A Head Start on Stem: Investigating the Relationship Of Early Childhood Educator Knowledge and Self-Efficacy

Paula Thompson
Dena Harshbarger
Jane Strawhecker
Libby Yungdahl
University of Nebraska at Kearney

ABSTRACT

Research substantiates that providing high-quality STEM experiences at an early age is important for young children to become college and career ready (Moore et al, 2016). However, not all early childhood educators are as knowledgeable and/or confident in supporting early STEM instruction. How educators feel, think, and motivate themselves on the job is often influenced by their self-efficacy beliefs. Individuals with strong self-efficacy tend to commit to goals that challenge their current capabilities (Bandura, 1993). Therefore, educators may be more inclined to implement early STEM lessons if they feel knowledgeable and confident. The study used a multiple method design including scales, surveys, and self-reflection logs of 13 Head Start preschool educators over 11-months. The findings suggested a significant increase from pre-survey to post-survey in the participants' self-efficacies for supporting preschool-age children's STEM instruction.

KEYWORDS
Early STEM, self-Efficacy, Head Start, STEM instruction, professional development, early childhood educator preparation, preschool

Why STEM Instruction?

Between 2019 and 2029 in the United States, science and engineering careers are predicted to grow by nearly 10% (Bureau of Labor Statistics, 2020). During this timeframe, new jobs requiring strong skills in science, math, technology, and engineering (STEM), such as science and engineering managers, health care practitioners and technicians, and computer/mathematical scientists are predicted to grow the most. To meet the nation's workforce needs, it is essential that PK-12 educators provide high-quality STEM instruction to positively impact future generations in college and career readiness (McClure et al., 2017). "By providing practitioners with the tools they need to continue facilitating progressive STEM

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Contact: Paula Thompson - thompsonpj@unk.edu

learning, we are leveraging a growth-based approach that supports success beyond the early childhood years," (Frank Porter Graham Child Development Institute, 2022). To address the United States (U.S.) workforce needs, many professional organizations (e.g., National Association for the Education of Young Children (NAEYC), National Council of Teaching Mathematics (NCTM), National Science Teachers Association (NSTA)) through standards, frameworks, guidelines, and position statements advocate for the inclusion of STEM curriculum during the early years.

Why Early STEM Instruction

According to the American University's School of Education (2020), birth to age five is when young minds are most malleable and capable of developing lifelong thinking skills. During this time-period, young children are rapidly making connections and creating neural pathways in the brain at an unparalleled rate. If these connections are not developed and fostered during the early years; the neural pathways will be lost. To prevent this from occurring, early childhood (EC) educators must support the development of these essential pathways by tapping into young children's inherent curiosity (NSTA Position Statement, 2014). Young children want to know how things work and why things happen. According to the National Science Teachers Association (2014), on average, preschool-age children ask 100 questions per day. In addition to asking questions, they also have the capacity and propensity to observe, explore, discover, and make sense of the world around them (National Research Council, 2001). The National Association for the Education of Young Children (NAEYC & NCTM, 2010) stated that young children can and should engage in developmentally appropriate science and engineering practices (i.e., making predictions, carrying out experiments, and collecting data) to set the foundation for successful K-12 learning. Throughout these early STEM experiences, young children are not only gaining STEM knowledge but simultaneously developing character traits such as critical thinking and persistence (Sarama et al., 2018). These traits may help young children build foundational background knowledge and interest in STEM over time. Because STEM is inextricably linked to other disciplines, the experiences may enhance learning and academic achievement in other content areas (American University's School of Education, 2020). Early STEM investigations and results can be used to launch discussions and elicit written expressions to better understand STEM concepts thus, creating a direct link between science and/or math instruction and the improvement of literacy and language learning (Clements & Sarama, 2014; Sarama et al., 2018). Therefore, when early childhood educators provide intentional and ongoing early STEM opportunities, young children's academic knowledge can continuously grow and advance, which increases the likelihood of career readiness for STEM-based jobs.

Young children's STEM readiness

While STEM experiences offer many benefits to young children, there are external factors that can hinder young children's preparedness and success with STEM instruction. EC educators face several challenges in supporting young children's STEM learning, including their varied levels of understanding, experiences, and skills (Lange et al., 2019). Young children considered at risk of school failure often come from low-income homes and/or are minorities. Young children considered at risk are often underserved and face barriers that negatively affect their STEM readiness and academic achievement. Recently, ACT scores for underserved students correlate with a cumulative suppressing effect on college readiness (ACT, 2017). Furthermore, a significantly lower percentage of high school students who represent more than one of the underserved student criteria (e.g., minorities, low income) met the nation's ACT STEM Benchmark (Allen & Radunzel, 2017).

Since 1965, the federal Head Start program has provided care and education services to our nation's most vulnerable young children, often at-risk for school failure. Examples of risk factors include living in poverty, receiving special education services, experiencing homelessness, and receiving public assistance. Poverty can impact many areas of a child's life, such as limited access to food, adequate living conditions, health care, and quality care and education (e.g., childcare, preschool). Currently, the maximum income for a qualifying Head Start family of four is $31,200.00 (Office of the Assistant Secretary for Planning and Evaluation, United States Health and Human Services, 2024).

Since Head Start educators are charged with supporting these vulnerable populations, steps must be taken to provide the knowledge, skills, and dispositions necessary to promote school and future career readiness for the young children they serve. EC educators and those that support EC educators (i.e., managers, instructional coaches) must be confident and equipped to plan and implement STEM instruction for young learners. Unfortunately, research shows that several factors hinder EC educators' abilities to do so.

EC Educators' STEM Beliefs, Attitudes, and STEM Subject Matter Knowledge

Many EC educators' beliefs and attitudes about STEM are sometimes negative or steeped in feelings of anxiety, possibly due to previous personal experiences. Lange et al. (2019) reported EC educators' lack of confidence as a limiting factor to young children's STEM success, stating that past experiences and current attitudes, often lead EC educators to be less inclined to provide STEM opportunities for young children. To address these past issues and current beliefs, Lange et al. (2019) suggested immersing EC educators in engaging, inquiry-based, and purposeful STEM-based teaching practices. These purposeful experiences should provide opportunities for EC educators to revise their beliefs and begin to cultivate positive attitudes toward STEM instruction so they may be more inclined and equipped to be effective role models during STEM activities with young children.

According to Wilson et al. (1987) content knowledge refers to knowledge specific to the disciplinary concepts, skills, or topics being taught. Kind et al. (2022) reiterated that content knowledge allows educators to be better equipped to design and implement high-quality instruction for any given discipline(s). If educators have a good understanding of content knowledge relevant to the lesson being taught, they can strategically select "instructional strategies appropriate for a student group, justify choices by explaining how these meet student learning needs; and track students' learning and adapt in-class activities accordingly" (Kind et al., 2022, p. 331). In other words, strong content knowledge allows educators to interpret and respond to learners' needs more effectively and intuitively when teaching in educational settings. Therefore, EC educators should be provided with opportunities to learn content knowledge specific to the concepts and skills they teach to young children within the four STEM disciplines.

For science, educators must have knowledge related to the Next Generation Science Standards (NGSS) (NRC, 2013) Cross Cutting Concepts (i.e., structure and function, cause and effect, and patterns) as they apply to the four domains or Disciplinary Core Ideas (DCIs) (Physical Science, Earth Science, Life Science, and Engineering Technology and Applications of Science). According to the NGSS Standards (2013), educators also need knowledge, skills, and dispositions related to Science and Engineering Practices which emulate what scientists do to investigate the world as well as how engineers design and build systems so that they can effectively teach STEM to young children.

For math, NAEYC along with NCTM (2010) and Clements & Sarama (2014) stated educators must understand the mathematical learning trajectories to provide developmentally appropriate instruction that serves as a foundation for future learning. EC educators, themselves, require foundational knowledge of mathematical concepts such as number and operations, geometry, spatial relationships, and measurement, as well as having background knowledge of essential mathematical process skills (e.g., composing and decomposing, and unitizing) to support young learners' mathematical understanding.

However, having mathematical and science content knowledge does not necessarily make one an effective STEM educator. Educators must also have pedagogical content knowledge (Wilson et al., 1987) to effectively convey the meaning of STEM concepts in a way young children can understand and apply to new situations (Lange et al., 2019). It is recommended that high-quality early STEM experiences incorporate educators' pedagogical content knowledge through use of the following strategies (Lange et al., 2019):

- provide and facilitate hands-on, exploratory learning opportunities
- provide opportunities for young children

to “play” within the STEM disciplines using blocks, games, socio-dramatic play, and/or manipulatives
- ask open-ended questions to make young children think and wonder
- listen, observe, and take anecdotal notes about alternative conceptions and what young children understand about STEM concepts
- use anecdotal notes to tailor and individualize future instruction
- promote creativity and encourage multiple responses or different ways to solve problems or complete tasks even if “incorrect”
- make connections within STEM disciplines and other cross-curricular subjects
- encourage young children to communicate and explain their thinking using evidence
- refer to young children as scientists, mathematicians, or engineers as they design, test, and improve plans or prototypes through trial-and-error experiential learning
- suggest ways to extend the investigation to explore emerging ideas

The importance of early STEM instruction is supported by research; however, increasing knowledge of the STEM disciplines and/or learning how to teach early STEM concepts, using child-centered strategies may be overwhelming and intimidating for many EC educators (Clements & Sarama, 2016; NSTA, 2014), possibly due to past experiences and confidence levels related to one or more of the STEM disciplines.

EC Educators’ Self-Efficacy for STEM Instruction

According to Bandura (1977), self-efficacy is an individual’s belief in one’s ability to reach a specific goal. Unfortunately, many EC educators reported a lack of confidence, having low self-efficacy related to their abilities for designing and facilitating early STEM instruction (Lange et al., 2019). A study by Gerde et al. (2018) found that self-efficacious educators were typically more willing and motivated to incorporate newer approaches such as those often aligned with STEM instruction. However, they also noted when EC educators lacked self-efficacy in STEM, they were less likely to provide STEM experiences for the young children they served. Accordingly, EC educator self-efficacy is yet another factor that may impact young children’s future STEM preparedness and success with STEM.

To increase EC educators’ STEM self-efficacy, it is recommended that they participate in ongoing and interconnected professional development (PD) opportunities that are intentionally designed to grow STEM content knowledge and to model developmentally appropriate pedagogy (McClure et al., 2017). When EC educators partake in PD that models the same hands-on, engaging learning experiences and practices recommended for young children, it can positively impact their pre-existing anxiety and/or attitudes about STEM. For instance, a recent study (Chen et al., 2021) indicated that EC educators who participated in STEM-related activities and/or STEM PD, reported higher levels of STEM self-efficacy. In 2016, Zee and Koomen found that teachers who held positive affective attitudes were more likely to implement and further develop innovative pedagogical beliefs. The findings supported PD opportunities for educators as an effective means of increasing self-efficacy and promoting STEM instruction.

Professional Development and Early STEM Instruction

There are many research-based recommendations for designing and implementing quality STEM instruction. According to Sarama et al. (2018), effective PD opportunities should support EC educators in three areas including (1) learning developmentally appropriate STEM concepts and practices; (2) becoming familiar with pedagogical strategies that strengthen early STEM learning; and (3) applying strategies to promote inclusiveness and cultural responsiveness to form home connections with families, caregivers, and the community. However, PD should not be done using a “one and done” approach (Darling-Hammond et al., 2017). To be effective, PD opportunities for EC educators should be ongoing, connected to their personal teaching practice, and/ or instructional setting, and tailored to the EC educator’s changing needs (Desimone, 2009; Sarama et. al, 2018). When designing PD opportunities for EC educators, research suggests maximizing the benefits by including one or more of the following (Sarama et al., 2018, p. 4):

- one-on-one coaching
- well-structured professional learning communities or cohorts (i.e., a group of educators who participate in multiple PD opportunities together over time)
- opportunities to rehearse, analyze, reflect on instructional practice, and set goals
- engagement of teachers as leaders who facilitate early STEM PD activities and provide a range of supports to their colleagues.

Relatedly, Blonder and Vescio (2022) found that PD opportunities with formative feedback from peers, coaches, and/or instructors, as educators applied what they were learning, increased educators' self-confidence. A conceptual framework for effective PD suggested by Desimone (2009) indicated that active learning, coherence, and collaboration are three essential components of PD. During PD teachers engaged in active learning practices like observing, receiving feedback, and analyzing student work whereas coherence ensured alignment with teacher knowledge, teacher beliefs, and student needs. To foster collaboration during sustained PD, teachers within the same grade or subject build a supportive professional community. Furthermore, the benefits of PD opportunities were often compounded when teachers engaged in self-reflection and goal setting based upon formative feedback (Desimone, 2009; Melton et al., 2019; Miller et al., 2019). The primary purpose of the study was to determine how PD opportunities specifically designed to support participants' knowledge for planning and implementing STEM with preschool-age children and incorporating research-based methods/approaches (e.g., self-reflection, goal setting), impacted EC educators' self-efficacy and perceptions of early STEM instruction. There were two main research questions:

1) What impact does a targeted professional development program have on early childhood educators' self-efficacy of STEM teaching?

2) What impact does a targeted professional development program have on early childhood educators' planning and implementation of STEM instruction?

Methods

Participants

This study used a sample of Head Start educators, all enrolled in the same online graduate-level courses and engaged in an ongoing, collaborative early STEM project at a midwestern university. The project provided a cohort model of instruction with four online graduate courses over a span of one year: two with a concentration on early STEM, one on improving instruction in early math, and one focused on deeper understanding of developmentally appropriate practices in early childhood education. The Primary Investigator (PI) for the study invited the Head Start educators by email to participate in the study. Initially, fourteen Head Start educators consented to participate, however one chose to withdraw prior to pre-survey completion.

The thirteen participants were white, English-speaking females, working in Head Start programs as preschool classroom teachers (54%) or managers/coaches supporting preschool classroom teachers (46%) in the same midwestern state. Most participants fell within the 26 to 35 year age range (54%), with 31% of the participants in the 36 to 45 age range. All participants held a bachelor's degree and for the majority (77%), the degree was in early childhood education (ECE). Those without a bachelor's degree in ECE had degrees in related fields (e.g., elementary education, social services). All participants (100%) were working in or supporting teachers working in preschool classroom settings. On average, participants had seven years of experience working directly with preschool-age children (e.g., ages 3-5) with a range of 3 to 17 years of experience. At the time of the post-survey, only twelve participants were retained. Table 1 provides a summary of participants' demographics.

Table 1
Participant Demographics

Characteristics	Participants (N = 13)
Employment Role/Title	
Classroom Teacher	7
Management (non-coaching)	4
Coach	2
Age Range in Years	
19 – 25	1
26 – 35	7
36 – 45	4
46 – 55	1
Gender	
Female	13
Race	
White, non-Hispanic	13
Language Preference	
English	13
Highest Level of Education	
Master's Degree (Early Childhood)	1
Bachelor's Degree (Early Childhood)	9
Bachelor's Degree (Other)	3
Average Years of Experience	
Working with Young Children	
Ages Birth to Three	3
Ages Three to Five	7
Ages Birth to Five	7
Ages Five to Eight	2

Demographics

Demographic information collected related to the participants' age, gender, race, primary language, age range of children served, type of classroom (e.g., full year), employment (e.g., job role, work schedule), additional/outside employment (e.g., summer employment), experience working with young children, highest education level achieved, and licensure/certifications.

Measures

This study used two main sources of information to explore participants' behaviors and self-efficacies associated with planning and implementing STEM content for preschool-age children. A pre/post survey was completed to assist in answering research question one, gathering quantitative data related to participants' change in self-efficacy for teaching early STEM. The pre-survey, which was administered after participants consented and prior to beginning a graduate-level college course specific to the cohort, collected both demographic and self-efficacy data. Eleven months after the pre-survey and near the completion of the study, a post-survey collected self-efficacy data. The post-survey used the same self-efficacy survey questions previously asked in the pre-survey. STEM self-reflection logs were completed to assist in answering research question two, gathering quantitative and qualitative data for participants' planning and implementation of early STEM instruction. STEM self-reflection logs were used to collect perceptive data about how the participants implemented and/or promoted STEM learning activities in preschool classrooms.

EC Educator Self-Efficacy Scale (ECESES) for supporting preschoolers' STEM development

The ECESES-STEM was developed for the current study by examining two existing self-efficacy scales. The Coaching Efficacy Scale (Feltz et al., 1999), a 24-item scale, focused on coaching individual athletes and/or athletic teams, whereas the Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990) used a 25-item scale to determine elementary teacher self-efficacy for teaching science. Both scales were considered in the development of the ECESES-STEM to assist with wording of questions and scale format. The ECESES-STEM included a total of 40-items, 10-items in each of the four STEM disciplines (i.e., science, technology, engineering, math). Wording was consistent across each of the four STEM disciplines, however each subset of ten focused on one STEM discipline. For example, item one for the Science discipline stated, "I believe I can effectively use observation/documentation to find out if a preschooler is in need of individualized support in science," whereas item one for the technology discipline replaces the word "science" to "technology". The scale was rated on a 5- point Likert scale asking participants to indicate the confidence with which they felt each statement to be true (1 = Not Confident to 5 = Extremely Confident). The stem for each item was "I believe I can…." (e.g., I believe I can effectively use observation/documentation to find out if a preschooler is in need of individualized support in science). Overall mean ratings were calculated for each of the 40 items. In addition, overall mean ratings were calculated for each of the four STEM disciplines. Mean ratings between 4 and 5 suggested participants had higher perceived confidence for planning and implementing content for preschool-age children. Mean ratings of 3 to 3.9 suggested moderate perceived confidence, and mean ratings of 1 to 2.9 suggested lower perceived confidence.

The ECESES-STEM has not been validated for use with EC educators; however, the PI conducted a pilot study of the ECESES-STEM with three-experienced EC educators not affiliated with this study prior to its use in the current study. The pilot group completed the scale via Qualtrics and provided written feedback via email to the PI regarding: ease of use, length of scale completion time, and general feedback on the wording and clarity of questions. The pilot group feedback was utilized to fine-tune the survey prior to implementation by establishing an anticipated completion time, and rewording instructions to increase clarity. A copy of the ECESES-STEM is available upon request.

STEM Self-reflection Logs

The STEM self-reflection logs used in this study were a modification of logs available from the Friday Institute for Educational Innovation (Friday Institute for Educational Innovation, 2012).The logs were modified to align with research question two and for use with preschool educators rather than elementary teachers. The logs were used to collect perceptive data about how the participants implemented and/or promoted preschool STEM learning activities over time. Six monthly self-reflection logs were emailed to the participants as linked Google forms to gather data about early STEM lesson applications in the preschool work setting and establish goals for future early STEM instruction. A link to the log was emailed to each participant on the 20th of the month, followed by one email reminder on the first day of the subsequent month. The self-reflection logs used five open-ended prompts (e.g. Something I tried this month to promote STEM learning through the use of indoor environment was...). The three subsequent prompts asked about early STEM learning through the outdoor environment, direct instruction, and family engagement. On the final question, participants were prompted to share their feelings and thoughts regarding the implementation and/or outcomes of early STEM instruction with preschool-age children. A copy of the STEM Self-Reflection Log is available upon request.

Procedures

Recruitment and informed consent

The PI for the current study emailed the potential participants, explained the study, and obtained informed consent. Once informed consent was obtained, participants were prompted to complete an online Qualtrics survey that included a collection of demographic information and self-efficacy for planning and implementing STEM content for preschool-age children (pre-survey).

ECESES-STEM survey

The demographic survey and self-efficacy scale were generated using Qualtrics (2021) software, and participants utilized their own computer and internet connection to complete the survey and scales within the stated 2-week time period. The completed surveys provided information about participant demographics, as well as their self-efficacy data for planning and implementing STEM content for preschool-age children.

ECESES-STEM Survey Scoring

Individual mean ratings were calculated for the ECESES-STEM pre-survey and post-survey. Additionally, mean ratings from the pre and post surveys were calculated for each of the 40-items and the four STEM disciplines (i.e., science, technology, engineering, math).

STEM Self-reflection Logs Review

Each of the six individual participants' self-reflection logs were combined into one transcript, for a total of six transcripts (i.e., February, March, April, September, October and November). Using an inductive coding method, two independent observers completed a first cycle review of each transcript to establish emerging codes. After reviewing the self-reflection logs' transcripts, the two coders met to create a codebook. A total of two self-reflection logs' transcripts (30%) were randomly selected for a check of interrater agreement. The same two independent observers coded the randomly selected self-reflection logs' transcripts and were required to be 80% reliable (Salkind, 2006) across all previously identified codes. Interrater agreement scores below 80%, prompted mutual review of the code definitions and consensus for coding those transcripts. Individual codes had interrater agreements of 80% - 96%, except for three; teacher responsiveness (29%), hands-on exploration (55%), and teacher growth (56%). After establishing consensus of the codes and updating the codebook, the two observers completed a second and final independent review, with each observer coding half of the self-reflection logs' transcripts.

Analysis

To allow for a richer understanding of the participants' knowledge, skills, and self-efficacies for plan-

-ning and implementing developmentally appropriate STEM activities for preschool-age children, a multiple methods research design (Morse, 2003) was used. First, quantitative data from the self-efficacy scale pre and post ratings were collected and summarized. This data provided information about participants' perceived confidence for planning and implementing STEM content for preschool-age children (e.g., self-efficacy pre and post survey data).

Specifically, data was analyzed for the ECESES-STEM scale completed by the participants at two different times (pre and post) for this study. The results from the pre and post surveys represented participants' perceptions of their self-efficacy for planning and implementing STEM learning for preschool-age children. An overall mean rating was calculated for each pre and post survey. In addition, mean ratings were calculated for each of the 40-items across the four STEM disciplines.

A visual inspection of the mean scores was used to examine how Head Start preschool educators' self-efficacies differed from pre-survey to post-survey. The four STEM disciplines pre and post-survey means offered insight to the participants' self-efficacy levels for 1) identifying individual needs of preschool children, 2) recognizing age appropriate skill development, 3) evaluating skill development, 4) facilitating effective activities, 5) providing individualized supports, 6) providing independent learning opportunities through use of the indoor and outdoor learning environments, 7) promoting content through everyday situations and daily routines, 8) involving parents in the learning process, 9) answering young children's content questions, and 10) teaching STEM content as well as they do other content areas (e.g., language, literacy, creative arts). In addition, a t-test was used to compare the mean scores and to examine whether the change was statistically significant.

Next, quantitative data from the coded STEM Self-Reflection Logs' transcripts was collected and analyzed. The frequency of each code was determined by adding up the number of times each associated code was used over all six combined transcripts. The most frequently mentioned codes were identified from the data. In addition, qualitative data from the transcripts was analyzed through visual inspection, providing evidence for understanding and describing the 'participants' planning and implementation of early STEM instruction over the 11-month time frame.

Results

Self-Efficacy for Supporting Preschool-Age Children's STEM Development

Mean ratings from the ECESES-STEM pre and post surveys were used to evaluate participants' self-efficacy for supporting preschool-age children's STEM development. The scale was rated on a 5- point Likert scale asking participants to indicate the confidence with which they felt each statement to be true (1 = Not Confident to 5 = Extremely Confident). Table 2 provides the mean ECESES-STEM pre and post survey scores categorized by the four STEM disciplines, along with the overall pre and post survey means. At both pre and post survey, participants reported higher confidence levels in the STEM disciplines pertaining to science and math in comparison to technology and engineering.

Pre-survey

On the ECESES-STEM pre-survey, mean scores ranged from 1.3 to 4.2. Participants reported the highest confidence level at for three criteria, all within math instruction (M = 4.2): *using observation/documentation to identify individual supports; facilitating activities to support development; and promoting skill development through everyday situations/daily routines.* The lowest levels reported in the pre-survey included confidence for *teaching one specific STEM discipline (of the four) at the same level of confidence as for non-STEM disciplines such as literacy*. The mean scores ranged from 1.3 (engineering) to 2.4 (math).

Post-survey

Post-survey mean scores ranged from 2.5 to 5.0. At the time of the post-survey, the highest confidence level (M = 5.0) was for facilitating activities to support development for math. As shown on the last post-survey item, lower perceived confidence levels still existed for teaching technology at the same confidence level as other subjects (M = 2.6) and teaching

Table 2

Mean Ratings for 1st and 2nd Completion of the Early Childhood Educator Self-Efficacy Scale for Supporting Preschool-Age Children's STEM Development

Scale		Mean Rating Pre-Survey					Mean Rating Post-Survey			
		S	T	E	M		S	T	E	M
ECESES-STEM		3.7	3.2	3.0	4.1		4.6	4.3	4.2	4.6
ECESES-STEM Overall Means		3.3					* 4.3			
Prompt: "I believe I can..."										
use observation/documentation to identify individual supports.		3.7	3.5	3.2	4.2		4.4	4.3	4.3	4.5
recognize age-appropriate development.		3.5	3.2	3.0	4.0		4.6	4.3	4.1	4.7
evaluate age-appropriate development.		3.5	3.2	2.9	4.1		4.5	4.2	4.3	4.5
facilitate activities to support development.		3.9	3.2	3.0	4.2		4.7	4.5	4.3	5.0
provide opportunities for those in need of additional support.		3.7	3.2	3.0	4.0		4.7	4.3	4.3	4.5
promote independent opportunities through learning environments.		3.8	3.3	3.2	3.9		4.6	4.3	4.4	4.6
promote skill development through everyday situations/daily routines.		3.8	3.2	3.2	4.2		4.7	4.3	4.3	4.6
involve parents in their child's skill development.		3.5	3.1	2.9	3.7		4.2	4.1	3.9	4.3
answer children's questions.		3.8	3.3	3.0	4.3		4.6	4.3	4.0	4.6
teach ______ as well as other subjects. (e.g., science, technology, engineering, math)		2.0	1.6	1.3	2.4		3.2	2.6	2.5	3.2

Note. The scale is measured on a 5-point Likert scale; EC = Early Childhood; ECESES-STEM = Early Childhood Educator Self-Efficacy Scale for Supporting Young Children's STEM Development; S = Science; T = Technology; E = Engineering; M = Math; *$p < .0001$.

engineering as well as other subjects (M = 2.5). The lowest yet still moderate to higher confidence levels at post-survey were shown for involving parents in their child's engineering skill development (M = 3.9) and teaching science and math as well as other subjects (M = 3.2). See Table 3.

Confidence levels across all four disciplines increased from pre-survey to post-survey, with a statistically significant difference in the overall ECSES-STEM means (M = 3.3; M = 4.3). The results from the pre-survey (M = 3.3, SD = 0.5) and post-survey (M = 4.3 SD = 0.5) indicate that the participants' self-efficacies for early STEM changed, t = 25.71, p <.0.0001. See Table 3.

Implementation of STEM in preschool classrooms

The 13 participants were asked to self-reflect six times over the 11-month timeframe about their implementation and/or promotion of STEM activities in preschool classrooms. Data from the self-reflection logs revealed six common themes including: 1) Implementation of Early STEM Activities, 2) Child Responsiveness, 3) Teacher Growth, 4) Teacher Responsiveness, 5) Sharing with Colleagues, and 6) Hands-on Exploration. The frequency of each theme was determined by the number of times the participants mentioned each theme within the combined self-reflection logs' transcripts, as shown in Table 4. Qualitative data for each of the six themes follows in rank order of the frequently mentioned themes.

Table 3

Overall Mean for Pre-Survey and Post-Survey Scores on the ECESES-STEM (N = 13)

Survey	*Mean*	*Standard Deviation*	*t-value*
Pre-Survey	3.34	0.54	
Post-Survey	4.26	0.50	25.7093

Table 4

Themes: Number of Times Mentioned in Combined STEM Self-Reflection Logs Transcripts

Theme	Number of Times Mentioned
Implementation of Early STEM Activities	78
Child Responsiveness	75
Teacher Growth	67
Teacher Responsiveness	44
Sharing With Colleagues	42
Hands-On Exploration	35

Theme 1: Implementation of Early STEM Activities. Participants most frequently mentioned implementation of planned early STEM activities through direct teaching and/or use of the indoor and/or outdoor environments. This theme was mentioned by participants 78 times within the combined self-reflection logs transcripts.

Building and engineering activities. The participants commonly described the implementation of early STEM activities in which young children built and engineered structures. For instance, one EC educator shared that small groups of young children used provided materials to build structures stating, "Many of the children used the materials to build and engineer different structures based on their own developmental levels." Other participants described how they implemented early STEM activities in which the young children engineered and built houses, towers, musical instruments, water pipes, and sprout houses to plant seeds.

Outdoor STEM activities. Accounts of early STEM implementation went beyond the classroom setting with many participants purposefully planning and providing outdoor STEM experiences. One EC educator described the use of "STEM boxes or bins" [a box, tub, bin, kit containing purposefully provided materials] so the young children could readily explore outdoors. Two examples of young children using an outdoor STEM box included using materials to experiment with how long it takes snow to melt and to see what kind of food ants prefer eating.

Additionally, participants implemented early STEM activities outdoors. One described, "...building ramps on the playground using different materials to zoom matchbox cars down." Another participant connected early STEM to their study of physical science simple machines unit by encouraging the young children to find different machines around their playground. This outdoor exploration of simple machines led to the implementation of an indoor investigatory early STEM activity where young children learned more about how a teeter totter worked as a machine. "The children worked in small groups indoors to build teeter totters and find ways to make it [the teeter totter] balance using plastic counting bears" as weights.

Early STEM discipline activities. Many participants mentioned implementation of early STEM learning opportunities directly related to particular STEM disciplines such as science or math. Instances of implementing science activities were most frequently mentioned in participants' February, March, and October self-reflection logs. For instance, one EC educator described taking young children on nature walks and having them use magnifying lenses to explore and describe their surroundings during their walk. Several participants described how nature walks led to discussions about life science topics collectively including leaves, bark, tree beans, pumpkins, and pinecones. Participants described implementing physical science activities such as light and shadows, sound, magnetism, density, and properties of matter. One EC educator described a physical science activity in which young children took rhythm sticks outdoors to try to find "instrumental objects" [objects that make sounds when moved or manipulated] and then compared the sounds the objects made. Another participant shared how they implemented water play with a sandbox creating a "mud kitchen" as a means of investigating the physical science concept of properties of matter (e.g., liquids, solids, and mixtures. A third EC educator shared how the students explored physical science with magnets.

> *Just last week we spent time identifying the kind of things the magnet would or would not stick [to] and coming up with the reason why that is. We also explored a little with the magnetism in the sense that the magnetic pull can go through things such as a piece of paper, book, and table to make the paper clip move around.*

Implementation of math activities was most frequently mentioned in the participants' self-reflection logs during the months of September, October, and November. Reported instances of implementation of early STEM activities highlighting math concepts included subitizing, graphing, using 10-frames to create numbers, and geometry/shape-related activities. Incorporating math talk and using activities from the Learning Trajectories website (Clements and Sarama, 2017/2019) were commonly mentioned. One EC educator described planning and implementing a large group activity in which they "drew two shapes and the children identified and discussed their attributes, similarities, and differences." Another EC educator described having young children create shapes with various materials, stating, "the children composed different-shaped bubble wands and tested different types of bubble solutions." Yet another EC educator incorporated shapes into a unit about clothing.

Using stories to launch early STEM activities. Several participants mentioned using young children's stories to introduce or enrich early STEM experiences for large group activities or in conjunction with learning centers. Two participants described a project in which young children used different materials to build a house after reading the story, The Three Little Pigs. Another EC educator described using a different version of the traditional story,

> *We read the story, The Three Little Super Pigs. Afterwards, I asked the kids what they could build to keep the wolf in. First the kids drew their building plan and then they got to build it [their planned building].*

Several participants mentioned reading children's books aloud during large group times and then implementing related early STEM activities during small group time and/or center time. One EC educator shared,

> *One of my recent favorites involved reading the children's book, After the Fall: How Humpty Dumpty Got Back Up Again (Santat, 2019) in a large group setting and then challenging my students to work in small groups to create a safer wall for Humpty Dumpty using Legos and other materials.*

Another EC educator referenced, *Dreaming Up: A Celebration of Building* (Hale, 2012), stating, "Earlier this month we talked about towers and how we think they were built. The kids then explored with building up. It has taken off. Students loved it." Yet another EC educator read the story, *10 Sparkly Snowflakes* (Tales, 2017) and had the young children go outdoors to collect snowflakes so they could look at them through magnifying glasses. This EC educator shared how the young children noticed and discussed, "the unique patterns of each snowflake before making their own snowflakes using various mediums."

Theme 2: Child Responsiveness. The theme of Child Responsiveness was mentioned by participants 75 times within the combined self-reflection logs transcripts. *Child responsiveness* conveyed the participants' perceptions of how the young children responded to planned/implemented early STEM activities, learning environments, and/or materials provided. Descriptions included but were not limited to: (a) the children's enjoyment; (b) finding multiple ways to solve problems or complete challenges; and (c) social interactions, discussions, and learning.

Children's enjoyment. The words, "fun" and "enjoyed" frequently emerged in the participant's self-reflection logs when describing young children's responses to planned/implemented early STEM activities. Three examples follow, "Seeing how real snowflakes are all different was such a fun activity for all involved," and "It was a lot of fun- students really loved it and learned a lot!" Another participant described creating a song,

> *This [musical STEM activity] was super FUN! We somehow created the pattern with floor sticks while playing a pattern. One of my friends [child] made the connection to a song, and belted out, We will… we will…rock you!*

Instances of participants describing young children's enjoyment follow, "The kids really enjoyed making their pond," while another EC educator stated, "I did my final project from my STEM class [developed during one of the courses completed as part of the study], the kids really enjoyed all the extra things in the centers." Other participants shared that the young children enjoyed subitizing math games, graphing activities, mathematical learning trajectories activities, exploring with funnels and sand to figure out why wet sand gets stuck, yet dry sand goes through, and predicting and testing items to see which sink or float. Several participants shared that the children enjoyed the early STEM activities, and the children wanted to do the activities again.

Children's participation and engagement. Many of the participants described the young children's active participation and engagement during early STEM activities. One stated, "Children were engaged, responded to the question she [educator] asked, and they were excited to predict what was going to hap-

-pen." Another EC educator reported feeling "amazed" as she watched the young children so engaged in working through the problem. Yet another EC educator described the young children as being "engaged and wanting to learn more about trees" and being "engaged when they were actively exploring the room and making discoveries of what a magnet will stick to." Two additional participants stated, "I love that they [children] got so engaged and they [children] were in so much control of their learning" and "I am in a 6-hour classroom with 25 students who have numerous disabilities, and all of the students absolutely love STEM time."

Multiple ways to solve problems or complete challenges. Participants mentioned the young children wanting to solve problems or complete STEM challenges. One EC educator shared, "Some of them [children] even got excited when their towers fell because they were able to build it better." Another EC educator stated, "the children really had to think about and discuss how they wanted to design and build the roof of their house in terms of size and shape [flat or inclined]."

Several participants described the young children's use of imagination during open-ended STEM activities. For instance, an EC educator described, "the children had fun finding new ways to use the STEM materials through ongoing exposure and opportunities to use them." Another EC educator described the young children using their imagination during play,

> *The students were pretending that the swings were rocket ships and they were on them and were flying to the moon. Then when they got inside, they started building 'rocketships with Legos.*

Yet another EC educator shared, "It was absolutely awesome to see what my preschoolers came up with and listen to them explain their thought process about why their wall was safer."

Social interactions, discussions, and learning. Several participants' self-reflection logs included descriptions of young children working together and interacting with one another. The young children were frequently described as working in small groups and talking to one another as they solved problems and completed early STEM activities. Several participants cited instances of young children making suggestions about how to use the materials and/or building upon their peers' ideas and designs. Additionally, participants mentioned that the young children asked and answered questions while learning from one another. One EC educator wrote, "It [the STEM activity] increased conversations about the topic and students asked questions we hadn't even thought to talk about previously," and another EC educator shared,

> *[One] little guy had never thought to build [the tower] against a wall so with the right questions and inquiries, it became his idea. The next thing the little guy knew, he had several friends with him trying to build a tower as high as they could against the wall.*

Theme 3: Teacher Growth. Participants described Teacher Growth 67 times within the combined self-reflection logs transcripts. Reflections related to Teacher Growth related to: (a) increased self-efficacy; (b) collaboration; and (c) other benefits of the study in terms of professional development opportunities.

EC educator self-efficacy. Many participants shared positive or affirmative statements regarding their self-efficacy or confidence related to early STEM implementation across the six self-reflection logs. Many described personal growth and/or feeling more confident. For instance, one EC educator described STEM implementation as "feeling natural" in her classroom and others described STEM implementation as becoming easier with experience. . One EC stated, "In the past, it was always easy to overthink implementing science and math activities or even trying to implement technology and engineering." Another EC educator shared, "I love how much easier it is getting to implement STEM into day-to-day activities! I see STEM teaching opportunities in places where I hadn't thought of before."

"One EC educator described STEM implementation as "feeling natural" in her classroom and others described STEM implementation as becoming easier with experience. "

Four different participants shared, “It’s still taking some adapting to spending more time on projects and lessons, but it is getting so much better!” “I love doing different STEM activities all day long and I have learned to implement it as part of my lesson that it has just become such an easy transition.” “I am feeling that what I have learned has made me a better teacher and supervisor because now I am able to teach my staff as well which make me proud,” and, “I need to slow down a little because I get so excited and I want to implement everything all at once - I constantly remind myself this is not the most effective way to promote STEM learning.”

Collaboration. Participants often stated feeling more confident using a team approach to early STEM instruction. One shared, “We’re learning together as a team to break lessons and topic down more and spread it out so we can really dive into it.” Another stated,

> *My team has been printing off many of the lesson ideas to have for future reference and have been working on implementing more STEM based lessons. We have also been adding more STEM materials to our classroom and exploring them along with the kids to kind of learn as we go.*

Yet another shared,

> *This was a wonderful opportunity for Head Start Staff. The STEM team [study team] has provided us with so much knowledge, practical approaches, experiences along with a wealth of resources that we can make our programs STEM Rich!*

Benefits of professional development opportunities related to the study. Many participants identified early STEM materials, resources, and practices/strategies shared within the college courses they completed as part of the study as being beneficial to their professional growth and development. Participants’ responses included, “I feel like I’m getting more and more resources with every class [course taken as part of the study]” and “I appreciate that we’ve gained so many ideas through these classes [courses provided as part of the study] to share with children.” Another stated,

> *I am really enjoying the textbook, specifically the STEM books. Since graduating college almost 10 years ago, a lot has changed! I think I understand STEM better as it being described more as an approach-all day everyday- rather than one solitary experience.*

Participants also shared the benefits of the graduate-level college courses in terms of camaraderie provided as part of the overall study. The final December self-reflection logs contained the following participants’ comments, “I am absolutely loving all that I am learning, along with the collaboration with instructors and classmates - this has been incredibly valuable, and I am beyond grateful!” Another EC educator wrote,

> *As this is my last reflection log, I cannot begin to explain how invaluable our coursework, our professors, the people in our cohort has been to me. I feel so grateful that I will be able to provide more meaningful, engaging STEM lessons in my classroom, which will benefit my students for years to come.*

Other participants described future collaboration, including this quote,

> *We are working to plan a family STEM night at our next parent meeting! We’re hoping to set up some fun and engaging STEM activities for parents to engage in with their preschoolers. I have so many ideas I have gleaned from our classes.*

Theme 4: Teacher Responsiveness. Participants’ STEM self-reflection log transcripts also contained descriptions of and/or perceptions of how the EC educators responded before, during, or after adult-child interactions, activities, or using learning environments. This theme emerged 44 times within the combined self-reflection logs transcripts.

Many self-reflection logs entries conveyed a sense of teacher enjoyment about using early STEM activities with the young children. For instance, the following quotes were shared by various participants: “I am having a blast teaching the [STEM] lessons!”, “I have actually enjoyed bringing the math lessons [shoe graph and math game] into the classroom.”, “Students and staff enjoyed it and were really engaged!”, and “Teachers loved the activities because they were easy to follow and kept students engaged in activities.”

EC educators' responses and facilitation during early STEM activities. Participants shared instances of how they responded to or facilitated early STEM activities. One participant shared,

> After viewing a video [in a college course related to the study] of a child who couldn't stop his tower from tipping and then moving to build it against a wall, I saw this same opportunity within the classroom and seized it once the little one became upset that he couldn't get Godzilla to the top.

Another EC educator shared that the young children initially thought they could only collect insects in the containers she provided for them to use during outdoor exploration. Once she noted this, she explained to the young children that the containers could be used to hold any item they wanted to bring back for closer observation in the classroom. Once she clarified this point, she shared that, "the containers have been in constant use." Another EC educator shared that the young children wanted to make different shapes, so she brought out more supplies for them to do so. Yet another EC educator described how she followed the child's lead and tried to engage the young children in different challenges using the materials in the "STEM boxes or bins she had created for one of the early STEM college courses she had completed as part of the study.

EC educators' goals and adjustments for future early STEM implementation. After implementing early STEM activities, several participants shared goals for doing the same early STEM activities again and/or modifying and adjusting the early STEM activity for future early STEM implementation. For instance, one EC educator shared, "I would like to spend more time doing intentional activities with the materials so that students have a better understanding of what the materials are and ideas for using them." Other participants mentioned wanting to change up materials throughout the year and using a variety of open-ended materials to enhance the young children's experience. One EC educator noted, "When there are more of those open-ended materials the young children seem to engage with them for a longer amount of time both during the day and over a duration of days." Another EC educator described incidentally implementing a early STEM activity using sand and funnels and how she now planned to build upon this "happy discovery" in the future by "having the children try it with materials other than sand, such as water, snow, and ice." After seeing the young children engage in outdoor exploration, another EC educator described her plan to make exploratory STEM kits containing magnifying glasses, clipboards, paper, pencils, and bug catchers that go outdoors daily with the young children.

Theme 5: Sharing with Colleagues. The self-reflection logs' entries referenced how many of the participants shared or planned to share information or ideas for early STEM instruction with other educators, colleagues, and/or administrators via training opportunities and/or coaching. The theme emerged 42 times within the combined self-reflection logs transcripts.

Training opportunities. Several participants described how they provided or planned to provide STEM training for colleagues and/or team members. One participant shared, "I think it would be wonderful to introduce STEM and train staff on it when they return in August." Another participant described developing a short training for teaching staff in January, "I am excited to share what we have learned and how it can easily be included into our lesson plans." Yet another EC educator wrote, "I want to work with teaching staff to intentionally focus on challenging the students by posing the questions and problems and emphasizing Twenty-First Century Skills."

Coaching. Many participants described coaching as a means of providing suggestions for their colleagues and/or other EC educators. Suggestions that participants shared or planned to share with colleagues and staff included: using math language daily, using STEM during choice time, providing more time for early STEM projects, incorporating small group or team activities, and taking materials outside. One EC educator shared an instance in which she was observing in an EC classroom that was struggling with classroom management. "I suggested changing up the lesson plans and providing more hands-on, engaging activities, and I suggested open-ended materials where they [the children] can create their own things."

Other participants shared or planned to coach by sharing specific information and/or resources with colleagues and/or EC educators from the early STEM college courses they completed during the study. For instance, many participants indicated that when coaching colleagues or other EC educators, they planned to recommend the use of resources from Learning Trajectories website (Clements & Sarama, 2017/2019). Another stated, "In completing some of my STEM activities for our classes [college courses completed as part of the study], I have encouraged my co-teachers to do similar activities with their groups and they have (subitizing, graphing, science experiments)." Another participant wrote, "I have encouraged a few of my teaching staff to try and use my STEM kit [created during courses completed as part of the study] in their classroom.

Theme 6: Hands-on Exploration. The participants also described how the young children used hands-on materials for building, creating, or exploring in various learning environments. This theme emerged 35 times within the combined transcripts. Many participants reported early STEM activities in which the young children used hands-on materials to design, engineer, create, explore, and/or build. Participants mentioned using household and/or recyclable materials for early STEM activities including 3D foam pieces, felt, blocks, cardboard tubes, rocks, toothpicks, glue, markers, straws, wooden craft sticks, toothpicks, and a type of clay referred to as 'model magic.' Participants also cited young children using mathematical and scientific materials such as ten-frames, tweezers, magnifying lenses, petri dishes, balances, scales, and STEM boxes or bins for hands-on experiences.

Many participants described how the young children used hands-on materials and manipulatives to create structures or models. For instance, young children created shadows, shapes, houses, buildings, teeter totters, and snowflakes with the varied materials provided by the participants. Other participants described how the young children solved a particular problem or challenge using hands-on materials in the classroom or in an outdoor environment. For example, after reading a story about the Three Little Pigs, some participants described young children using materials to design a house that could withstand the wolf's "huffing and puffing." Others described young children using hands-on materials to build sprout houses for planting seeds, designing catapults, creating shadow towers, making a volcano out of a pumpkin, crafting animal habitats, and fashioning musical instruments so they could have, "their very our own little marching band." Additionally, several participants described how the young children engaged in open-ended opportunities in which they used hands-on materials to explore and create with minimal constraints or directions from the participants.

Discussion and Implications

The multiple methods study examined Head Start preschool educators' self-efficacy and instructional practices for supporting preschool-age children's STEM learning during their participation in a targeted professional development program that consisted of four graduate-level courses. As shown by the results, each of the 40 ECESES-STEM confidence-level mean scores increased. At the time of the pre-survey, six of the 10 indicators were deemed to be at the lower level of perceived confidence whereas after the intervention, only two mean ratings fell below 3.0. Consistent with findings from Sarama, et al. (2018), the implementation of a cohort model for professional learning over time and connected to educators' classrooms, increases the likelihood that change will occur. With an increased understanding of how to integrate STEM in early childhood classrooms, educators are more likely to involve young children in purposeful interactions with STEM materials, increasing opportunities for young children's development of critical thinking skills (Englehart, 2016). Relatedly, with opportunities for formative feedback overtime and from the college instructors and peers, the participants' confidence levels were positively influenced (Blonder & Vescio, 2022).

In addition to survey data, the combined transcripts from the self-reflection logs revealed six common themes (e.g., *Implementation of Early STEM Activities, Child Responsiveness, Teacher Growth, Teacher Responsiveness, Sharing with Colleagues, and Hands-on Exploration*) which contained perceptive data related to the participants' confidence and instructional STEM practices.

Three of the themes (i.e., *Teacher Growth, Teacher Responsiveness, and Sharing with Colleagues*) relate to participants' increased confidence. Several participants described personal growth in terms of increased preparedness and confidence throughout the study and professional development opportunity. Many mentioned greater early STEM understanding and/ or having more confidence after trying STEM activities with the preschool-age children. These findings align with what is known about self-efficacy and PD. Educators are more likely to gain confidence when they participate in ongoing and interconnected PD opportunities designed to increase content and pedagogical knowledge (Desimone, 2009; McClure et al., 2017). This study incorporated Sarama et al. (2018) recommendations for effective PD opportunities as it was ongoing (i.e., four courses taken over 11 months), connected to personal teaching practice and/ or instructional setting (i.e., preschool educators, instructional coaches, and program directors), and tailored to the EC educators' needs (i.e., instructor and peer feedback, e-meeting times). Consistent with a study conducted by Chen et al. (2021), many participants in this study reported higher levels of STEM self-efficacy after participating in early STEM-related activities and PD.

Furthermore, the self-reflection logs' transcripts frequently suggested an increase in participants' confidence via *Teacher Responsiveness*. In this study, Teacher Responsiveness included opportunities to apply what was learned, self-reflect and set professional goals, all of which are known to be impacted by one's self-confidence (Bandura, 1993; Gerde et al., 2018). The participants frequently shared instances of teacher responsiveness after applying their early STEM knowledge to their own instructional setting. Their self-reflection logs often conveyed personal enjoyment when watching young children partake in early STEM activities, suggesting a positive effect. Many of the participants mentioned their eagerness to plan for and implement additional early STEM activities. The findings confirm Zee and Koomen's (2016) study showing that educators with positive affective attitudes are more likely to implement and develop innovative pedagogical beliefs.

Relatedly, the theme of S*haring with Colleagues* suggests educators must have confidence in order to willingly exchange instructional strategies and/or ideas with other educators. Several of the participants disclosed either a future goal for sharing or having shared their early STEM knowledge and/ or activities with colleagues. The EC educators in this study participated in structured PD in which they had ongoing opportunities to engage as educational leaders. For example, they facilitated early STEM PD activities and provided a range of supports to their colleagues with frequent opportunities to rehearse, analyze, reflect on instructional practices, and set goals (Sarama et al., 2018, p.4). The results of this study parallel previous studies (Chen et al., 2021; Desimone, 2009; McClure et al., 2017) related to ongoing PD opportunities as an effective means of increasing self-efficacy and promoting early STEM instruction.

The remaining themes of I*mplementation of Early STEM Activities, Hands-on Exploration, and Child Responsiveness* pertain to the participants' instructional practices. The prevalence of the Implementation of Early STEM Activities theme indicates ongoing implementation throughout the study. As advocated by Lange et al. (2019) and Sarama et al. (2018), the participants frequently described whole and/or small group early STEM implementation in which young children simultaneously incorporated STEM disciplines to investigate and/or solve a phenomenon-based, real-world problem. As recommended by Lange (2019), the self-reflection logs transcripts contained descriptions of participants incorporating early STEM experiences in which young children used multi-modal senses to observe and explore, discover patterns, and learn through trial-and-error. Many participants provided play-based indoor and/ or outdoor learning experiences to immerse young children in the scientific process. Research supports the role of "play" as fundamental to effective STEM instruction (Stipek, 2017).

The participants' implementation of early STEM included specific references to math, science, engineering, and technology. All four NGSS (2013) Disciplinary Core Ideas (e.g., Life Science, Earth Science, Physical Science, and Engineering, Technology, and Systems) were represented in the participants' account of early STEM implementation. The participants described using exploratory science experiences in which young children asked questions, made predictions, observed, explored, collected, and discussed the data collected through hands-on, inquiry-based investigations. Bredekamp (2019) supports these experiences since they allow young children to grow their knowledge and skills related to life science, physical science, earth science, and engineering.

STEM technology refers to materials, resources, or tools that young children can use to solve a problem or to complete a design task (Lange et al., 2019). The participants provided accounts of young children using technologies, including hands-on materials (e.g., household items or tools) to explore scientific phenomena or complete engineering designs. As supported by Bredekamp (2019), blocks, math manipulatives, and games were also frequently used for STEM implementation.

"The participants provided accounts of young children using technologies, including hands-on materials (e.g., household items or tools) to explore scientific phenomena or complete engineering designs. "

The self-reflection logs' transcripts also contained evidence of teaching specific mathematical process skills including *reasoning and problem solving, communicating, and composing and decomposing* (National Research Council, 2009). These interrelated skills have the potential to collectively enrich young children's understanding of STEM concepts, helping young children develop the character traits of curiosity, problem-solving, and perseverance (Lange et al., 2019).

Additionally, many participants described young children's responses to planned/ implemented early STEM activities in terms of fun and enjoyment. The findings align with a study by Atma et al. (2021) stating when students enjoy and are motivated to learn, they have a positive attitude. Similarly, Cudney and Ezzell (2017) stated that motivation fostered a desire to learn and encouraged students to produce meaningful work. The results of the current study indicate that the young children enjoyed early STEM activities and wanted to do them again, suggesting a desire for continued learning.

Relatedly, many participants described the young children's active participation and engagement during early STEM activities. Reeve et al. (2004) described *engagement* as a student's emotional and active involvement during a learning activity. Active learning engages students and is therefore considered to be a teaching technique that supports learning (Atma et al., 2021). The participants' self-reflection logs' transcripts provide evidence to support the National Association for the Education of Young Children and National Council of Teachers of Mathematics' (NAEYC & NCTM, 2010) joint position statement affirms that young children can engage in the science and engineering practices (i.e., making predictions, carrying out experiments, and collecting data). Furthermore, the National Research Council (2001) stated that in addition to asking questions, young children should have the capacity and propensity to observe, explore, discover, and make sense of the world around them.

One way that young children in this study were reported to make sense of the world around them during early STEM activities was through social interactions. Accounts of groups or pairs of preschool-age children working and interacting with one another as they engaged in learning from one another while participating in early STEM activities substantiates what is known about social learning (Vygotsky, 1986). In addition, the young children being reported as actively participating in early STEM activities, the participants also described how young children persisted and often found multiple ways to solve problems or complete challenges. This is supported by Sarama et al. (2018) and Lange et al. (2019) who found that STEM experiences allow young children to gain STEM knowledge while simultaneously developing character traits that may build foundational background knowledge and interest in STEM.

Limitations and Future Studies

While the findings are encouraging, it must be acknowledged that the small sample size used for this study limits generalization of the findings. In addition, the study yielded inconsistencies with the return rate for the six self-reflection logs.

Future research focusing on EC educators' abilities and use of strategies for promoting early STEM instruction in both indoor and outdoor learning environments, particularly during times of inclement weather may help in preparing teachers to effectively and efficiently plan and implement early STEM instruction. In addition, focusing on the dyadic relationship between coach and coachee and their self-efficacy levels before and after shared professional development opportunities, may assist the field in further defining the value of the coaching model and potential benefits for alignment of coaching and PD experiences.

While it is important to remember the ever-increasing STEM workforce demands, it is equally if not more important to consider how STEM knowledge, skills and self-efficacy may impact career choices and/or readiness of young children, our future workforce. Workforce demands often lead to higher compensation and benefits. Ensuring EC educators, particularly those providing care and education to Head Start children, often at higher risk of school failure is important not only to fill the increased STEM workforce demands, but to provide pathways toward financial stability.

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