lead teachers feel assistants play in classroom management and teaching? *Early Education & Development*, *22*(4), 676–706. https://doi.org/10.1080/10409289.2010.497432

Tanas, J., & Fulmer, G. (2023). A content analysis of alignment messages to the next generation science standards. *Disciplinary and Interdisciplinary Science Education Research*, *5*(1), 1–18. https://doi.org/10.1186/s43031-023-00073-6

Tanik Onal, N., & Ezberci Cevik, E. (2022). Science education in outdoor learning environments from the perspective of preschool teachers: Definitions, opportunities, obstacles, and possible solutions. *Malaysian Online Journal of Educational Sciences*, *10*(1), 37–51.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53. https://doi.org/10.5116/2Fijme.4dfb.8dfd

Teaching Strategies. (n.d.). *The creative curriculum for preschool*. https://teachingstrategies.com/product/the-creative-curriculum-for-preschool/

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

Tuttle, N., Kaderavek, J. N., Molitor, S., Czerniak, C. M., Johnson-Whitt, E., Bloomquist, D., Namatovu, W., & Wilson, G. (2016). Investigating the impact of NGSS-aligned professional development on PreK-3 teachers' science content knowledge and pedagogy. *Journal of Science Teacher Education*, *27*(7), 717–745. https://doi.org/10.1007/s10972-016-9484-1

Van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *38*(2), 137–158. https://doi.org/10.1002/1098-2736(200102)38:2%3C137:AID-TEA1001%3E3.0.CO;2-U

Vaske, J. J., Beaman, J., & Sponarski, C. C. (2017). Rethinking internal consistency in Cronbach's alpha. *Leisure Sciences*, *39*(2), 163–173. https://doi.org/10.1080/01490400.2015.1127189

Wagner, B. D., & French, L. (2010). Motivation, work satisfaction, and teacher change among early childhood teachers. *Journal of Research in Childhood Education*, *24*(2), 152–171. https://doi.org/10.1080/02568541003635268

Watters, J. J., Diezmann, C. M., Grieshaber, S. J., & Davis, J. M. (2001). Enhancing science education for young children: A contemporary initiative. *Australasian Journal of Early Childhood*, *26*(2), 1–7. https://doi.org/10.1177/183693910102600202

Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession. A status report on teacher development in the United States and abroad*. National Staff Development Council.

Wells, M. B. (2015). Predicting preschool teacher retention and turnover in newly hired head start teachers across the first half of the school year. *Early Childhood Research Quarterly*, *30*, 152–159. https://doi.org/10.1016/j.ecresq.2014.10.003

The White House. (2010). *Educate to innovate*. http://www.whitehouse.gov/issues/education/educate-innovate

Whittaker, J. V., Kinzie, M. B., Vitiello, V., DeCoster, J., Mulcahy, C., & Barton, E. A. (2020). Impacts of an early childhood mathematics and science intervention on teaching practices and child outcomes. *Journal of Research on Educational Effectiveness*, *13*(2), 177–212. https://doi.org/10.1080/19345747.2019.1710884

Willis, G. B. (2004). *Cognitive interviewing: A tool for improving questionnaire design*. Sage Publications.

Won, H. R., & You, H. (2022). Next-generation science and engineering teaching practices in a preschool classroom. In *Early childhood education-innovative pedagogical approaches in the post-modern era*. IntechOpen. https://doi.org/10.5772/intechopen.105564

Yoon, J., & Onchwari, J. A. (2006). Teaching young children science: Three key points. *Early Childhood Education Journal*, *33*(6), 419–423. https://doi.org/10.1007/s10643-006-0064-4

Zaslow, M., Tout, K., Halle, T., Whittaker, J. V., & Lavelle, B. (2010). Toward the identification of features of effective professional development for early childhood educators. Literature review. In *Office of planning, evaluation and policy development* (pp. 1–251). US Department of Education. https://eric.ed.gov/?id=ED527140

Zembal-Saul, C., Siry, C., Monteira, S. F., & Bose, F. N. (2022). Preparing early childhood teachers to support young children's equitable science sensemaking. In J. A. Luft & M. G. Jones (Eds.), *Handbook of research on science teacher education* (pp. 69–82). Routledge.

Zhang, L., Yu, S., & Liu, H. (2019). Understanding teachers' motivation for and commitment to teaching: Profiles of Chinese early career, early childhood teachers. *Teachers & Teaching*, *25*(7), 890–914. https://doi.org/10.1080/13540602.2019.1670155