DETERMINING THE EFFECTIVENESS OF A PROFESSIONAL DEVELOPMENT EXPERIENCE FOCUSED ON INTEGRATING COMPUTER SCIENCE INTO EARLY CHILDHOOD CURRICULUM

A Record of Study

by

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ABSTRACT

No doubt exists that literacy and mathematics are the primary foci of early childhood education. Children have limited exposure to computer science-related topics, including robotics, coding, and engineering design. This study is based on prior research evidence indicating that early childhood teachers' confidence and competence can be enhanced with professional development in computer science-related areas, which in turn can enhance the exposure of children and increase their interest and skills in computer science. In this record of study using both quantitative and qualitative methods, I address early childhood teachers' lack of knowledge and experience in coding, engineering design, and robotics, and by conducting three, six-hour workshops focused on these concepts. Participants engaged in hands-on activities and discussions and were provided resources to support learning and classroom integration. Participants completed two pre- and two identical post- assessments measuring a) competence levels in engineering design, robotics, computational thinking, and coding and b) their confidence levels in using coding, engineering design, and robotics in their classrooms. Positive gains were made in both confidence and competence levels of the teachers. The artifact created is a framework that can be used to design and deliver focused professional development. The key factors within the framework include reflective practice, providing appropriate and timely resources, and building a personal network. Designing sustained professional development that includes the key factors may lead to an increase in confidence and competence in integrating computer science concepts across the early childhood curriculum.

DEDICATION

I dedicate this record of study to my partner in life, Jack O'Connor, and my son, Brendan. Thanks for being patient and supportive along my journey. To Jack, your unwavering support carried me through this journey. I know we are not always on the same page about higher education, but thank you for recognizing and understanding my aspirations. To Brendan, I hope you see that education can open doors, hearts, and minds. Mark Houlahan said, "If you want your life to be a magnificent story, then begin by realizing that you are the author and every day you have the opportunity to write a new page." Take your pen, my sweet boy, and begin to write your story. Be patient, great things are to come.

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Contributors

This work was supervised by a record of study committee consisting of Dr. Mary Margaret Capraro [Chair], Dr. Robert M. Capraro [Co-Chair], Dr. Lynn Burlbaw of the Department of Teaching, Learning, and Culture, and Dr. Glenda Musoba of the Department of Educational Administration and Human Resource Development.

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NOMENCLATURE

AP	Advanced Placement
BS	Bachelor of Science
CSP	Computer Science Principles
EC	Early childhood (Prekindergarten- 2nd grade)
ECS	Exploring Computer Science
EDP	Engineering Design Process
ESC	Educational Service Centers
ME	Mechanical Engineering
MS	Masters of Science
PLN	Personal Learning Network
PMNS	Perot Museum of Nature and Science
ROS	Record of Study
STEM	Science, Technology, Engineering, and Math
T-TESS	Texas Teacher Evaluation and Support System
TEA	Texas Education Agency
TEKS	Texas Essential Knowledge and Skills

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CHAPTER I

INTRODUCTION

Most early childhood teachers who participate in the science, technology, engineering, and mathematics (STEM) Teacher Institute (the Institute) at the Perot Museum of Nature and Science (PMNS) do not have the knowledge or experience to integrate robotics, coding, and engineering design into their classroom. A preliminary survey of 34 elementary and middle schools in North Texas showed that fewer than 5% of elementary schools offer learning experiences in robotics, coding, and engineering design. These results are in contrast to the more than 90% of middle schools that offer such learning experiences. Understanding that the STEM pipeline begins to narrow as students begin to lose interest in the fourth grade for STEM related content (Huneycutt, 2013), waiting until middle school to introduce computer science activities and experiences to students is too late.

The Context

National Context

Computer science opportunities for students are limited nationwide. As computing becomes a more prominent part of life and work, students will need the exposure and skills to adapt and thrive in such an environment. The United States Department of Labor Bureau of Labor Statics (2018) predicts that jobs in computer and information technology will grow by 13% between now and 2026 (U.S. Department of Labor, 2018). Code.org (2018) has formulated nine policy ideas or recommendations for making computer science a core part of K-12 education. The nine policy ideas can be placed in one of four, foundational categories: Clarity, Capacity, Leadership, and Sustainability (Code. Org, 2018). Table 1 shows the policy ideas by the foundational category. Column 1 lists policy ideas that relate to Clarity. Column 2 shows policy ideas that represent Capacity. Column 3 shows policy ideas that represent Leadership. Column 4 lists policy ideas that convey Sustainability for computer science education.

Table 1

Policy Ideas by Foundational Category

Clarity	Capacity	Leadership	Sustainability
State plan for K-12 computer science education	Allocate funding for computer science education	Establish computer science positions in state education agency	Require that high schools offer a computer science course
Create rigorous computer science standards	Provide paths for computer science teacher certification		Allow computer science to count as a core class for graduation requirements
	Provide opportunities in computer science to pre-service teachers		allow computer science to count towards admissions to colleges and universities

Code.org, 2018

Code.org tracks in real time nationwide progress of implementation of the nine policy ideas. Three policies tie to this study: have a state plan for the incorporation of computer science into K-12 education, develop rigorous standards, and require high schools offer computer science courses.

The United States lacks having state policies or plans for K-12 computer science education. Currently, only three states, Arkansas, Rhode Island, and Maryland have a state policy or plan for computer science education (Code.org, 2018). Connecticut, Hawaii, and

Kentucky are currently in the process of drafting a state policy. However, more states have or are moving towards developing rigorous standards related to computer science as well as defining computer science at the state level. Table 2 shows the progress of states in creating computer science standards. Column 1 lists the states that currently have computer science standards. Column 2 lists the states that are currently working on designing computer science standards. Column 3 lists the states that are considering creating standards in the future.

Table 2

Progress Towards Computer Science Standards

States with Standards	States with Standards in Progress	States with Standards being Considered
Arkansas	Alabama	Connecticut
Florida	Arizona	North Carolina
Idaho	California	Ohio
Indiana	Colorado	Rhode Island
Massachusetts	Delaware	
New Jersey	Hawaii	
Pennsylvania	Iowa	
South Carolina	Kentucky	
Virginia	Maryland	
Washington	New Hampshire	
Wisconsin	Nevada	
West Virginia	Oklahoma	

Code.org, 2018

Finally, Code.org notes how many states currently require high schools to offer computer science to their students either in-person or remotely. Arkansas, Delaware, New Jersey, Nevada, Texas, Virginia, and West Virginia currently require that computer science be offered to secondary students. Iowa addressed this requirement in the 2019 legislature.

The K-12 Computer Science Framework (The Framework) and the revised K-12 Computer Science Standards complement the policy ideas from Code.org. The K-12 Computer Science Standards posed by the Computer Science Teachers Association (CSTA) in 2011 offer a progression of learning beginning with "simple ideas about computational thinking" (Computer Science Teachers Association, 2011, p. 8) in grades K-3 to "applying concepts and creating real-world solutions" (p. 8). Both the Framework and CSTA Standards propose the groundwork states can use for designing and implementing policy and standards for computer science. The revised Framework is "a high-level guide for states, districts, and organizations implementing computer science education" (K-12 Computer Science Framework, 2016, p. 14). The Framework presents a continuum of learning for developing "a foundation of computer science knowledge" (K-12 Computer Science Framework, 2016, p. 9) in which states can use to change the trajectory of computer science education. Though the Framework does not offer specific standards for computer science, the Framework provides a blueprint for "designing curriculum, assessment, course pathways, certification, and teacher development programs" (K-12 Computer Science Framework, 2016, p. 3).

State Context

Texas is slowly implementing the recommended policy ideas for K-12 computer science education. While Texas does not have a state plan, computer science standards, or dedicated funding, computer science is offered in high schools across the state. Texas does not have standards specific to computer science; however, computer science concepts are included in the

Texas Prekindergarten Guidelines and the Texas Essential Knowledge and Skills (TEKS) for Technology Application (Tech Apps) standards for grades Kindergarten - 2nd grade.

The Texas Prekindergarten Guidelines provide a holistic approach to the social, emotional, and academic development of a prekindergarten student and are aligned to the kindergarten TEKS. The Guidelines are divided into ten domains, including the Technology Applications domain (X). The Technology Applications domain emphasizes how the prekindergarten student can "expand their ability to acquire information, solve problems, and communicate with others" through consistent "access and exposure to computers and related technology" (Texas Education Agency, 2015, p. 122).

Examples of child behaviors and sample instructional strategies to meet the guidelines are offered in each domain. One example of child behavior is for guideline X.A.3 relating to using digital means to communicate ideas is in the Texas Prekindergarten Guidelines (Texas Education Agency, 2015). An instructional strategy for guideline X.A.1 is that the teacher "provides a variety of opportunities to enhance learning experiences through the use of digital learning applications and programs" (Texas Education Agency, 2015, p. 122). iPad applications such as ScratchJr® and Kodable® make coding accessible to young students and would help the teacher meet both of these guidelines by providing age appropriate learning experiences.

The TEKS for Tech Apps for K-2 includes concepts related to creativity, innovation, communication, and collaboration. A teacher could present computer science concepts and meet various Tech Apps standards. §126.6(b)(1)(C), (D), and (E) express that students are expected to explore programming languages, use steps to complete a task, and evaluate and change the steps to complete a task (Texas Education Agency, 2012). While these standards do not explicitly refer to computer science, the expectations can be aligned to foundational computer science concepts such as algorithms and debugging.

The Problem

Current Professional Development Opportunities

Professional development for elementary teachers in computer science is limited in the Dallas Fort Worth area. WeTeach_CS Collaboratives and Code.org offer specialized professional development for teachers interested in teaching computer science. The WeTeach_CS Collaboratives are comprised of 31 projects across the state of Texas. The WeTeach_CS program is part of The Center for STEM Education at the University of Texas in Austin. "Collaborative teacher participants increase their content knowledge and pedagogical skills through research-based instruction and are provided opportunities to network with other computer science teachers from across the state" (Werst, 2017, para. 2). The projects offer 60 hours of computer science professional development, as well as training, focused on preparing teachers to take the TExES 8-12 Computer Science certification test. There are six projects in the Dallas Fort Worth area for 2018: Texas A&M Commerce (TAMU-C), The University of Texas at Dallas (UTD, Southern Methodist University (SMU), Fort Worth ISD, and UTeach Central Texas. In 2017, no elementary teachers were participating in the Collaboratives from the Dallas Fort Worth area.

Educational Service Centers (ESC) were established by the Texas Education Agency to provide services such as professional development to school districts across the State. Region 10 is one of the 20 ESCs in the state of Texas offering a variety of services to schools. Region 10 is located in North Texas in a suburb of Dallas and covers 10 north Texas counties, including Dallas County. Region 10 supports over 140 public school districts, charter, and private schools with approximately 840,000 students, with about 214,000 students enrolled in prekindergarten through 2nd grade. PMNS served over 110,000 students from a Region 10 school and 115 teachers currently teaching in Region 10 during the 2016-2017 school year. There are twenty ESCs. Region 10 ESC serves Dallas and surrounding cities. Region 11 ESC serves Fort Worth and surrounding cities. Both offer minimal professional development opportunities in computer science for early childhood teachers. Region 10 offers one workshop presented by Code.org each spring. Region 11 does not offer computer science related workshops for early childhood teachers. Workshop calendars for ESCs are fluid, so opportunities in computer science may be added throughout the year.

Code.org offers onsite and online professional development. Code.org's vision, "is that every student in every school should have the opportunity to learn computer science, just like biology, chemistry or algebra" (Code.org, 2017, para. 1). Lessons are available for elementary, middle, and high school students. Lessons are completed online by using the Code Studio. Code.org also provides teachers with access to free online resources as well as local professional development opportunities focused on using Code.org. Each December, Code.org hosts Hour of Code encouraging students and educators across to the world to participate in coding to develop an interest and awareness of the opportunities in the computer science field. Code.org offers a yearlong professional development program for middle and high school teachers. Elementary teachers are able to attend a six seven-hour workshop or independently complete online modules. Code.org's professional development is free for teachers.

The research that I conducted during this Record of Study (ROS) is focused on teachers, administrators, professional development coordinators, and Museum educators in Region 10.

During my internship, I conducted interviews with stakeholders to uncover values related to professional development, computer science in early childhood, STEM, and community priorities. With responses from these interviews coupled with the results of the quantitative and qualitative data from my ROS, teachers, administrators, professional development coordinators, and Museum educators are informed, encouraged, and able to make decisions on the type of professional development needed to increase teacher's competence and confidence in integrating computer science in early childhood development.

Ideally, schools would have competent and confident teachers able to integrate computer science learning experiences into classrooms as early as prekindergarten. A variety of high-quality professional development opportunities focusing on not only the basics but also on how to integrate computer science into early childhood classrooms would be widely available and easy to identify.

Research Questions

To assess the effectiveness of the professional development program. I designed a study which would use both quantitative and qualitative methods within my research design. I collected quantitative data to answer questions 1 and 2. To supplement the quantitative data collected in question 2, and obtain data to answer questions 3 to 6, I collected qualitative data in the form or interviews and observations.

1. How effective is focused professional development in alleviating low-confidence levels and the lack of content knowledge in robotics, coding, and engineering design of early childhood teachers?
2. What are the teachers' current confidence and competence level of integrating robotics, coding, and engineering design into early childhood curriculum?

3. How did teachers respond to focused professional development?
4. How did the professional development session affect the teachers?
5. What was the overall growth in the confidence and competence level of the teachers?
6. What are the teachers' overall perceptions about the effectiveness of professional development?

Personal Context

My career as a teacher began over 10 years ago as a substitute teacher. I now hold several Texas Standard Teaching certificates including Early Childhood- 4th Grade (EC-4) Generalist. I taught kindergarten for five years and 2nd grade for two years. While my background is not explicitly computer science, I have taken computer science courses in junior high and high school.

My journey to the problem originates from my experience as a classroom teacher in a high-performing elementary school in a high-performing district. As demands for computer science skills grew in the district and nationally, I felt that students in early childhood were being overlooked when providing such learning experiences, unlike their middle school and high school counterparts who had computer science learning experiences. My interest for integrating computer science into early childhood classrooms surfaced as I began integrating technology and engineering into my lessons. I noticed that students were able to use technology, such as an iPad or desktop computer, but did not necessarily have the foundational concepts behind the technology to produce a product outside of a Microsoft Office document or presentation. Or, when I would introduce an engineering project, students would jump to the build step without regard to the design step. I also noticed that students were not resilient learners and would become frustrated and give up on a challenging task.

Understanding that the STEM pipeline begins to narrow as students begin to lose interest in the fourth grade for STEM related content (Huneycutt, 2013), I had difficulty reconciling why schools wait until upper elementary or middle school to introduce computer science concepts. I understood that most teachers and administrators felt the need or urgency to provide learning opportunities in computer science based on data showing the small percentage of students choosing careers in computer science (S. Moran, personal communication, October 6, 2016; H. Robinson, personal communication, October 8, 2016; V. Warren, personal communication, November 5, 2016). As an EC-4 generalist certified teacher, I understood that most early childhood teachers have limited, if any, background in robotics, coding, and engineering design. When I transitioned from a classroom teacher to the informal learning space of a t Museum, I saw that the community was asking for the Museum staff to offer computer science learning opportunities for younger students. The Museum was currently providing camps focusing on robotics and engineering (J. Liken, personal communication, October 11, 2016) for upper elementary students. As I began speaking with Museum educators and educators participating in the Institute about how they integrate computer science concepts into their classrooms, I realized that elementary teachers wanted to, but did not know where to start or were uncertain about how they could with no background in computer science (A. Montgomery, personal communication, November 8, 2016; K. Foronda, personal communication, November 7, 2016; G. Pollom, personal communication, October 4, 2016).

The problem became clear. In early childhood classrooms, which I note for this study as Prekindergarten- 2nd grade, teachers do not have the knowledge or experience to integrate computer science into their classroom. In addition, there is a lack of sustained professional development for EC teachers focused on computer science for early learners. It is my personal opinion that EC teachers need to increase their competence and confidence in teaching computer science concepts in order to provide meaningful learning experiences to students. Meaningful learning experiences increase STEM content interest and engagement as well as enhance 21st century learning skills such as problem solving and collaboration. By waiting until 4th grade to integrate computer science concepts, EC students are missing out on the initial groundwork for achievement in STEM related disciplines.

Researcher's Role. With the help of EC teachers participating in the STEM Teacher Institute at PMNS and the support of their administrators, I proposed to help increase teachers' competence and confidence in integrating computer science into early childhood education by designing a professional development experience focused on robotics, coding, and engineering design. For my record of study, I used surveys to gauge teacher confidence and assessments to gauge teacher competence during their attendance in a series of focused professional development workshops. Based on these data, I gauged the success of the workshops and make adjustments for future workshops.

Stakeholder Groups and Values. Educators at the Museum desire to design and implement computer science learning experiences for early childhood students. The PMNS Vice President of School and Community Engagement notes that the Museum as a whole is struggling with how to define early childhood learning. Without a clear definition and a cohesive thought on how to engage early childhood students while at the Museum, adding computer science learning experiences does not seem appropriate. During conversations with both the Vice President of School and Community Engagement and the Museum educators, it was found that they possess strong beliefs that teachers need focused professional development in robotics, coding, and engineering design. The struggle becomes how to meet budgetary needs, resolve conflicting views of early childhood education, and meet the needs of a community desiring such learning opportunities.

The Museum's professional development coordinators believe that teachers in the Institute need and want professional development focused on computer science because sustained professional development increases competence and confidence (A. Montgomery, personal communication, September 6, 2017; M. Morgan, personal communication, August 31, 2017). For the 2017-2018 school year, the coordinators delivered three workshops focused on Raspberry Pi® and Makey Makey®. While the workshops had low attendance from early childhood teachers, the feedback from early childhood teachers focused on their desire for more unplugged activities or activities using ScratchJr.® or Scratch® that they could share with PreK-2nd grade students. The coordinators developed workshops for Institute teachers that focus on engineering design and design thinking in early childhood. Workshops were conducted during the 2018-2019 school year.

CHAPTER II

REVIEW OF SUPPORTING SCHOLARSHIP

American students lag behind the world in science, technology, and math. This shortcoming is not a current trend in contemporary education. Gutek (2013) found "American students to be seriously deficient in science and mathematics" (p. 141) in the mid 1950's. With that being said, students lack exposure to and experiences with computer science concepts, especially in early childhood education. Even though students born after 1980 are generally considered digital natives, teachers must consider how to create learning experiences to build technology fluency in the early childhood educational setting. Practices in the classroom should support increasing computer science knowledge through relevant and applicable experiences such as robotics, coding, and engineering design. Robotics, coding, and engineering design enhances 21st century learning skills such as innovation, collaboration, critical thinking, and problem solving.

Constructivism and Constructionism

Constructivism and constructionism provide a foundation for teaching and learning in computer science. Taylor, Breed, Hauman, and Homann (2013) explained that in "computer science…a passive student with no participation fails in learning" (p. 76). Constructivists posited that learners construct their own knowledge (Ultanir, 2012; Schcolnik, Kol, & Abarbanel, 2006). Learning is viewed as an active process, beyond teachers merely transmitting knowledge to students, and becomes learner-centered rather than teacher-centered (Ultanir, 2012). Constructivism is generally linked to the theories of Piaget and Vygotsky. According to Ultanir (2012), "Piaget's main focus of constructivism has to do with the individual and how the individual constructs knowledge" (p. 201). The construction of knowledge varies depending on the learner's stage of development and the learner's interaction with the knowledge. This inclusion of cognitive development terms Piaget's constructivism as cognitive constructivism. Vygotsky focused on "the social interaction of learning" (Schcolnik et al., 2006, p. 12). Theorists who are social constructivists considered "that learning and development is a collaborative activity and that children are cognitively developed in the context of socialization" (Ozer, 2004, para. 10). Vygotsky believed that knowledge acquisition was continuous and that "one's opinion will change" (Pelch & Pieper, 2010, p. 13) through social interaction.

Seymour Papert, a professor at Massachusetts Institute of Technology and author of the book *Mindstorms: Children, Computers, and Powerful Ideas*, was at the forefront of using computers in the classroom. Papert built upon constructivism to introduce constructionism (Martinez & Stager, 2013; Kim, Psenka, Haapala, Schmidt-Jackson, & Okudan-Kremer, 2017). "Constructionist learning has a long tradition in computer science education" (Przybylla & Romeike, 2014, p. 241). If constructivism can be equated to learning by doing, then constructionism can be equated to learning by making. Kim et al. (2017) noted:

> Constructionism follows the constructivist paradigm in which the building of knowledge structures occurs best in natural and spontaneous ways, but reconstructs constructivism by additionally positing that this learning happens 'especially felicitously' in this process of constructing a 'public entity' to make ideas concrete for sharing and visually reflecting upon. (p. 9).

Martinez and Stager (2013) suggested that "maximum agency over the computer is critical for modern knowledge construction" (p. 132). With that being said, using computer science concepts such as programming parallels constructionism.

Conceptual Framework

My conceptual framework as presented in Figure 1 shows the flow of processes that lead to positive student outcomes by integrating computer science learning experiences into early childhood curriculum. Sustained professional development is the foundation of the framework. Sustained professional development cultivates the competence and confidence teachers need to integrate computer science learning experiences into early childhood curriculum. Teachers will gain knowledge and resources from participating in sustained professional development. They may in turn become confident to integrate computer science learning experiences into the classroom. When teachers integrate computer science learning experiences, students gain exposure to computer science. Computer science learning experiences emphasize skills such as problem solving, critical thinking, and 21st century skills such as collaboration. As students gain more exposure to such learning experiences, their competence and confidence increases as well as their interest in computer science.

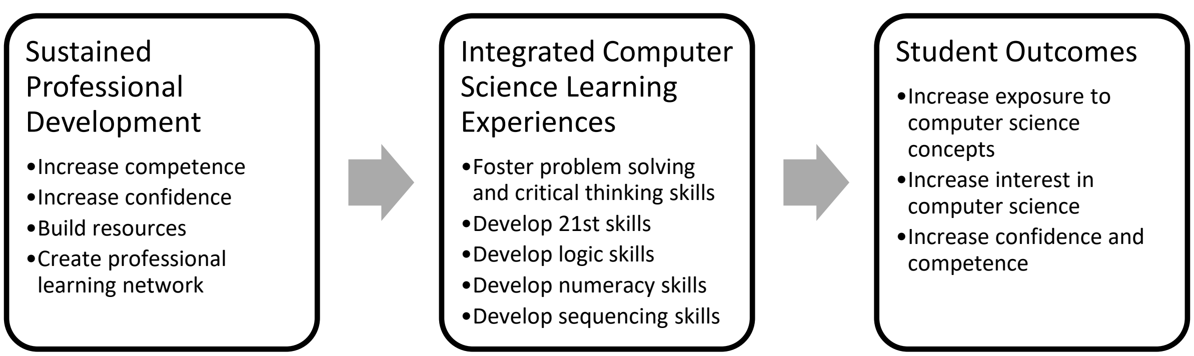

Figure 1. Conceptual framework.

Most Significant Research

I have grouped the literature I found significant for my study into four categories: (a) Educational Theories, (b) Professional Development and Adults as Learners, (c) Integrating Curriculum, and (d) STEM Related Content Areas: Robotics, Coding, and Engineering Design. These four categories combine to provide a cohesive picture of how integrated curriculum is being used in early childhood education. While there exists some literature focusing of the above-mentioned four areas, there is little focus on research concerning integrating computer science into early childhood education. The research in this area seems to focus mostly on middle school and high school environments.

Educational Theories

Educational theories center on how students learn. I reviewed literature focused on specific educational theories such as constructivist approach, social learning theory, and experiential learning. By reviewing literature focused on educational theories, teachers can apply the principles in appropriate ways to integrate computer science concepts into early childhood classrooms.

The early childhood classroom is an active environment. Early childhood classrooms are filled with hands-on activities and opportunities for students to explore the world around them. Young children benefit from active learning experiences and learning experiences that build upon prior knowledge to construct new meanings (Burnett, 2010; Nicholls, 1998; Rushton & Larkin, 2001; Spodek & Saracho, 1999). A constructivist worldview provides a theoretical background for this study. Pelech and Pieper (2010) defined constructivism as “a philosophy that views knowledge as a subjective process that is shaped and structured by one's experiences" (p. 8). Arlegui et al. (2009) noted that the active learning and progression of skills used during programming and building robots reflect a constructivist approach. Building robots in the early childhood classroom provides hands-on learning experiences. In addition, the increased complexity of skills needed as students continue to work with robots enables students to build upon their knowledge.

As young children navigate the classroom environment, they begin to interact with their peers in new ways learning from each other whether directly or indirectly. Pelech and Pieper (2010) discussed that "students learn by working with others" (p. 41) and "when they teach others" (p. 33). Characteristics of the constructivist worldview such as learning with and building relationships with others (Pelech & Pieper, 2010) reflect Bandura's social learning theory. Bandura (1971) explained that "new patterns of behavior can be acquired through direct experience or by observing the behavior of others" (p. 3). Nicholls (1998) supports social learning theory by explaining that science involves active participation, thus providing a social context for young children. Bers (2008) further supported social learning theory by expressing that children working with robotics can "learn to work in groups and develop socioemotional skills" (p. 121). Bers (2008) continues to add that engaging with robotic manipulatives "invite[s] children to participate in social interactions and negotiations while playing, and learning to play" (p. 4). Building connections with peers is part of the classroom experience, and participating in robotics activities can help foster social relationships between children in the early childhood classroom.

A common instructional method in early childhood classrooms is experiential learning, or learning by doing whereby children engage with the learning through hands-on-activities rather than merely the teacher transmitting information. In thinking about the instructional approach of learning by doing (Bers, Flannery, Kazakoff, & Sullivan, 2013; Cejka, Rogers, & Portsmore, 2006), promote hands on education. The hands-on requirement transitions the experience of learning by doing (constructivism) to learning by making (constructionism). Robotics and engineering design usually have a product as a result of an activity. For instance, robotics activities involve constructing “physical artifacts” (Bers, Ponte, Juelich, Viera, & Schenker, 2002, p. 129). An added benefit of hands-on activities is the development of fine motor skills that is essential to the overall development of a young child. Robotics and engineering design are important to the early childhood classroom because the two merge constructionism and constructivism while simultaneously contributing to the development of early learners.

Computational thinking is a foundational skill in computer science. Wing (2006) described computational thinking as a way of “solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science” (p. 33). Bers (2008) noted that “through the process of designing and debugging computer programs, children would develop a metacognitive approach toward problem-solving and learning” (p. 15). Papert (1993) presented computational thinking as a way of using systematic instructions in an iterative process including debugging that can be used to develop thinking and problem solving skills. By fostering computational thinking skills in learning experiences, teachers are also enhancing critical thinking and problem solving skills.

One way to cultivate computational thinking skills is to integrate robotics activities into the curriculum. Robotics help children develop computational thinking skills (Catlin & Woollard, 2014). Bers et al. (2013) used the TangibleK Robotics Program curricula to foster computational thinking, develop computer-programming skills, and develop robotic concepts of kindergarten students. These researchers found that the TangibleK Robotics Program curriculum was an engaging and developmentally appropriate way to integrate robotics, programming, and computational thinking into the kindergarten classroom.

Spatial thinking is equally as important as computational thinking and is another foundational skill that should be developed at an early age. Spatial thinking, as explained by Newcombe (2010), "concerns the locations of objects, their shapes, their relations to each other, and the paths they take as they move" (p. 30). Spatial thinking is an aptitude that spans across multiple content areas and disciplines (National Research Council, 2006). Spatial thinking is a fundamental skill needed for STEM success (DeSutter & Stieff, 2017; Newcombe, 2010; Gagnier & Fisher, 2016) yet it is currently not an integral part of K-12 curriculum (National Research Council, 2006). Because spatial skills can be seen as building blocks to STEM success, learning experiences focused on building spatial skills should be provided at an early age.

Professional Development and Adults as Learners

Literature in this section centers on components of professional development opportunities that support adults as learners. Components include focused content, partnerships with universities, and length of time. Reviewing literature on professional development and adults as learners is presented to demonstrate how continuous learning is essential for professional and personal growth.

Professional development and learning are essential in preparing educators to become competent and confident in utilizing integrated curriculum. Many educators feel "unprepared to teach science" (Atiles, Jones, & Anderson, 2013, p. 287) yet alone robotics, coding, and engineering design. Kermani and Aldemir (2015) have suggested that educators need to not only overcome preconceived notions of what science education looks like, but also recognize and analyze their beliefs about science education and integrating curriculum. While professional development focusing on science in early childhood is growing (Bers & Portsmore, 2005), designing focused professional development can increase competence and confidence in teachers. Increasing teachers' competence and confidence can lead to greater student learning.

Researchers such as Bers and Portsmore (2005) and Burrows (2015) have shown that creating partnerships between university faculty, engineering students, secondary educators, and early childhood educators can increase the success of professional learning. Partnerships with pre-service early childhood educators allowed aspiring educators to see "the potential offered by technology and what they would need to know" (Bers & Portsmore, 2005, p. 72) while simultaneously having the "safety net of experts (engineering students)" (p. 72). These partnerships can also increase educators' self-efficacy. Burrows (2015) noted that partnerships created a support system that translated into "higher self-efficacy" (p. 29) as well as the "likelihood of STEM content implementation" (p.37). Atiles et al. (2013) found that increased knowledge in science was positively correlated to higher self-efficacy. In addition, educators were likely to have "greater ownership" (Avery & Reeve, 2013, p.65) of their learning motivating educators to continue integrating STEM into the curriculum. Vaca-Cárdenas et al. (2016) created a laboratory to provide pre-service elementary teachers with coursework and experiences to increase their technological skills and self-efficacy in programming as well as increase digital literacy. Vaca-Cárdenas et al. (2016) felt that coursework or programs during pre-service training increased self-efficacy and skills, and teachers overwhelmingly had positive experiences and felt the programming activities encouraged creativity. Forming various types of partnerships as a method of professional learning increases pre-service teachers' confidence in their ability to teach STEM content and provides motivation to integrate STEM content into the curriculum.

Professional development workshops can range in length of time. Research has suggested that focused, multi-day workshops provided greater opportunities for professional learning (Atiles et al., 2013; Avery & Reeve, 2013; Bers & Portsmore, 2005; Burrows, 2015; Nadelson & Seifert, 2013; Nadelson et al., 2013). Further investigation will need to be completed to evaluate why multi-day workshops are successful at increasing competence, confidence, and educators' ability to retain information versus single day workshops. Details found during investigation may lead to educators and administrators designing professional learning opportunities that are consistently focused on fostering competence and confidence. Immersion may be an underlying reason for the success of multi-day workshops. Nadelson et al. (2013) further suggested that focused professional learning affects areas beyond efficacy and content knowledge. Designing focus, sustained professional development may simultaneously affect competence and confidence.

Integrating Curriculum

Literature in this section defines an integrated curriculum, what it means to integrate various content areas, and how using an integrated curriculum benefits young learners. Literature in this section also uncovers obstacles teachers face in creating integrated learning experiences and ways to support designing these experiences. Reviewing this literature was beneficial in revealing how to build transferable skills, create connected learning, and recognize challenges for teachers.

Utilizing an integrated curriculum in early childhood helps students to transfer skills across various subjects when learning. An integrated curriculum can be seen as one that is connective across multiple content areas or themes (Drake & Burns, 2004; Harvey & Reid, 2001; Kelly, 2001). Moreover, an integrated curriculum is more reflective of not only how children learn but also how competencies are applied in the workplace. A productive workforce will need to be proficient problem solvers and possess scientific and technological skills. Engineering design is an engaging and a cross-disciplinary way to strengthen these proficiencies. Marulcu and Barnett (2012) determined that engineering design should be integrated into elementary science curricula as a means to support science instruction as means to "gain conceptual understanding" (p. 1843). Mangold and Robinson (2013) add that the EDP naturally incorporates problem solving and critical thinking skills that can be applied to science, technology, and math learning and daily life. The National Academy of Engineering and National Research Council (2009) concluded that "design activities provide a real-world focus…which may have a positive impact on learning not only in engineering, but also other subjects, such as mathematics and science" (p. 57). EDP can provide a means to incorporate multiple content areas across the curriculum; thus, supporting the development of problem solving and critical thinking skills that can be applied beyond the classroom.

Learning does not happen in a silo. Integrated curriculum reflects "children's natural way of learning" (French, 2004, p. 141). French (2004) further suggested that curriculum divided by academic categories was counterintuitive to this natural way of learning. A student's ability to utilize skills across various curricular areas helped in making connections and making learning applicable to them. In an early childhood setting, the role of an educator is to reinforce the learning and provide hands on experiences to support "intellectual and linguistic development" (p. 140). Moomaw and Davis (2010) corroborate this notion and add that such learning experiences enable young students to make interdisciplinary connections and develop "foundational concepts" (p. 18). Kermani and Aldemir (2015) continued with this idea by stating that integrating curriculum in early childhood education classroom "supports…the formation of awareness and interest towards science, and eventually affects their overall school performance" (p. 1505). Kermani and Aldemir (2015) confirmed that integrating curriculum in early childhood education is natural and necessary to students' future success. Hoachlander (2015) explained that truly integrated STEM helps link knowledge and skills to make experiences applicable and help develop a pathway to STEM careers. By using an integrative approach to learning, early childhood students build connections and make learning applicable in a meaningful way.

Even though integrating curriculum can be viewed as natural and necessary to student development and success, obstacles such as lack of time and resources and educators' low self-efficacy have contributed to an absence of integrated curriculum in early childhood classrooms. Lack of time and resources seems to be an underlying theme across the literature describing integrating curriculum. Time allotted for science instruction has decreased over the years (Atiles et al., 2013). Integrating concepts and skills across curricular areas aids in relieving some of the challenges with lack of time. Educators can help ease pressures of limited resources by investing in items that are "reusable and durable" (Cejka et al., 2006, p. 711). For example, Tank, Pettis, Moore, and Fehr (2013) found that using storybooks to introduce science concepts and engineering principles helped "facilitate meaningful STEM learning" (p. 60). Students gained exposure to science concepts and engineering principles through their literacy learning. Literacy and science seem to be a complimentary pair of curricular areas. Many skills in science reflect those needed in literacy. Predicting, making inferences, and evaluating solutions can be applied in both science and literacy. Wilson-Lopez and Gregory (2015) goes a step farther to explain how such comprehension strategies enable students to become "more thoughtful engineers" (p. 25). Utilizing resources that can span multiple content areas can help teachers make better use of limited time and resources.

Designing integrated curriculum can be challenging for a teacher that is not familiar with the process. The STEM Education Quality Framework (SQF) provides a structure in which teachers can utilize to ensure components of an integrated STEM unit are included. The SQF as presented by Pinnell et al. (2013) helps a teacher link components such as engineering principles, STEM careers, assessment, and technology. Teachers can use the SQF rubric to evaluate the level in which they are integrating one or more of the ten components of the framework into their STEM instruction. By continuous use of the SQF rubric, teachers may uncover components that are consistently incorporated into STEM instruction or components that need more attention. In addition, continuous use may increase teacher's self-efficacy in designing an integrated curriculum focused on STEM.

STEM Related Content Areas: Robotics, Coding, and Engineering Design

Literature in this section centers on specific STEM related content areas: robotics, coding, and engineering design. Prior literature focuses on ways to introduce robotics, coding, and engineering design to young learners and how to integrate these STEM related concepts into literacy. Prior researchers reveal how introducing robotics, coding, and engineering design to young learners may enhance problem solving and critical thinking skills. Reviewing this literature was important to understanding what is appropriate for early childhood classrooms and how young learners will benefit from engaging in activities related to specific STEM content areas.

Robotics, coding, and engineering design can be beneficial for engaging early childhood learners. Robotics is usually integrated at the middle and high school level but can offer benefits in early childhood such as increased fine motor skills and hand-eye coordination (Bers, 2008; Bers, Flannery, Kazakoff, & Sullivan, 2014). The integration of robotics, coding, and engineering design may help improve STEM knowledge. By using robotics and computer programming in pre-kindergarten and kindergarten classrooms, Kazakoff, Sullivan, and Bers (2013) evaluated how intense robotics programs in early childhood classrooms would increase sequencing ability in both mathematics and language arts, and may help increase ability in areas of mathematics and literacy, particularly number sense and sequencing. Though STEM is gradually being integrated into early childhood education (Bers et al., 2013), Bers (2008) found that "early childhood educators have had little or no experience with technology or engineering concepts and processes" (p. 122). This lack of experience may be attributed to math and literacy being the primary focus in early childhood education (Bers et al., 2013). A curriculum including robotics, coding, and engineering design would not only provide added benefits to the early childhood classroom, but would also reinforce STEM teaching and learning.

Robotics, programming, and Creative Hybrid Environment for Robotic Programing (CHERP) are accessible to students in early childhood if stages of development are taken into consideration. Flannery and Bers (2013) noted that Piaget's cognitive stages of development were being revised to include technology use. Skills such as problem solving and computational thinking can be linked to phases of cognitive development. Robotics is usually integrated at the middle and high school level but can offer benefits in the early childhood classroom such as increased fine motor skills and hand-eye coordination (Bers, 2008; Bers et al., 2013). Flannery and Bers (2013) found there is a need for differentiated learning experiences and curricula considering cognitive stages. Parents and educators can design meaningful learning experiences with technology and computer science concepts based on cognitive stages and learning needs of the student.

Science instruction does not receive as much time as literacy and engineering instruction receives even less time. Early childhood education students do not understand what it means to be an engineer if asked (Pantoya, Aguirre-Munoz, & Hunt 2015). With literacy instruction being the focus in early childhood education, literacy is an appropriate avenue to introduce engineering concepts. However, there is lack of literature that includes engineering concepts for early childhood students. Pantoya et al. (2015) created a literacy component or storybook that could pair with curriculum being used in the classroom such as Full Option Science Systems (FOSS). The storybook provided a way for teachers to introduce engineering concepts and vocabulary as well as spark interest in engineering and related disciplines. Furthermore, the book included a drawing activity that would help gauge student understanding of the concept of what it means to be an engineer. Interjecting engineering concepts into early childhood literature provides a viable avenue to hook young students as well as provide opportunities to introduce engineering concepts (Pantoya et al., 2015). Martinez and Stager (2013) further noted that “if playful, creative inclinations of young children were nurtured in an engineering context, their understanding of the increasingly elusive math and science facts would be developed in a meaningful natural context” (p. 39-40). For early childhood students to gain understanding and interest in engineering, literature focused on engineering concepts is a beneficial addition to current literacy curriculum.

Programming can be seen as a way to increase higher order thinking skills and problem solving skills. However, elementary school teachers usually do not possess a high level of technical knowledge or experience in programming. Programs such as Hour of Code are making programming more accessible to elementary students and teachers (Remis, 2015; Wilson, 2013). Logo, a programming language developed by Papert in 1967 for children and adults alike, "is accessible to beginners" (Kim et al., 2017, p. 5). Scratch® is a block-based programming experience that "was intended for students to learn…without expert teacher intervention" (Martinez & Stager, 2013, p. 138). Other programming languages exist such as BASIC and StarLogo. Martinez and Stager (2013) recommended that no matter which language a teacher chooses for the classroom, "choose one language and stick with it" (p. 135). "Students will gain much more proficiency and confidence if they are able to grow with one language" (p. 135). Concentrating on one language will support both the student and the teacher in learning programming as well as increasing cognitive skills and efficacy.

The most significant research is grouped into four categories: (a) Educational Theories, (b) Professional Development and Adults as Learning, (c) Integrating Curriculum, and (d) STEM Related Content: Robotics, Coding, and Engineering Design. Educational theories such as constructionism and constructivism, social learning theory, and experiential learning helped frame this study. Reviewing literature on computational thinking and spatial reasoning helped show the needed foundational concepts. The literature on professional development and adults as learners revealed how continued learning is essential for professional and personal growth. The literature also revealed the necessity to continue investigating professional development formats such as immersion and length of time. Building transferable skills, creating connected learning, and presenting challenges for teachers, were important pieces examined when reviewing literature focused on integrating curriculum. Although literature revolving around integrating computer science skills into early childhood is growing, it is still limited.

The literature reviewed provided the groundwork for this study. Components and the format of the workshops are a result of the literature reviewed. For example, workshops included hands-on, and active learning experiences. All the content and resources selected for my EC workshops were grounded in the literature reviewed. A review of the supporting literature guided me when creating my study as well as in choosing the appropriate methods.

CHAPTER III

SOLUTION AND METHOD

Proposed Solution

Teachers' low capacity and confidence can be attributed to inadequate and infrequent professional development in these content areas. To build teacher capacity, teachers attended a professional development experience focused on increasing confidence and competence in computer science. Teachers attended three, 6-hour workshops on Saturday focused on robotics, coding, and engineering design and how to integrate these content areas into early childhood classrooms. The workshop content overview is included in Appendix A. At the conclusion of each workshop, teachers completed an exit ticket to gauge teachers' connection to the learning. Exit ticket questions are included in Appendix B. After attending the workshops, it was anticipated that teachers would have increased knowledge of computer science and increased confidence to present learning experiences in computer science to early childhood students. Data were collected through surveys, assessments, and interviews to uncover if teachers' confidence and competence is increasing.

Context

The research site was the Perot Museum of Nature and Science (PMNS) in Victory Park in downtown Dallas. Origins of PMNS date back to the Texas Centennial in 1936 as the Dallas Museum of Natural Science. In 2006, the Dallas Museum of Natural Science, the Science Place, and Dallas Children's Museum merged to become the Museum of Nature and Science at Fair Park. In 2008, the Museum of Nature and Science was officially named the Perot Museum of Nature and Science. PMNS opened a new location in downtown Dallas in December of 2012.

The Fair Park location is still open for visitors once a week. PMNS in Victory Park has seen over one million visitors since its opening (Perot Museum of Nature and Science, 2017).

STEM Teacher Institute. PMNS has offered a variety of professional development opportunities since 1999; however, the STEM Teacher Institute (the Institute) is currently the only professional development opportunity offered by PMNS. The Institute began in 2015 and is the evolution of the previous campus-based professional development program, *Leaders in Science*. The Institute is a free, year-long professional development opportunity for PreK- 8th grade teachers in the Dallas-Fort Worth Metroplex.

The Institute has a competitive application process, accepting approximately 13% of the annual applications. During the application process, accepted teachers are placed into one of four categories based on years of science teaching experience: Pre-service, Novice, Advanced, and Mentor. For the 2017-2018 school year, 132 teachers enrolled in the Institute. Table 3 shows the grade levels represented in the Institute for the 2017-2018 school year. Column 1 shows years of service for teachers participating in the Institute. Column 2, 3, 4, and 5 indicate the number of teachers in grade bands. Column 6 shows the number of preservice teachers in the Institute. Column 7 indicates teachers who teach multiple subjects, STEM teachers, or science coordinators.

Table 3

Institute Teachers by Grade Levels and Years of Service

Service (years)	Grade Levels				Preservice	Non-teachers
	PreK-2	3-5	6-8	9-12		
Preservice	0	0	0	0	10	0
1-4	10	23	3	3	0	0
5-9	9	5	4	2	0	4
10-14	7	2	7	4	0	2
15-19	1	7	2	1	0	0
20-24	0	2	4	0	0	0
25+	3	0	1	0	0	0
Unknown	4	6	3	0	0	3

Teachers enrolled into the Institute are required to attend a 4-day summer academy and a minimum of five workshops throughout the school year. The topic of the summer academy focuses on one of the four major reporting categories of the Texas Knowledge and Skills (TEKS) for Science and rotates yearly: Matter and Energy; Force, Motion, and Energy; Earth and Space; and Organisms and the Environment (Texas Education Agency, 2016). While the summer academy topic focuses on one reporting category each year, workshop topics throughout the school year cover all four reporting categories.

Participants

Out of 132 teachers participating in the Institute, 34 teachers taught PreK- 2nd grade. Study participants who met inclusion criteria were selected from this group. Inclusion criteria were those currently teaching PreK-2nd grade, currently participating in the Institute, and able to commit to attending all three workshops. Seventeen teachers who met inclusion criteria were unable to commit to attending all three workshops or could only commit to attending one workshop. Nine teachers who met inclusion criteria did not respond to requests for study participants. Table 4 shows the breakdown of study participants who enrolled in the study by grade level. Column 1 indicates the grade level or multi-level. Column 2 shows how many teachers taught at that grade level or levels. Two teachers who originally met inclusion criteria, signed consent forms, and enrolled in the study changed grades before attending the first workshop and therefore are not included in the reporting of pre- and post- scores.

Table 4

Study Participants by Grade Level(s) Taught

Grade level	Number of teachers
Prekindergarten	1
Kindergarten	2
2nd	1
Prekindergarten- 2nd	1
Prekindergarten- 5th	1
Kindergarten- 2nd	1
Kindergarten-5th STEM	1

Participants who enrolled in the study have various years of service and teach at different types of schools. Teacher A has taught for five years at a parochial school. This year was her first year teaching Kindergarten- 5th grade STEM. Teacher B has been teaching prekindergarten-

5th grade for nine years at a parochial school. Teacher C has been teaching kindergarten at the same public school for 5 years. Teacher D has been teaching prekindergarten- 2nd grade for 7 years in a private school. Teacher E is a prekindergarten teacher and has taught 12 years at the same private school. Teacher F has 16 years of teaching various elementary grades in the same public school. This year was her first year teaching 2nd grade.

Research Paradigm

Quantitative and qualitative data were used together in this study (Creswell, 2014) to measure the success of the professional development experience. Using quantitative data alone did not help me totally understand the participants' perceptions or the context. I reflected on the quantitative data while simultaneously reflecting on the qualitative data throughout the study. The qualitative data were used to expand upon the quantitative data. For example, when the quantitative data from an assessment showed very low scores, the qualitative data helped provide insight into why the scores were low. Quantitative and qualitative data were used together to produce the story of the professional development experience.

Data Collection Methods

Instrument Pilot Study

A pilot study of the assessment instruments was conducted before recruitment of the study participants. The purpose of this pilot study was to identify an instrument that reflected the fundamentals a PreK-2nd grade teacher would need to know to competently engage early childhood students in computer science activities. The pilot study included N= 5 Prekindergarten through 2nd grade teachers ranging from those who were novice teachers to those who possessed advanced computer science experiences. The average years of teaching experience for the sample was 5.9 years. The sample was asked to complete three assessments to gauge competence, the Exploring Computer Science (ECS) Unit 4 assessment (2015) and questions 1, 4, 5, 6, 8, 10, 11, 13, 14, and 17 from the AP Computer Science Principles (CSP) Sample Exam Questions provided in the AP Computer Science Principals Course Exam Description (2016). Teachers also completed the Robotics and Engineering Design Assessment based on the end of unit tests in the Vex Robotics™ curriculum designed by myself in collaboration with the Museum's Sr. Lead Educator. Teachers were given one week to complete the paper assessments at a location of their discretion.

Teachers with no or minimal experience in computer science concepts fared better on the ECS Unit 4 assessment. The content and the open ended format of the questions of the ECS Unit 4 assessment seemed more managable for a teacher with no or minimal experience with computer science concepts. After reviewing these results, I decided to use the ECS Unit 4 assessment for my study. Early childhood teachers will need exposure to computer science concepts to be successful but it is not necessary for them to be masters of concepts and syntax as presented in the AP CSP exam. In addition, I was able to determine the teacher's thinking through the open ended questions. The ECS Unit 4 assessment contained several questions referencing Scratch® which is an appropriate program used in elementary classrooms.

Quantitative

Teachers completed the survey instruments prior to the first workshop and after the final workshop. Two instruments were used to measure competence. Teachers completed the Exploring Computer Science (ECS) Unit 4 assessment (2015) and the Robotics and Engineering Design Assessment based on the end of unit tests in the Vex Robotics™ curriculum designed by myself in collaboration with the Museum's Senior. Lead Educator. The Robotics and Engineering Design Assessment is included in Appendix C. To measure confidence in integrating computer science concepts in early childhood classrooms, teachers completed the Teacher Efficacy and Attitudes Toward STEM (T-STEM) Elementary Teacher Survey (2012). The T-STEM Survey is included in Appendix D.

Questions on the T-STEM Survey were categorized into seven areas. For the purposes of this ROS, six of the seven sections were used: Personal Teaching Efficacy and Beliefs, Teaching Outcome Expectancy Beliefs, Student Technology Use, STEM Instruction, 21st Century Learning Attitudes, and STEM Career Awareness. Personal Teaching Efficacy and Beliefs measures a teacher's self-efficacy and confidence when teaching STEM (Friday Institute for Educational Innovation, 2012). Teaching Outcome Expectancy Beliefs describes how much the teacher believes they can impact student learning (Friday Institute for Educational Innovation, 2012). The section on Student Technology Use represents how often technology is used in the classroom (Friday Institute for Educational Innovation, 2012). STEM Instruction refers to the use of specific STEM instructional practices in the classroom (Friday Institute for Educational Innovation, 2012). The section on 21st Century Learning Attitudes represents how teachers feel about 21st century learning (Friday Institute for Educational Innovation, 2012). The final section on the T-STEM survey used in this ROS was the STEM Career Awareness section. This section refers to if teachers are aware of the types of STEM careers and where to locate resources (Friday Institute for Educational Innovation, 2012). I modified the survey excluding questions about Teacher Leadership Attitudes because those questions did not relate to the research questions used in this ROS.

Using a dependent means *t*-test, I compared the mean of the ECS and Robotics and Engineering Design pre-assessment scores to the mean of the post-assessment scores. I also used a dependent means *t*-test to compare the mean of the pre-survey scores on the T-STEM survey to the mean of the post-survey scores. The independent variable was the workshops, and the dependent variables were the competence assessments (ECS Unit 4 Assessment and Robotics and Engineering Design Assessment) and the confidence survey (T-STEM Survey). I expected that attending focused professional development workshops causes an increase in competence and confidence. After all data were collected, I used regression analysis to predict scores or the potential growth of teachers' confidence and competence after attending successive workshops (Salkind, 2014).

Qualitative

I conducted semi-structured, individual interviews at the beginning and the end of the study based on an interview protocol as prescribed by Creswell (2014). Interviews lasted from 45 minutes to one hour and 30 minutes. I took handwritten notes during the interviews. All notes had identical elements: a heading, the initial questions, possible probes to follow up on responses from the interviewee, and a notes space where I could reflect after the interview (Creswell, 2014). I developed a log to organize the notes from each interview. I used content analysis to analyze responses on the interview transcripts. The content analysis included (a) an initial read through of all the interview transcripts; (b) highlighting recurring ideas during the second reading of all interview transcripts; (c) assigning a code to ideas; and (d) organizing codes for comparison and classification. Using Tesch's (1990) eight step coding process in conjunction with steps provided by Creswell (2014), I was able uncover themes and relationships between the codes. The steps used are listed below:

Step 1: I read through all transcripts and field notes and made note of any general thoughts or ideas that came to mind.

Step 2: I selected what I thought was the most interesting transcript to re-read and reflect on the meaning. While reading, I noted my thoughts in the margin.

Step 3: I re-read the transcripts and made a list of topics that I begin to group with similar topics.

Step 4: I revisited the transcripts and began to add the topics to the data using an abbreviated code for the topics. I also made note of any new topics that appeared.

Step 5: I categorized words that best described the topics.

Step 6: I finalized and alphabetized my list of codes.

Step 7: I put all data for each category into an Excel document. I sorted based on category for analysis.

Step 8: I recoded data as needed.

During workshops, I held informal conversations and observed teachers to understand the attitudes of participants during the study and not just at the beginning and the end of the study. I organized these field notes into a reflection journal that was used while analyzing interview transcripts. Stake (2010) notes that "some qualitative study is fundamentally the capture of a story" (p. 170). The themes and my reflections on how I arrived at the themes is interconnected to build the narrative story of the study participants (Creswell, 2014). This story will "improve the reader's level of understanding" (Lincoln & Guba, 1985, p. 358) of how teachers felt about the professional development experience.

Pre-pilot survey

Prior to completing the ECS Unit 4 Assessment and the AP CSP Sample Exam Questions, teachers were asked to complete a survey inquiring about their background in computer science, how long they have been a teacher, and how long they have taught computer science to elementary, middle school, and high school students. Teachers were asked similar questions asking about their background in robotics and engineering prior to completing the Robotics and Engineering Design Assessment. Based on responses on the computer science background survey, one teacher had no background with computer science. Three teachers had taken a computer science course in high school, attended computer science workshops, or were self-taught. One teacher possesses a Bachelor of Science (BS) and Masters of Science (MS) in Mechanical Engineering (ME). The average years of teaching computer science in elementary, middle school, and high school was 1.4 years. Based on responses on the robotics and engineering background survey, two teachers had no background with robotics and engineering. Two teachers have attended a robotics and engineering workshop or were self-taught. One teacher possesses a BS and MS in ME. The average years of teaching varied between elementary, middle school, and high school. The averages were 1.8 years, 1.5 years, and 0.9 years respectively.

Computer science assessments. The ECS Unit 4 Assessment is a combination of open ended and mulitple-choice questions. The assessment is compared to a rubric with a maximum of 21 total points. The average score of the ECS Assessment was 10.3 points out of a total of 21 total points (SD = 4.76). The teacher with degrees in ME scored 18 points out of 21 total points. The average score of the teachers with minimal or no background with computer science was 8.375 points out of 21 total points (SD = 2.35).

The AP CSP Sample Exam has 22 multiple questions. Ten questions were selected to include in the pilot study based on the learning objective that the question addressed. The average score of the AP CSP Sample Exam Questions was considerably lower with an average of 34% (SD = 31.30). The teacher with degrees in ME had the high score of 90%. The teachers with minimal or no background with computer science struggled with this assessment. The average score was 20%. These teachers were successful on questions 10 and 13 but were unable to answer the other questions.

After reviewing the results of both assessments, the AP CSP Sample Exam Questions appeared too complex and at an inappropriate level for early childhood teachers. Early childhood teachers will need exposure to computer science concepts to be successful in early childhood classrooms and not necessarily masters of concepts and syntax. The ECS Unit 4 assessment had several questions referencing Scratch®, which is an appropriate program used in early childhood classrooms.

Robotics and Engineering Design Assessment. The Robotics and Engineering Design Assessment was created in collaboration with the Museum's Sr. Lead Educator. The Sr. Lead Educator has over ten years of background with Vex Robotics™ and LEGO® Robotics. Questions were taken from the Vex Robotics™ end of unit tests and were based on general robotics and engineering concepts. Questions #10 and #17 on the piloted assessment were discarded because the questions were duplicates. The average score on the Robotics and Engineering Design Assessment was 66% (*SD* = 14.31). The teacher with degrees in ME had the high score of 90%. The average score of the teachers with minimal or no background with robotics and engineering was 59.5% (*SD* = 5.0). Based on the results from the pilot study, the ECS Unit 4 Assessment and the Robotics and Engineering Design Assessment were used as instruments for the study to gauge the competence of the early childhood teachers.

Data Analysis

I utilized both quantitative and qualitative methods. Quantitative data were collected in the form of pre- and post- assessment scores on the ECS Unit 4 Assessment, the Robotics and

Engineering Design Assessment, and the T-STEM survey. Qualitative data were collected in the form of interviews, informal conversations, and observations. The independent variable was the workshops, and the dependent variables consisted of the competence assessments and the confidence survey.

According to Salkind (2014), a dependent means *t*-test is used when comparing a single group under two situations. A dependent mean *t*-test was used to measure participants before and after attending three workshops. A dependent means *t*-test was used because the research questions sought to identify the relationship between attending workshops and the participants' confidence and competence levels of computer science concepts.

Timeline

Table 5 shows the timeline for the data collection and methods for this ROS. Column 1 shows the date of collection and Column 2 shows the method used to collect data. Column 3 lists the artifact or proof of data collected.

Table 5

Timeline of Data Collection Methods

Date of Collection	Method	Artifact/Proof
07/05/2016	Obtain site authorization letter.	I received a letter from Director of School Programs stating that research can be conducted at the Perot Museum.
09/23/2016	Obtain approval for the IRB proposal.	Confirmed study complies with federal guidelines for collecting data from human subjects.

Table 5 Continued

Date of Collection	Method	Artifact/Proof
07/07/17	Obtain email list of PreK-2nd grade teachers participating in Institute.	Professional Development and Campus Partnerships Manager emailed .xls file.
08/15/17	Send initial surveys and assessments to survey participants.	Study participants received electronic versions of surveys and assessments.
08/23/17	Conduct pre-study interview.	I visited one participant at their campus for the initial interview.
08/26/17	Conduct pre-study interview.	I visited one participant at their campus for the initial interview.
08/31/17	Conduct pre-study interview.	I visited one participant at their campus for the initial interview.
09/06/17	Conduct pre-study interview.	I visited one participant at their campus for the initial interview.
09/09/17	Hold design thinking and engineering design workshop.	Participants attended workshop and completed exit ticket at end of workshop.
09/23/17	Hold computational thinking and coding workshop	Participants attended workshop and completed exit ticket at end of workshop.
10/14/17	Hold robotics workshops	Participants attended workshop and completed exit ticket at end of workshop.
10/14/17	Send final surveys and assessments to participants.	Study participants received electronic versions of surveys and assessments as well as paper copies.
11/16/17	Conduct post-study interview and classroom observation.	I visited one participant at their campus for the final interview and observation.
11/28/17	Conduct post-study interview.	I visited one participant at their campus for the final interview.
12/13/17	Conduct post-study interview and classroom observation.	I visited one participant at their campus for the final interview and observation.
12/20/17	Conduct post-study interview.	I visited one participant at their campus for the final interview.

Reliability and Validity

During my ROS, I considered the reliability and validity of the data in hand. A high reliability indicates that participants would, on a second administration of the instrument, perform similarly (Creswell & Plano Clark, 2011) and is an indicator of potential robustness of fiundings (Golafshani, 2003). Validity, in part, can mean that the "instrument[s] are accurate" (Golafshani, 2003, p. 599) and "refers to the accuracy of research data" (Yilmaz, 2013, p. 318). The instruments I chose for my ROS have both been evaluated for reliability and validity. The ECS unit program and assessments were developed from a "three-year qualitative research project" (Goode, Chapman, & Margolis, 2012, p. 48), and instruments were built and piloted in collaboration with SRI Education in the Principled Assessment of Computational Thinking Project (PACT) (SRI Education, 2018). The T-STEM survey was piloted, underwent revisions, and evaluated using factor analysis until the Cronbach's Alpha "performed as expected" (Friday Institute for Educational Innovation, 2012, p. 2). The Robotics and Engineering Design Assessment was created using a nationally vetted program and was piloted.

I have identified potential threats to reliability and validity in my ROS. My field notes may be a potential threat to reliability because I may have failed to document relevant data. In addition, since I was the single coder, results may be subject to bias. Selection of participants may be a potential threat to validity. One participant teaches kindergarten - 5th grade STEM. She teaches engineering, so her knowledge in engineering may be at a higher level than teachers who do not. Two participants teach multiple grades up to 5th grade, which is an extension of inclusion criteria.

I took the following steps to address the concerns to reliability and validity that I have identified. In addition to handwritten notes, I used a digital recorder to document interviews. No personal identifying information was recorded as I began recording after introducing the interview segment to the interviewee. I used triangulation to examine and validate data from interviews, informal conversations, surveys, and assessments (Stake, 2010). Through informal conversations with the multi-level teachers, I learned that their experience level with computer science was consistent with the other participants.

CHAPTER IV

ANALYSIS AND RESULTS

The purpose of this ROS was to determine the effectiveness of a professional development experience focused on integrating computer science into early childhood curriculum. I utilized both quantitative and qualitative methods within my research design to address the following research questions:

1. How effective is focused professional development in alleviating low-confidence levels and the lack of content knowledge in robotics, coding, and engineering design of early childhood teachers?
2. What are the teachers' current confidence and competence level of integrated robotics, coding, and engineering design into early childhood curriculum?
3. How did teachers respond to focused professional development?
4. How did the professional development session affect the teachers?
5. What was the overall growth in the confidence and competence level of the teachers?
6. What are the teachers' overall perceptions about the effectiveness of professional development?

Quantitative data were collected in the form of pre- and post- assessment scores on the ECS Unit 4 Assessment, the Robotics and Engineering Design Assessment, and the T-STEM survey. Qualitative data were collected in the form of interviews, informal conversations, and observations. The independent variable was the workshops, and the dependent variables consisted of the competence assessments and the confidence survey. Scores from the ECS Unit 4 Assessment, the Robotics and Engineering Design Assessment, and the T-STEM survey were used to measure competence. Using a dependent means *t*-test, I compared the mean of the ECS and Robotics and Engineering pre- scores as well as the T-STEM pre- survey scores to the mean of the post- scores. Semi-structured interviews were conducted then coded using Tesch's (1990) eight step coding process in conjunction with steps provided by Creswell (2014) to measure confidence.

There is one primary issue for this study due to the small sample size. Because of the small sample size, there is an elevated chance of creating a Type II error and skewing the results. There is a strong possibility that my sample behaves in ways that do not truly represent the population (Acheson, 2010). I am also concerned about being underpowered because the results have not met the requirement for the Law of Large Numbers. The larger the sample size, the closer the sample average will be to the population average (Lohmeier, 2010). As the number of participants completing the pre- and post- assessments increases, the actual probability approaches the theoretical probability (experimental vs. theoretical). Therefore, to mitigate the potential for a Type II error, I will be reporting effect sizes in addition to my *p* calculated statistics.

Standardized effect sizes are used to show the magnitude of the difference between the pre- and post- assessments. The effect size shows the impact the intervention had on the study participants independent of the sample size (Hu, 2010). Hedges' *g* was calculated using the mean of the pre-assessment minus the mean of the post- assessment then divided by the pooled weighted standard deviation. Similar to interpreting Cohen's *d*, a Hedges' *g* as 0.2 or lower is considered a small effect, 0.5 is considered a medium effect, and 0.8 or larger is considered a large effect. Hedges' *g* will be used throughout my study.

Research Question 1

For research question 1, I examined the effectiveness of focused professional development in alleviating low-confidence levels and the lack of content knowledge in robotics, coding, and engineering design of early childhood teachers. To uncover confidence levels, participants completed the T-STEM Survey. To uncover content knowledge, participants completed the ECS Unit 4 Assessment and the Robotics and Engineering Design Assessment.

Using SPSS, a dependent means *t*-test was conducted for each category of the T-STEM survey to compare the pre- survey scores and the post- survey scores after teachers attended three workshops. The sections of Science Teaching Efficacy and Beliefs and Mathematics Teaching and Efficacy and Beliefs were averaged together to obtain the Personal Teaching Efficacy and Beliefs score. The sections of Science Teaching Outcome Expectancy and Mathematics Teaching Outcome Expectancy were averaged together to obtain the Teaching Outcome Expectancy Beliefs score. Hedges' *g* was calculated using the mean of the pre-assessment minus the mean of the post- assessment then divided by the pooled weighted standard deviation. There was a statistically significant difference in the pre- survey scores for the Personal Teaching Efficacy and Beliefs category of the T-STEM survey (M=3.74, SD= .72) and the post- survey scores for this section of the T-STEM survey (M= 4.30, SD= .60); $t(11) = -2.99$, $p = 0.012$. Scores on the pre- survey for the Teaching Outcome Expectancy Beliefs section of the T-STEM survey were statistically significantly different (M= 3.86, SD= .67) from the post- survey scores for this section of the T-STEM survey (M= 4.10, SD= .72); $t(11) = -3.33$, $p = .007$. On the Student Technology Use section, there was a statistically significant difference in the pre- survey scores (M= 3.08, SD = .62) and the post- survey scores of this section (M= 3.42, SD= .54); $t(5) = -2.79$, $p = .03$. There was a statistically significant difference in the pre- survey scores of the

STEM Instruction section of the T-STEM survey (M= 3.37, SD= .51) and the post- survey scores of this section of the T-STEM survey (M= 3.97, SD= .26); $t(5)= -3.03$, $p= .02$. There was statistically significant difference in the pre- survey scores of the 21st Century Learning Attitudes section of the T-STEM survey (M=4.30, SD= .31) and the post- survey scores of this section of the T-STEM survey (M= 4.83, SD= .20); $t(5)= -4.02$, $p= .01$. Finally, unlike the previous sections, there was no statistically significant difference between the pre- survey scores of the STEM Career Awareness section of the T-STEM survey (M=4.16, SD= .54) and the post- survey scores of this section of the T-STEM survey (M= 4.70, SD= .36); $t(5)= -2.07$, $p= .09$. Though scores between the pre- and post- survey did not show a statistically significant difference on all six sections, teacher confidence on Personal Teaching Efficacy and Beliefs, STEM Instruction, 21^{st} Century Learning Attitudes, and STEM Career Awareness did show a modest increase between the pre- and post- survey scores (Hedges' $g= .85, 1.48, 2.03, 1.17$) respectively.

Table 6 shows pre- and post- survey scores on the T-STEM survey by section. Column 1 illustrates the section of the T-STEM survey. Column 2 presents the pre- survey scores, and Column 3 represents the post- survey scores. Column 4 displays the difference in the mean between the pre- and post- survey scores. Column 5 represents the effect sizes.

Table 6

T-STEM Pre- and Post- Survey Scores by Survey Section

Survey Section	Pre- survey Scores	Post- survey Scores	Difference in Mean	Effect Sizes
Personal Teaching Efficacy and Beliefs	3.74	4.30	-.56	.85
Teaching Outcome Expectancy Beliefs	3.86	4.10	-.24	.35
Student Technology Use	3.08	3.42	-.34	.58
STEM Instruction	3.37	3.97	-.60	1.48
21^{st} Century Learning Attitudes	4.30	4.83	-.53	2.03
STEM Career Awareness	4.16	4.70	-.54	1.17

n=6

Participants completed the ECS Unit 4 Assessment and the Robotics and Engineering Design Assessment to uncover content knowledge. Using SPSS, a dependent means *t*-test was conducted to compare the pre- assessment scores and the post- assessment scores after teachers attended three workshops. Hedges' *g* was calculated using the mean of the pre-assessment minus the mean of the post- assessment then divided by the pooled weighted standard deviation.

There was a statistically significant difference in the scores on the ECS pre- assessment (M= 9.08, SD= 4.99) and the scores on the ECS post- assessment (M= 12.50, SD= 5.00); $t(5)= -2.89$, $p= .034$. There was a statistically significant difference in the scores for the Robotics and Engineering pre-assessment (M= 11.00, SD= .89) and the scores for the Robotics and Engineering post- assessment (M= 14.16, SD= 2.31); $t(5)= -3.23$, $p= 0.23$. Teacher performance on both assessments showed an increase between the pre- and post- assessment scores (Hedges' $g= .68, 1.81$). Table 7 displays the pre- and post- test scores by assessments for the participants. Column 1 shows the assessment name. Column 2 and 3 show the pre- and post- scores. Column 4 displays the difference in the mean between the pre- and post- assessment scores. Column 5 represents the effect sizes.

Table 7

Pre- and Post- Scores by Assessment

Assessment	Pre- Scores All Teachers (*n*= 6)	Post- Scores All Teachers (*n*= 6)	Difference in Mean	Effect Sizes
ECS Unit 4	9.08	12.50	-3.41	.68
Robotics and Engineering Design	11.00	14.16	-3.16	1.81

Research Question 2

In research question 2, I focused on uncovering the teachers' current competence and confidence level of integrated robotics, coding, and engineering design into early childhood curriculum. The scores from the initial ECS Unit 4 Assessment and Robotics and Engineering Design Assessment provided the current competence levels. The scores from the initial T-STEM Survey provided the current confidence levels. Although not all participants were interviewed, responses from the participants who were interviewed provided insight into the initial competence and confidence levels as well.

Competence

Teachers completed the ECS Unit 4 Assessment and the Robotics and Engineering Design Assessment prior to attending the first workshop to benchmark their knowledge level in coding, robotics, and engineering design. Table 8 shows the initial competence scores for each teacher by assessment. Column 1 shows the teacher's number. Column 2 displays the pre- score on the ECS Unit 4 Assessment. Column 3 represents the pre- score on the Robotics and Engineering Design Assessment. Worth noting are the high and low scores on the initial assessments. The high score for the ECS Unit 4 Assessment was 17.5 out of 21, and the low score was 4.5 out of 21. The high score for the Robotics and Engineering Design Assessment was 12 out of 21, and the low score was 10 out of 21.

Table 8

Initial Competence Scores on Assessment by Teacher

Teacher	ECS Pre- Score (out of 21)	Robotics and Engineering Pre-Score (out of 21)
Teacher A	6.00	12

Table 8 Continued

Teacher	ECS Pre- Score (out of 21)	Robotics and Engineering Pre-Score (out of 21)
Teacher B	11.50	10
Teacher C	5.00	10
Teacher D	17.50	11
Teacher E	4.50	11
Teacher F	10.00	12

Confidence

Teachers completed the T-STEM Survey prior to attending the first workshop to gauge their initial confidence level. Table 9 displays the percent of teachers who were generally positive in the six areas of the survey. Column 1 lists the survey section, and column 2 represents the percent of teachers who agreed or strongly agreed in each section of the survey. Student Technology Use had the smallest percentage of teachers who agreed or strongly agreed at 16.6%. 21st Century Learning Attitudes had the greatest percentage of 100% with all teachers responding agree or strongly agree.

Table 9

Percent of Teachers Generally Positive on Initial T-STEM Survey

Survey Section	Percent who "Agree/ Strongly Agree" (n= 6)
Personal Teaching Efficacy and Beliefs	50.0%
Teaching Outcome Expectancy Beliefs	50.0%
Student Technology Use	16.6%
STEM Instruction	33.3%
21st Century Learning Attitudes	100.0%
STEM Career Awareness	83.3%

Interviews

Interviews were used to gain insight into individuals' competence and confidence levels from their point of view. Four teachers participated in individual interviews in their classrooms prior to attending the first workshop. I asked five probing questions using a semi-structured interview protocol. Interview questions are included in Appendix E. From the responses of the initial interviews, four main themes emerged. These themes that emerged included: (a) perceptions of integrating computer science into current curriculum, (b) knowledge and experience with computer science, (c) perceptions of computer science professional development, and (d) perceptions of how their administration values integrating computer science.

Teachers' perceptions of integrating computer science into current curriculum. When discussing integrating computer science into current curriculum, teachers focused on inadequate time, the challenges and being overwhelmed, how to integrate concepts, and the role of integrating technology. All four interviewees reported that the lack of time available is the greatest obstacle to integrating computer science into their current curriculum. Lack of time was mentioned eight times. Teacher C noted, "I can only do so much with the time I have." Teacher D said, "There's no time anymore." The lack of time added to three teachers feeling that integrating computer science was challenging. For example, Teachers B and D responded, "I have a hard time wrapping my head around it," and "I'm just going to have to work really hard because this is so uncomfortable to me" respectively. Two teachers perceived integrating computer science as overwhelming, and Teacher B noted, "I feel overwhelmed about what the appropriate level is." Conversely, Teacher C mentioned being overwhelmed in a positive sense because he was already using robots during language arts and mathematics time. He indicated that, "it's overwhelming at times because I can't believe I am already doing this." Wondering how to integrate computer science was conveyed five times. Teacher C indicated she needed help to organize the content into a way she could plug into upcoming lessons. Teacher D was unsure how to give students exposure to concepts and ideas. Teacher C pointed out that, "I don't understand how to continually do it throughout the year." Finally, teachers discussed integrating technology as part of integrating computer science into current curriculum. Three teachers mentioned integrating technology in the classroom as a tool, while Teacher D discussed how to integrate technology "not just as consumption but using it to produce things." Teacher C was concerned that technology would be integrated as "expensive worksheets."

Teachers' knowledge and experience with computer science. Teacher's knowledge and experience with computer science was minimal. Teachers noted that they did not have formal experience with coding and/or never took a formal coding class. To differentiate a formal coding class from Code.org workshops, teachers consistently viewed a formal coding class as a high school or university level course. Teachers also reported seven times that they learned computer science concepts on their own. "I am trying to play around with and figure out stuff before I pull it into the classroom," said Teacher C. Teacher D noted, "I just picked it up on my own." Teacher D mentioned that she "would go practice and play, basically lots of trial and error." Even though the teachers had minimal or no experience with computer science, all four teachers noted the need to learn computer science concepts. Teacher D said, "I thought oh my gosh I need a class!" when her campus administrator encouraged faculty to integrate coding into their classrooms. Teacher D recognized her deficiency and said, "This is something I need to know."

Teachers' perceptions of computer science professional development. Teachers focused on the need for professional development, difficulties finding opportunities specifically geared towards early childhood grades, and connecting with other teachers as they discussed computer science professional development. Teachers recognized the need for professional development in computer science. The need was reported seven times during the interviews. Improving instructional practice was the most reported need. For example, Teacher C said she wanted to "do my job in a better way." Teacher D said she would participate in "anything that can help me improve." Teacher D indicated that she specifically wanted "to know how do I get these things scaled down for little kids." Teacher C had a different perspective since he had been integrating computer science concepts in his classroom. His need for computer science professional development centered around "reinforcing that I am on the right path" and "to enhance what I'm doing." Even though teachers have a need for computer science professional development, they were experiencing challenges finding opportunities specifically for early childhood. "Everything seems to start at 5th grade" and "for early childhood, it's just not available" were responses from Teachers B and F. Teacher D pointed out that not only finding computer science professional development for early childhood but also "finding good professional development" is a challenge. Four teachers reported the importance of connecting with other teachers during computer science professional development for early childhood. Teacher C mentioned being "engaged with like-minded teachers" was important during computer science workshops. Teachers B and D indicated that computer science professional development was a chance for them to "build a network" and "connect with other people." Trading information about computer science with other early childhood teachers was important to all four teachers.

Teachers' perceptions of how administrators value integrating computer science. All four teachers mentioned that their administrators are supportive as it relates to integrating computer science concepts into current curriculum. Teacher B noted that the teachers on her campus "have a lot of freedom to explore." Teacher D explained that her administration encourages teachers to try these new technologies. She further explained that her administration purchased 3-D printers to use in first grade English Language Arts classes. Similar to Teacher D's response, Teacher B explained that her administrators also purchase technology for the teachers to try.

None of the four teachers noted that there were specific district or campus initiatives regarding integrating computer science concepts. However, Teacher F stated her “new superintendent is pushing for technology integration through coding and robotics”. Teacher B noted, “They don’t have a lot of initiatives or pressures because we are always trying things and we’re encouraged.” She further mentioned, “There is an expectation, but not an ultimatum.” Teacher C explained that there is not a campus initiative but his “classroom is the guinea pig” and that his administrators likes to pilot new technologies with his students.

Teacher C discussed an interesting approach that his administrator is taking to integrate computer science concepts into current curriculum. The school where Teacher C works has been attempting to increase parental involvement because the school has noticed a decrease in parent involvement over the past few years. Teacher C talked about how his school uses Code.org lessons at home as a way to encourage parental involvement. Teacher C continued by stating, “Kids and parents can do it at home” and “that it has helped with parents helping with homework.”

Research Question 3

Responses during the final interviews along with informal conversations and observations during workshops and campus visits addressed how the teachers responded to focused professional development. The purpose of these interactions was to uncover any course of action teachers intended to take or may have taken after attending the workshops as well as their overall mindset while participating in the workshops. In addition to the informal conversations, I conducted two final interviews and observed two teachers leading a lesson inspired by the workshops.

Informal Conversations

During the workshops, I had informal conversations with teachers about their overall feelings as they participated in the workshops. From these conversations, three themes emerged: teachers as students, learning with peers, and resources.

Teachers as students. Each workshop consisted of six standard components: content presentation, hands-on activities, review/ sharing of resources, cross-curricular connections, sharing experiences of the day, and exit tickets. Consistently across all three workshops, the teachers requested additional time to network and collaboratively process what they were learning. While discussion time was built into all three workshops at the conclusion of each activity, this extra requested time emerged organically as new or challenging material was presented. The desire to engage in additional dialogue and to learn from each other was the most frequent request and action throughout the workshops. This desire was also reflected in the positive responses to having a balance between collaborative and independent activities. Teacher C felt that this format "helped to model how I can set up these types of lessons for my own students." Teacher D noted that, "I was not sure how to approach this with my students, but I think I have better ideas since we are acting as students right now." Teacher B expressed that, "the students can work on their own but can become the teacher if the group needs help. I like how the student and group becomes empowered and not just looking to me for help."

I solicited how teachers were feeling overall throughout the workshops. I spoke with teachers as they were participating in a group activity and by themselves. During the coding workshop while teachers were exploring programming such as Scratch® and ScratchJr®, being uncomfortable surfaced as the prominent reaction. Teacher E commented, "I am out of my comfort zone. Guess this is how my students feel!" Teacher A agreed and said, "I need to let my students be uncomfortable more. I feel like I am learning a ton."

Learning with peers. As I spoke with teachers during workshops, I discovered that teachers had limited opportunities to explore and try computer science concepts with other PreK-2nd grade teachers. All teachers noted that they felt these workshops were more valuable because they were learning with their peers who possessed similar classroom and learner needs. Teacher E revealed, "I usually just sit in other sessions because I am one of a few Prek teachers." Teacher C expressed, "Thank you for bringing us all together! It's nice to be with people who have the same classroom needs as me." Teacher B mentioned that working alongside peers who taught similar grades helped with understanding the concepts. Teacher F expressed, "I have no idea what I am doing right now, but that's okay because I am not alone." Teacher C added, "I agree. This is the first time I have seen some of this. I am nervous about learning all this. The other teachers here are so supportive. I don't feel like I am being judged."

Resources. Teachers need access to and an understanding of grade level resources. Resources provided to participants during this study were easy to read and use such as Engineering is Elementary Engineering Learning Trajectories to show what design thinking looks like at various ages and Computer Science Teachers Association's Computational Thinking Vocabulary and Progression Chart. All resources including an online bibliography of trade books and resource books were placed online for access after the study. As I engaged with teachers during the workshops, teachers revealed that while they had received resources related to computer science concepts at previous workshops, the resources were not explained or just handed to them in bulk fashion. The timing and type of resources was important to all the teachers throughout the series. Teacher A said, "thank you for not just handing me something to read." Teacher C mentioned that taking time to explain and relate the resources back to the early childhood classroom will help her understand and use them. Teacher F echoed that response. Teacher D appreciated that the resources were "what I needed to understand a very foreign topic." Teacher E stated that, "I will actually use these. I don't see them just sitting on a shelf or in a drawer as the many other things I get at PD."

Classroom Observations

To determine how teachers were using concepts learned in the workshops, I observed in two classrooms. Teacher C taught kindergarten and Teacher A taught K-5th grade STEM. Teacher C was leading a lesson about things in the sky during my visit. This lesson was the second one in the unit. As an introduction to the lesson, the class went on a STEM walk outside to observe things in the sky during the afternoon. As the students were walking, Teacher C would ask, "What do you notice?" As students would answer, he would recognize what they noticed without giving confirmation. Before the walk ended, Teacher C asked students, "Would you see the same things in the sky at night?" Students were sketching their observations in their science notebooks as they walked. When students returned to the classroom, they gathered in the group lesson area in the front of the classroom. I noticed there was an oversized sun and moon on the wall. Teacher C spent approximately 7 minutes reviewing what students had observed. He spent about the same amount of time discussing what things students may see in the night sky. Teacher C showed a short video that was from the study resource list. Finally, Teacher C gave students a preview of their final project for the unit.

Teacher C incorporated components from the workshops into his instruction and planning of a culminating project. As the students were discussing what they saw in the sky, Teacher C incorporated if-then statements, such as "if the clouds are dark, then". He used resources such as the video source to introduce the content. Students will use information in their science notebook to build a story that includes specific science content such as things in the sky. Once students have drafted their story, they will use a storyboard format to plan out their story to be created in ScratchJr®. Teacher C will direct teach how to use ScratchJr® in a separate time block. I also noticed he had a box of the ScratchJr® Coding Cards as one of the classroom stations. Teacher C mentioned that he wanted students to also explore on their own as he did during the workshops.

I observed Teacher A's kindergarten lesson on air and a walk through of a 4th grade STEM project. Kindergarten students built a house for the *Three Little Pigs* that would endure the Wolf's blow. This lesson was the third lesson in the unit. Prior to this lesson, Teacher A introduced students to the fairy tale of the Thr*ee Little Pigs* and introduced air and force. Students also had the opportunity to sketch and build a house out of items such as straws, clay, and popsicle sticks. Teacher A began this lesson by reviewing the fairy tale of the *Three Little Pigs*, referencing the book as she talked. She then reviewed what air is and that air can apply force to an object or push an object. Teacher A then asked the students to get the houses they built. Students gathered in a circle with their houses as Teacher A set up a fan. She asked the students, "How were the piggies thinking like engineers?" One student explained that they were trying to solve a problem. Another one added that the piggies were building. Then, one by one, students would put their house in front of the fan. Teacher A would start the fan on the low setting and then work up to the high setting. After all the students had participated, she asked them to redesign their houses so they would withstand the high setting on the fan. Students had access to the same materials as the original build. Students spent about 12 minutes adding or changing their original design. As students were redesigning their house, Teacher A walked around and interacted with the students. She would say, "We are thinking like engineers by trying something else." She would ask students, "Why are you using that material?" One student answered, "Straws are stronger." Another said, "I think the big sticks are stronger." Once the students were done, they had the opportunity to test the redesign.

After observing the kindergarten classroom, Teacher A shared with me the 4th grade student project focused on building a structure that could withstand a natural disaster with minimal damage. Students were able to choose from flood, extreme wind, or earthquake. Alongside the building was a sketch that also showed the angles of the connecting walls throughout the structure. Teacher A explained that the project was a demonstration of learning for science lessons focused on extreme weather and mathematics lessons focused on angles. I did not have the opportunity to observe students in the classroom working on this project. Students were provided a list of constraints such as the maximum height and width of structures, the type of angles, and the materials available for their structure. Students were mid-way through completing their project. Teacher A noted that she would simulate a flood, wind, or earthquake to test the structures.

During the kindergarten activity and as demonstrated in the 4th grade project, Teacher A utilized components from the workshops. She integrated a literacy connection as well as the engineering design process, including engineering notebooks for both grade levels. Teacher A used the Engineering is Elementary Engineering Learning Trajectories for developmentally appropriate design thinking activities. For example, kindergarten students had minimal constraints and a simpler version of the engineering design process whereas the 4th grade students had more constraints and used an engineering design process with more complex steps. In addition, the 4th grade students applied more complex science and mathematics concepts. For both grade levels, Teacher A encouraged design thinking and required the students to think in a logical sequence while building their structures. Students demonstrated spatial thinking skills as they worked together to build and strengthen their structures with various materials. Finally, Teacher A infused information about STEM careers by noting throughout the process that students at both grade levels were thinking and working like engineers.

Final Interviews

I conducted two final interviews with a PreK-2 teacher and a PreK-5 teacher. From their responses, two themes arose: actions inspired by the workshops and overall mindset after the workshops. Both teachers had minimal engagement with computer science concepts prior to attending the workshops.

Actions inspired by workshops. I asked teachers in the final interview if they had implemented any strategies learned from the workshops into their classroom practices. Teacher D and A both responded with items they had implemented, were planning to implement, or wanted to implement in their classrooms. Teacher A began by saying she felt she now had the resources needed for plugged and unplugged activities. Teacher D felt that she was going to be able to incorporate more hands-on instruction for engineering activities. Teacher D noted that she had started planning a club for "little ones." From the workshops, she now "had some ideas and resources to make it a real cool and useful club." Teacher D mentioned that she had ordered resources that were introduced during the workshops. She was going to implement the resources focused on NGSS to plan more design thinking activities. Teacher D explained that she purchased a storybook that was used during the workshop and was able to build a unit around the storybook. She incorporated literacy and the science concepts of friction and gravity into one unit. She was able to showcase her student projects in the school library. She also incorporated

STEM careers into the lesson noting that the students were acting like auto designers. Teacher D used the storybook as something different than the *Three Little Pigs*. Teacher A plans on incorporating more computational thinking activities, but she "needs to think about how." Both Teachers D and F were using F.A.I.L. (First Attempt in Learning) in their classrooms as reinforcement and motivation if students verbalized they "can't do it or it doesn't work." Both felt the concept of F.A.I.L. provided students a visual on the importance of trying and not giving up on challenging tasks and that "we rarely get it on the first try."

Overall mindset. Through responses during the final interview, I was able to uncover the teachers' overall mindset about the workshops. Both teachers exhibited a positive mindset about the workshops. Teacher D expressed that she now understood that "anyone can do computer science and it's not just limited to a certain age. It's something that's doable across all ages." She added that she was "very glad to have had the opportunity to participate. I felt the workshops were just what I needed to build confidence." Teacher A noted that "it was great to have a cohort defined. I could really bounce ideas off everyone. Even though some parts were super new and complicated and new for me, the workshops were really helpful." Both teachers expressed a desire to participate in more workshops in the future to continue their learning.

Research Question 4

In research question 4, I examined how the professional development sessions affected the teachers. Informal conversations during workshops and responses from final interviews helped bring to light the impact the workshops had on teachers personally and professionally.

Informal Conversations

During the workshops, I had informal conversations with teachers about their overall feelings as they participated in the workshops. From these conversations, two themes emerged: impact on confidence and growing personal network.

Impact on confidence. As the workshops progressed, the teachers' confidence levels increased. By the final workshop, teachers did not appear to be as timid while participating in activities and discussions. Teacher F expressed that the resources obtained during the workshops helped her to feel more confident. She also expressed that she was becoming more comfortable with trial and error and "realized it was okay. I feel like I am not afraid to try now." Teacher D noted that, "the more people I meet and the more great resources I get, I feel I am getting better at this." Teacher E celebrated by saying, "I can do this!" while Teacher B echoed, "yes we can!" Though Teacher C had experience with integrating computer science concepts into his kindergarten class, he also reflected an increased confidence from the workshops. "I feel good, I just feel good."

Growing personal network. Growing personal network was a theme that emerged frequently during informal conversations. Every participating teacher identified one or more peers they could add to their personal network for support, resources, and ideas. Teacher A noted that, "having access to people in my shoes is so helpful." Teacher B mentioned that "I know exactly who I am going to reach out to for whatever I need." Teacher C expressed that he did not have to continue to rely on peers on his campus. He continued by saying, "I have given my email out to everyone here!"

Several teachers noted that growing their personal network would assist with designing more cross curricular lessons. Teacher F felt that, "sometimes our planning time is really spent looking at data, discussing campus initiatives, or whatever. It is hard to just design lessons. With the people I have met here, I can lean on others who are stronger in other subjects but on the same path." Teacher E agreed and added that, "I see new ways to plan with my teammates who are stronger in math or ELA. They don't just have to plan an ELA lesson. Maybe the sequence lesson includes coding or ScratchJr or something."

Final Interviews

Following the completion of the three workshops, I conducted final interviews. From the final interviews, two themes emerged: impact on confidence and new relationships.

Impact on confidence. All interviewees echoed the positive impact the workshops had on their confidence levels. "I feel better and better the more I learn!" noted Teacher C. He added that the materials helped him develop greater confidence when working with young children: "These resources are cool and help me create better activities for my students. I would not have even thought of or tried some of things." Teacher D commented that "this is the first time I don't feel completely lost. I know my students will see that." Teacher A noted with enthusiasm that her younger students "will be just as excited as the older students" when she presents lessons because "I feel like I know what I am doing." Teacher A went on to express that she felt her largest area of growth from attending the workshops was her increased confidence. "It feels crazy to stand in front of my young students, and think to myself, 'yeah, I got this!'" I noticed that when the interviewees responded to questions during the final interview, each one had a more positive and confident tone than when responding to questions during the initial interview. Confidence could be seen and felt in their demeanor as well as in their responses.

New relationships. Similar to confidence, all interviewees echoed the positive impact participating in workshops had on building new relationships. Teacher C explained that he had been communicating with other participating teachers since the first workshop. "I have been able to send an email looking for help and everyone is ready to jump right in. I think it's because we're all in the same boat." He further explained that, "I would not have been able to meet any of these teachers if it was not for the workshops." Teacher A was excited to express that she has "a new friend in and out of work." "We just clicked!" she exclaimed. "I love that we can talk shop or whatever."

Research Question 5

I focused on revealing the overall growth in confidence and competence levels of the teachers. To gauge competence, participants completed the ECS Unit 4 Unit Assessment, the Robotics and Engineering Design Assessment, and the T-STEM Survey. Participants completed the pre- assessments and survey before attending the first workshop. I used these scores as the participants' baseline. Participants completed the assessments and survey again after attending the final workshop.

ECS Unit 4 Assessment Results

Participants completed the ECS Unit 4 Assessment prior to attending the first workshop. After instruction on fundamental concepts such as what is an algorithm and how to read and write simple code including loops, participants completed the assessment again after attending the final workshop. There was a statistically significant difference between the scores on the ECS pre- assessment (M= 9.08, SD= 4.99) and the scores on the ECS post- assessment (M= 12.50, SD= 5.00); $t(5)$= -2.89, p= .034. Hedges' g= .68. All six teachers demonstrated increases in score from the pre- to post- assessment. Teacher C showed the largest growth scoring 5 out of

21 on the pre- assessment and scoring 13.5 out of 21 on the post- assessment. Teacher D showed the least increase in scores 17.50 out of 21 on the pre-assessment and scoring 19 out of 21 on the post- assessment. Growth on ECS unit 4 assessment by teacher is shown in Figure 2.

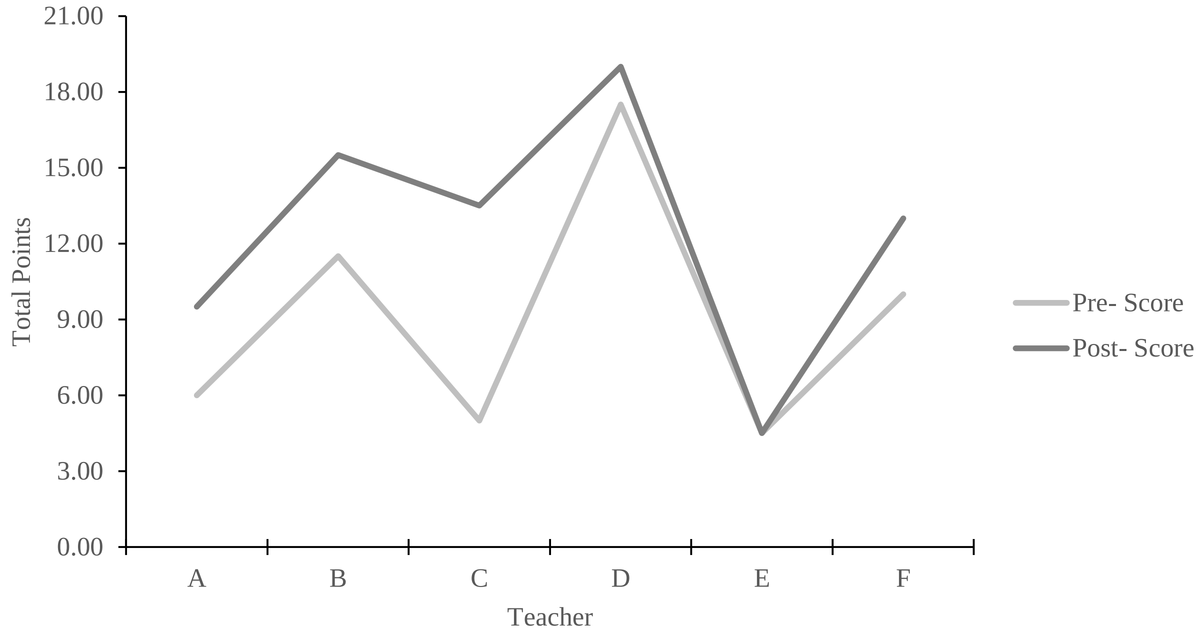

Figure 2. Growth on ECS unit 4 assessment by teacher.

Robotics and Engineering Design Assessment Results

Participants completed the Robotics and Engineering Design Assessment prior to attending the first workshop. After instruction on fundamental concepts such as what are the different parts and functions of a robot, what are degrees of freedom, and explaining and comparing the various layout of the engineering design process, participants completed the assessment again after attending the final workshop. There was a statistically significant difference in the scores for the Robotics and Engineering pre-assessment (M= 11.00, SD= .89) and the scores for the Robotics and Engineering post- assessment (M= 14.16, SD= 2.31); $t(5)= -3.23$, $p= 0.23$. Teacher performance on both assessments showed large gains between the pre- and post- assessment scores (Hedges' $g= .68, 1.80$). Growth on the Robotics and Engineering Design Assessment by teacher is displayed in Figure 3. Teacher B had the greatest growth, answering 7 more questions correctly on the post- assessment. Teachers E and F showed the least growth, answering one more question correctly on the post- assessment. Responses to questions relating to the design process, parts of a robot, and manipulators had the most change in the number of participants answering correctly between the pre- and post- assessment increasing at 57.14%, 42.85%, and 42.89% respectively.

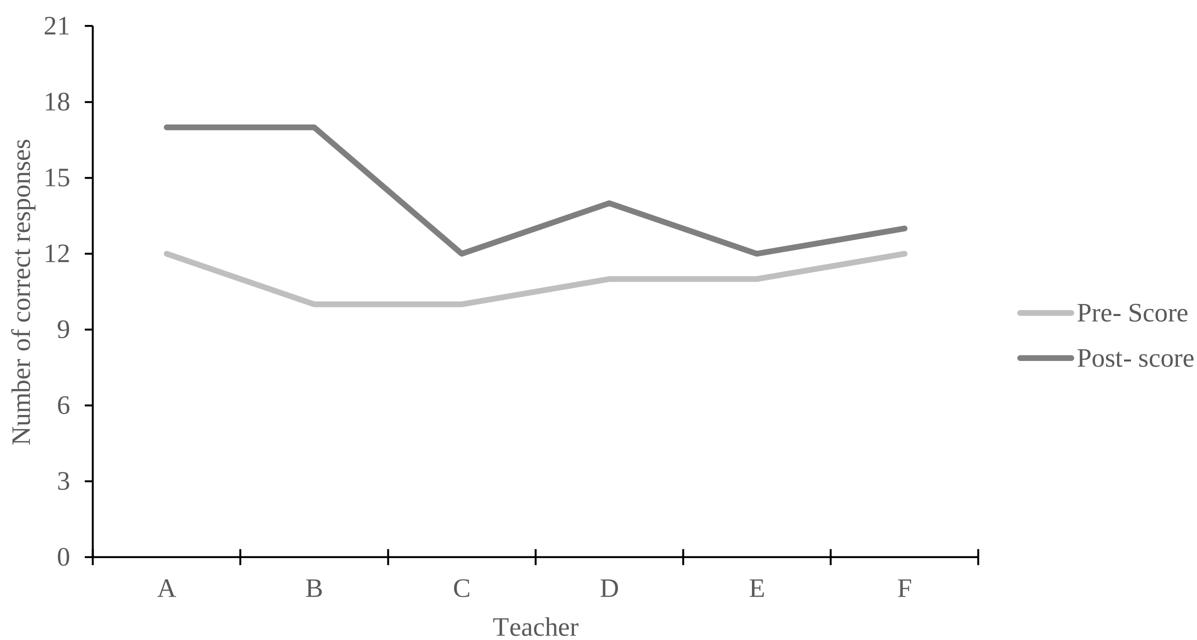

Figure 3. Change in correct responses on robotics and engineering design assessment by teacher.

T-STEM Survey Results

Overall growth of teachers on the T-STEM survey is shown in Figure 4.

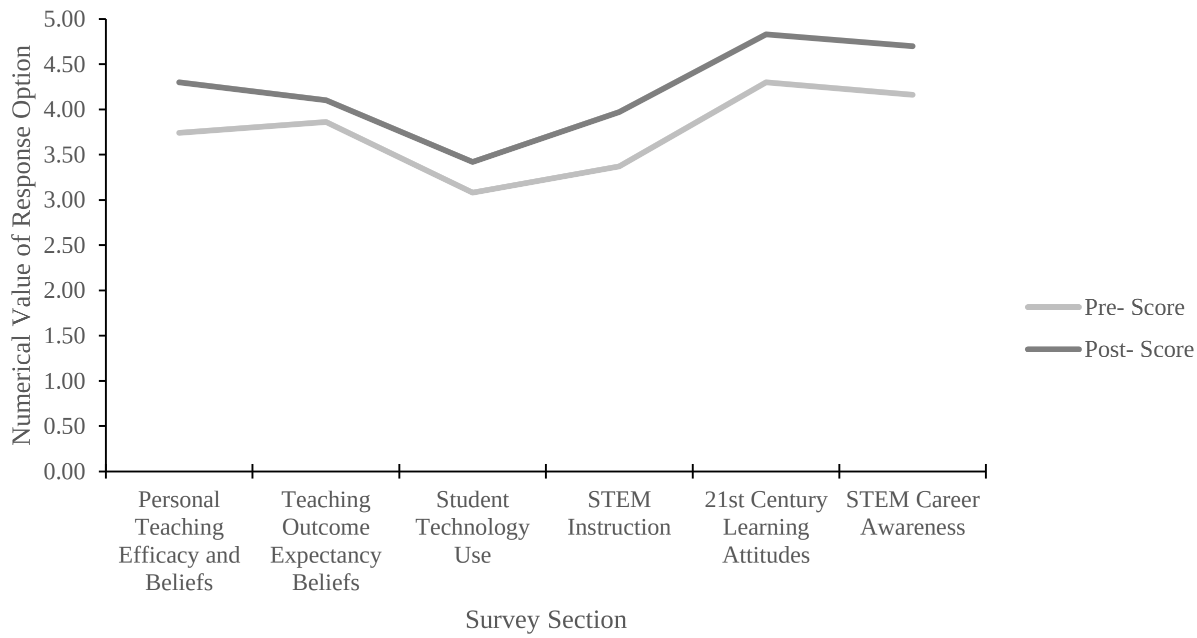

Figure 4. Overall growth of teachers on T-STEM survey.

On the Personal Teaching Efficacy and Beliefs section, Teacher F had the greatest amount of growth with a difference of -1.73 between the pre- and post- survey scores. Teacher B had the least amount of growth with no change between the pre- and post- survey scores. Teacher F showed the greatest amount of growth with a difference of -0.50 between the pre- and post- survey scores on the Teaching Outcome Expectancy Beliefs section. Teacher B showed the least amount of growth with no change between the pre- and post- survey scores. On the Student Technology Use section, Teacher A showed the greatest gain with a difference of -0.75 between the pre- and post- survey scores, and Teacher E showed no gain with by scoring the same between the pre- and post- survey scores on this section. Teacher A showed the greatest amount of change with a difference of -1.29 between the pre- and post- survey scores on the STEM Instruction section. Teachers C and E demonstrated the least amount of growth with a difference of -0.07 respectively between the pre- and post- survey scores on this section. On the 21st Century Learning Attitudes, Teacher E showed the greatest growth with a difference of -1.00 between the pre- and post- survey scores. Teacher F showed the least amount of growth with a difference of -0.09. Finally, on the STEM Career Awareness section, Teacher C showed the most growth with a difference of -1.75 on the pre- and post- survey scores. Teacher E showed no growth on this section. Overall, Teacher A showed the greatest amount of growth with a difference of -3.85 between the pre- and post- survey scores. Teacher E showed the least amount of growth overall with a difference of -1.61 between the pre- and post- survey scores.

Research Question 6

Informal conversations and semi-structured interviews were used to answer research question 6 that focused on the teachers' overall perceptions about the effectiveness of professional development.

Informal Conversations

During the workshops, I initiated informal conversations with teachers about their overall perceptions about the effectiveness of professional development. From these conversations, two themes emerged: workshop format and participant centric.

Workshop format. All participants mentioned how the workshop format contributed to the effectiveness of professional development. Teacher A pointed out that the experience "is different. It's not a one-time thing." Teacher E added, "We are building on what we learn each week." Teacher D felt that the format was effective because she "had a chance to learn, try it in my classroom, and then come back. I never felt like the learning was over." Teacher B added that "other workshops don't seem to be as effective because the learning in crammed and fast and then we leave." The group agreed when Teacher C said that, "PD can be too much sometimes. Too much content, too many people. I like how this is the exact opposite. A small group getting small bits that grow each time. That to me is effective." Teacher F focused on the materials used and presented during the workshops as a way to demonstrate effectiveness. She said, "So many times you go to a PD and I can't afford anything to take it back to my classroom like the tech or the things are not easy to get. I just tune it out at that point." Teacher A agreed that varied activities and resources that were "attainable and realistic" contributing to effective professional development.

Participant centric. Five teachers expressed that being audience centric contributed to effective professional development. Teacher C expressed that effective professional development "focused on me. What I need, when I need it, or what I need from it rather than sticking to a set agenda." Teacher F added, "That has been one of the most effective parts for me. We weren't going super fast to get through everything. We have time to learn and do and talk to each other at the group's pace, not the presenter." Teacher E introduced how important choice was to effective professional development. "I may need something more or less than the person next to me. I like how we have had choice during these workshops. It makes the learning much more meaningful to me." Teacher A continued stating, "It is about us and not the presenter." Teacher D noted, "No matter how hard this is, I am learning so much because I feel supported by you and the other teachers. Not just trying to get in the workshops for your study."

Final Interviews

I conducted final interviews following the completion of the three workshops. From the final interviews, two themes emerged: learning progression and useful content.

Learning progression. All three teachers interviewed noted that the progression of learning from workshop to workshop contributed to the effectiveness of the learning during and between the professional development days. Teacher C stated, "Even though each day could stand on its own, I would not have the same understanding of how to use this stuff." Teacher F responded, "It's similar to how we spiral content with our students. Students have to relate and connect concepts for learning. I am no different when I learn." Teacher A said, "This is some of the most effective PD I have attended because everything built on each other. We had time to digest content and then add on. We were not packing as much content as we could in a typical 6-hour workshop."

Useful content. All three teachers interviewed responded that the content of the workshops was useful thus making the professional development effective. Teacher C expressed, "I can use the material in my classroom right away. I have the resources, the know-how, and support to hit go." Teacher D mentioned, "I sit through workshops that just aren't relevant or realistic. For me, effective PD means I can use what is presented without figuring out some obscure way to weave it into our curriculum." Teacher A responded, "The subject matter was foreign to me. The way it was presented in a useful and approachable way was so effective."

Interactions Between Research and Context

Context Impacts the Results

Beginning in June 2017, PMNS started rethinking what professional development meant to the institution. The Professional Development Manager, STEM Institute Coordinators, and I began by defining STEM leadership and drew comparisons and contrasts to current models of professional learning. We continued by mapping a teacher's journey through professional development, starting with why a teacher needs or wants to attend a workshop. Through several workdays and comparing professional development opportunities at similar institutions, we uncovered the need for opportunities in computer science at the elementary level. PMNS could leverage resources and educator expertise to design computer science learning opportunities for teachers and students. We could build on our mobile maker space, the Tinker Engineer Create Hack (TECH) Truck.

Operational issues. Operational issues did arise during the study. A change in Institute staff as well as changes to admission criteria for the 2017-2018 Institute caused some operational issues. Changes in staff caused a delay in receiving the Institute participant email list from the Professional Development Manager. A new Professional Development Manager was hired during the spring after the position was vacant for three months. In early summer, two new Institute Coordinators were hired. Once Institute staff was in place, they began to review incoming participants. Admission criteria was adjusted due to lower than expected enrollment. The Institute roster was not finalized until late June. These issues delayed study recruitment.

Operational issues arose regarding the research site. Professional development space for PMNS is located at the Fair Park campus. During the month of August, Fair Park experienced unscheduled and unforeseen maintenance to the air conditioner and the elevator that closed the building to the public. Unfortunately, I was unable to relocate workshops to PMNS Victory Park location due to unavailable workshop space. This delayed holding workshops during the month of August. From September 29 through October 21, the State Fair of Texas takes place in Fair Park. The professional development space was inaccessible during this time-frame. The final workshop was moved to PMNS Victory Park. Since there is not a dedicated professional learning space at Victory Park, the final workshop was held in two conference rooms.

Stakeholder participation and reaction. Stakeholders attended two of the three workshops. The Professional Development Manager and the secondary STEM Institute Coordinator audited the Design Thinking and Engineering Design workshop. They were facilitating a workshop at the same time, so were able to participate in a come and go manner. The secondary STEM Institute Coordinator wanted to determine how the information was presented for younger students because she did not have experience with younger students but facilitates professional development for K-8 teachers (M. Morgan, personal communication, September 9, 2017). After her interactions with the workshop, the Coordinator incorporated two of the activities, *A Place in the Shade* (Baumann, n.d.) and *Marble Run* (Code.org, n.d.), into the STEM workshop later in the month. She also provided resources from the study workshop to participants in the STEM workshop.

The Professional Development Manager not only participated in the Computational Thinking and Coding workshop, but also facilitated a Raspberry Pi® station in the afternoon. Even though the study participants did not have working knowledge of Raspberry Pi® and Python™, the programming language for Raspberry Pi®, she felt the workshop was a “safe place to learn together” (V. Warren, personal communication, September, 23, 2017). After the workshop, we met to discuss including the series of workshops in the 2018-2019 Institute (V.

Warren, personal communication, September 26, 2017). Like the STEM Coordinator, the Professional Development Manager planned to use the provided resources in upcoming workshops.

The Sr. Lead Educator at PMNS was enthusiastic after reviewing the resources I presented study participants during the workshops. The resources were a mixture of books, websites, and activities that focus on computer science concepts in early childhood. While she was thrilled with the how-to/ programming books, she was curious about the storybooks since she is trying to include a literacy component in school programs. With these resources, she believes that she now has the tools needed to begin incorporating concepts into existing school programs or the tools needed to design new ones (J. Liken, personal communication, December 12, 2017).

Research Impacts the Context

At the completion of each workshop, I would share observation notes, informal conversations, and workshop content and resources through email and face-to-face meetings with the Vice President (VP) of School and Community Engagement, the Professional Development Manager, and the Sr. Lead Educator. I have shared pre- and post- assessment and survey charts as well. The reactions were positive each time I shared results. The VP and Professional Development Manager seemed intrigued and curious. Through the qualitative data, we have baseline data about how teachers may want to engage with the Museum's professional development. We have started conversations about including the computer science workshops in future professional development offerings. The VP, Discovery Camp Manager, and I are having discussions about adapting one of our early childhood programs to include unplugged activities beginning in March 2018 (K. Gagne, personal communication, January 24, 2018; T. Lenling, personal communication, January 24, 2018). Finally, the Sr. Lead Educator and I are examining how to update or add programming for K-2 related to computer science concepts (J. Liken, personal communication, December 12, 2017). By openly sharing results of the study, the programs department at PMNS is actively considering ways to incorporate computer science concepts into learning experiences for teacher and students.

Suggestions for further study. After I shared results with stakeholders at the Museum, they provided suggestions for further study. The Professional Development Manager suggested that I follow up with teachers later in the spring semester and possibly next year to hear about or observe how they have continued to learn and integrate computer science concepts into the classroom (V. Warren, personal communication, January 2, 2018). She felt this would add depth to the qualitative data I had already collected by including a longer time period. She also added that following up with teachers would provide an opportunity to learn about the students' reactions to the learning experiences.

The Institute Coordinators were interested in expanding the number of workshops to possibly five over the course of a year and comparing the data. (A. Montgomery, personal communication, January 3, 2018; M. Morgan, personal communication, January 3, 2018). The Institute Coordinators were also interested in adding a Tier 2 with the same teachers and seeing how their learning progressed as they dove deeper into learning computer science concepts and had a longer timeframe to integrate concepts into the curriculum. I had envisioned this study as a multi-phase study, so the suggestions offered are possible.

In collaboration with the Director of Evaluation, I designed a multiyear evaluation of the Museum's educational programming. Year 1 consisted of assessing the needs and wants of teachers in educational programming offered by the Museum. Year 2 will encompass how schools are participating in field trips and how the community is engaging with educational programming at the Museum. Year 3 will focus on professional learning offered by the Museum. The VP suggested that during year 2 we include questions in our survey and interviews that solicit how the community values computer science education and what role the Museum can play (T. Lenling, personal communication, January 24, 2018). She also suggests that we begin to pilot computer science concepts in camps and school programs in order to gather feedback from students, teachers, and parents.

CHAPTER V

CONCLUSIONS

Implications for Practice

The Museum began reimaging its vision of professional development in April 2017. The results from this ROS coupled with the new vision will guide the development of future workshops. The Coordinators propose offering workshops in more of a series format rather than a single workshop with a single focus. For example, the Museum would offer a *Teacher as Researcher* program that focuses on cultivating the research skills and science communication skills of a small cohort of teachers. The program would be six-weeks long, and teachers would work alongside the Museum's paleontology department. This six-week duration supports prior research concerning sustained professional development. Capraro et al. (2016) found that 14 hours or more of professional development had "statistically-significant positive outcomes" (p. 183). Darling- Hammond and Richardson (2009) concurred and added that, "Programs offering between 30 and 100 hours spread out over 6-12 months" (p. 49) had the largest effect. Coursework would increase in complexity beginning with understanding the scientific method in a research setting to participating in fieldwork. Teachers participating in the program would be contributing to the active paleontology lab at the Museum. Teachers would have the opportunity to earn college credit and present their findings at a local conference. This approach to linking workshops is a new format for the Museum and our local peers.

The STEM Institute is a year-long series of workshops. The content of workshops, however, are not connected and do not offer a progression of learning. Moving forward, the Museum is designing workshops that are connected and offer an increasing complexity of content. In the 2018-2019 school year, the STEM Institute began offering workshops focused on computer science concepts. Based on the results of this ROS, the Institute Coordinators recognized the need for such workshops. Feedback from Institute teachers who participated in the study showed that the teachers want to continue learning computer science concepts. In addition, the content focus of the 2019-2020 Institute summer academy was engineering design. The summer academy was be a four-day intensive deep dive into the content focus, and the content focus will be woven throughout workshops during the year. This format and content differs from the format and content presented in prior Institute cohorts.

Lessons Learned

From conducting this ROS I have learned several important points. First, in order for classroom instruction to remain relevant and applicable, teachers need training and time to use and reflect on new practices. Teachers want to be current with their practice but become increasingly frustrated when they are not provided adequate training or the time to learn and use the latest and greatest initiative from administration. When they reach a certain level of frustration, teacher's competence and confidence fall, and they are no longer enthusiastic to continue trying the initiative. This is especially true when initiatives only last for one school year. Learning that teachers need more training and time to reflect on the learning illustrates Atiles et al. (2013) notion that teachers feel "unprepared" (p. 287).

Results from the research I conducted during this ROS suggest that focused professional development does have an effect on increasing a teacher's content knowledge. The results suggest that when teachers attend focused and sustained professional development, their knowledge of the specific content increases. Drawing from the constructivist and constructionist worldviews, the hands-on approach and opportunity to create while learning throughout the workshops contributed to the gains. In order to obtain a greater increase in post- assessment scores, teachers may need to attend additional workshops. Increasing the duration of professional development supports the notion of the positive effects of sustained professional development (Capraro et al., 2016; Darling-Hammond & Richardson, 2009; Nadelson et al., 2013). In addition, pre-assessment scores may be disaggregated by question content to uncover which specific subtopics within the content need to be addressed to increase competence.

Second, I learned that a teacher's personal learning network (PLN) is a factor in increasing competence and confidence. Building connections and relationships with peers supports social learning theory (Bandura, 1971; Creswell & Plano Clark, 2011). Components of the workshops such as time for networking and collaboration cultivated relationships with other teachers as well as provided a support network. These relationships extended beyond the workshops. Richardson and Mancabelli (2011) explained that relationships with our peers can "help us with our learning pursuits" (p. 21). As a teacher myself, my network of peers helps strengthen my practice by offering support, feedback, and resources. Helping teachers become connected via social media expands their personal learning network and broadens the resources and support needed to increase competence and confidence. While some see the personal learning network or community as a planning period, teachers who embrace this model find a group of peers that enhance each other's' instructional practice whether in person or online.

Third, I learned that teachers crave resources. Regardless of the years of service, access to appropriate and timely resources is invaluable to a teacher. Resources can range from trade books to current research and can come from a variety of sources, such as their PLN, the internet, or professional organizations. As Tank et al. (2013) noted, storybooks can help introduce content. Literacy connections were highlighted throughout the workshops. In addition to literacy connections, teachers were introduced to activities that were low in cost and could easily be transferred to the classroom. This practice echoed Cejka et al.'s (2006) notion of using "reusable and durable" (p. 711) items as resources to help ease the pressures of limited resources. Teachers are eager to access a variety and a wealth of tools in order to design excellent learning experiences for their students. Richardson and Mancabelli (2011) stated, "It's not about the next unit in the curriculum as much as it is about what we need to know when we need to know it" (p. 19). Resources that are useful help teachers become confident in utilizing an integrated curriculum. This in turns helps young learners connect multiple content areas and transfer skills across the curriculum.

Recommendations

Professional development is an essential method to furthering a teacher's practice. However, from this ROS, I recognize that a professional development workshop is only a part of what teachers need to increase competence and confidence. Figure 5 represents the professional development framework I recommend in order to increase a teacher's competence and confidence in integrating computer science concepts into early childhood. The professional development framework shows the overlapping relationship and demonstrates how the parts build upon each other to increase a teacher's competence and confidence. As a teacher engages in a sustained professional development experience, they need the opportunity to reflect and put into practice what they learned. During this period, a teacher needs appropriate and timely resources to enable them to continue to learn and use the new skill. Throughout a sustained professional development experience, a teacher builds a personal learning network that offers support, more resources, and feedback. These components when used concurrently lead to increased competence and confidence.

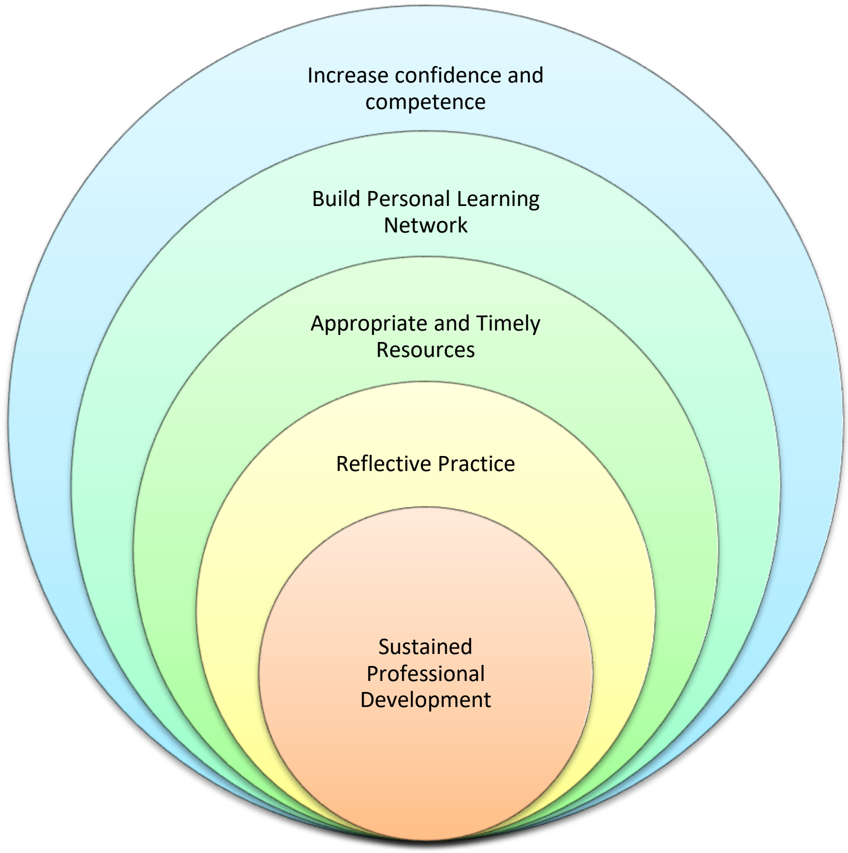

Figure 5. Professional development framework.

Reflective Practice

Teachers need time to reflect on new learning during sustained professional development. Teachers need the opportunity to think about their learning, put into practice, adjust as needed, and continue to learn. As part of sustained professional development, providing time for discussion with peers, trying lessons and ideas out in the classroom after each session, and receiving feedback may help teachers internalize the learning at a deeper level.

During professional development, teachers may not be familiar or comfortable with reflecting on practice. Modeling journaling, observing peers, setting goals based on feedback (from self or peer), and encouraging discussion may aid in making reflective practice purposeful and not an added task with no value. Journaling prompts can include (a) how are others using this; (b) what did I do well; (c) what do I still need; (d) what obstacles stand in my way and how can I overcome them. Assisting teachers with how to be reflective can enhance their practice.

For Teachers in Texas, using reflective practice helps them achieve a higher designation or performance level on the Texas Teacher Evaluation and Support System (T-TESS). T-TESS is a holistic approach to evaluating the effectiveness of teachers and their instructional practices (Texas Education Agency, 2020). Appraisers and teachers use the T-TESS Rubric to "provide evidence-based feedback" and "support efforts to improve instructional quality" (Texas Education Agency, 2020). The T-TESS Rubric dimension 4.2 (Goal Setting) focuses on teachers reflecting on practice. Coupling reflective practice with professional learning that alters practice moves a teacher higher on the scale.

Resources

Teachers need resources related to computer science content and integrating curriculum. For the resources to be helpful, they need to be appropriate and delivered at the right time. I recommend that resources be provided at "just in time support" that relates and applies to the content being discussed. Rather than providing all resources at the beginning of a professional development experience, resources should be provided at the time that they support, relate, and apply to the content being discussed at that time. The timing helps teachers review the resources and make connections to the content.

Providing resources through a variety of mediums can be valuable for teachers. When preparing for professional development experiences, I recommend selecting a collection of resources from various sources that are vetted and current. Sources such as the Massachusetts Institute of Technology (MIT) Media Lab provide research and articles focused on a variety of topics such as robotics and ScratchJr®. The Museum of Science in Boston provides resources for engineering design for prekindergarten through elementary students. Helping teachers navigate social media resources such as Twitter chats and popular feeds such as Kim Lane Clark (@askatechnogirl), CS for All Teachers (@CSforAllTchrs), or WeTeach_CS (@weteachcs) will not only provide a platform to gain resources and ask questions, but also a platform to build their personal learning network.

Personal Learning Network (PLN)

A teacher's personal learning network (PLN) can be a valuable system to increase competence and confidence. Richardson and Mancabelli (2011) define a PLN as "the rich set of connections each of us can make to people in both our online and offline worlds who can help us with our learning pursuits" (p. 21). These researchers (2011) continue by identifying why PLNs are effective and significant, expressing that PLNs provide a community where teachers can collaborate, communicate, offer support, share information, identify a mentor, and hold general conversation. Teachers can reach out to their PLN when needed to gain perspective and assistance. PLNs are not limited to the people on a campus but rather offer an opportunity for identifying others around the world that are passionate about the same topic.

For teachers in Texas, building a personal learning community for professional growth can help them achieve a higher designation or performance level on the T-TESS. The T-TESS Rubric dimension 4.3 (Professional Practices and Responsibilities) focuses on teachers enhancing the professional community. Seeking resources and opportunities for growth outside of the school walls in addition to enriching the professional community moves a teacher higher on the scale.

The need for students to have foundational knowledge in computer science concepts at an early age is growing. For students to be successful, teachers need to have the understanding and knowledge base to design experiences that cultivate these skills. Providing focused, sustained professional learning encompassing reflective practice, appropriate and timely resources, and building a PLN will create competent and confident practitioners.

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APPENDIX A

WORKSHOP CONTENT OVERVIEW

Design thinking and Engineering Design Workshop

- What is engineering?
- What is design?
- Introduce Engineering Design Process (EDP)
    - 3 steps of Vex EDP
    - What does EDP look like in each grade (EiE trajectories, NGSS progressions)
- The role of failing
    - F.A.I.L.
    - Fail vs. failure
- Design challenge
    - Picnic exercise
    - Share
- How to work as a team
    - Rosie Revere, Engineer p. 62
- Model an engineering lesson through science
    - A place in the Shade challenge
- Review and share resources
- Cross curricular connections
- Share out experience of the day
    - What do you still need?
- Exit ticket

Computational Thinking and Coding Workshop

- Computational Thinking
    - Operational definition
    - Vocabulary
    - Concepts and approaches
- What is an algorithm?
    - Krazy Characters activity
- The role of unplugged activities
    - Obstacle course challenge
    - debug
- Marble run
- Explore coding
    - ScratchJr

    - Scratch
    - Raspberry Pi
- PLC time
- Review and share resources
- Cross curricular connections
- Share out experience of the day
    - What do you still need?
- Exit ticket

Robotics Workshop

- What is Robotics?
- Fundamentals of Robotics
- Build robotic hand
- Explore robots
    - Cubelets
    - Ozobot
    - Ozmo
    - LEGO Mindstorm EV3
    - LEGO WeDo Robotics
    - Beebots
    - Sphero
    - Dash and Dot
    - Code & Go Robot Mouse
    - Ollie
- PLC time
- Review and share resources
- Cross curricular connections
- Share out experience of the day
    - What do you still need?

APPENDIX B

EXIT TICKET QUESTIONS

Design Thinking and Engineering Design Workshop

1. What is engineering?
2. What does an engineer do?
3. Briefly explain the 3 step engineering design process.

Computational Thinking and Coding Workshop

1. How do you define computational thinking?
2. List three algorithms used in everyday life. Why are these algorithms?
3. List 3 things you learned today about coding.

Robotics Workshop

1. What is robotics?
2. What are degrees of freedom?
3. Briefly explain 3 parts of a robot and their function.

APPENDIX C

ROBOTICS AND ENGINEERING DESIGN ASSESSMENT*

1. Quantitative Arguments are __________________.

A. Ones that can be measured
B. Ones that cannot measured
C. Ones that have a variable quantity
D. Ones that have an unknown quantity

2. Which of the following is not a part of the simple 3 step design process loop?

A. Implement
B. Test
C. Ideate
D. Design

3. Which step of the design process does includes doing background research on the problem be solved?

A. Understand
B. Explore
C. Define
D. Ideate

4. The process of repeating the design process over and over again in known as:

A. Refining
B. Repetition

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C. Ideate
D. Iteration

5. An Engineering Notebook is:

A. A record of the design process.
B. A loose leaf binder with engineering notes and calculations.
C. An electric document detailing the design process.
D. A collection of records, loose leaf binders and electronic documents of the design process.

6. Manipulators are used to:

A. Move the robot from location to location.
B. Interact with the environment around the robot.
C. Provide feedback to the robot.
D. Manipulate the feedback from robot.

7. Which of the following is not a form of robotic drivetrain?

A. Wheels
B. Legs
C. Manipulators
D. Tank Treads

8. The CPU of a robot processes information from sensors and makes decisions based on logic.

A. True
B. False

9. Restrictions on the parts of an assembly to control the degrees of freedom are called?

A. Projections
B. Constraints
C. Restraints
D. Work Planes

10. If a new part design is made from a previous sketch or another part model, this is called?

A. Bottom Up Modeling
B. Top Down Modeling
C. Interactive Modeling
D. Adaptive Modeling

11. Which of the following steps of the Engineering Design process is not considered part of strategic design?

A. Understand
B. Define
C. Explore
D. Ideate

12. Speed, Power, Agility, Low Center of Gravity are examples of what?

A. Robot Qualities
B. Robot Functionalities
C. Robot Behaviors
D. Robot Abilities

13. An example of a robot functionality would be:

A. Speed
B. Picking up an object
C. Power
D. Large wheels

14. A ________ is a manipulator that applies a single force to the side of an object.

A. Scoop
B. Gripper
C. Pinching claw
D. Plow

15. A ________ is a manipulator that applies force underneath an object so it can be elevated or carried.

A. Scoop

B. Gripper
C. Pinching claw
D. Plow

16. Another name for a friction grabber manipulator is a _______.

A. Scoop
B. Claw
C. Shovel
D. Linkage

17. Friction grabbers apply a _______ force between the object and a traction pad.

A. Vertical
B. Normal
C. Friction
D. Gravitational

18. Pinching claws require _______ in either the object being gripped or in the claw itself to provide a solid grip.

A. Friction
B. Rigidity
C. Elasticity
D. Stiffness

19. ___________ is type of robot mechanism used to pick up a large number of similar objects.

A. Scoop
B. Roller claw
C. Accumulator
D. Hopper

20. What kind of drivetrain can move in any direction by steering its wheels?

A. Tank
B. Arcade
C. Swerve
D. Omni-directional

21. A _________ refers to a robot's ability to move in a single independent direction of motion.

A. Range of Motion
B. Degree of Freedom
C. Linear Path
D. Axis of Rotation

22. Which of the following is not a type of degree of freedom?

A. Twisting
B. Linear movement
C. Rotation
D. Bending

23. What is it called if a new part design is made from a previous sketch or another part model?

A. Bottom Up Modeling
B. Top Down Modeling
C. Interactive Modeling
D. Adaptive Modeling

APPENDIX D

TEACHERS EFFICACY AND ATTITUDES TOWARD STEM (T-STEM) SURVEY*

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THE WILLIAM & IDA FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION

NC STATE UNIVERSITY COLLEGE of EDUCATION

Golden LEAF FOUNDATION

This project received support from The Golden LEAF Foundation

Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey

Elementary Teacher

Last Updated October 2012

Appropriate Use

The Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey is intended to measure changes in teachers' confidence and self-efficacy in STEM subject content and teaching, use of technology in the classroom, 21st century learning skills, leadership attitudes, and STEM career awareness. The survey is available to help program coordinators make decisions about possible improvements to their program.

Recommended citation for this survey:

Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey-Elementary Teachers*, Raleigh, NC: Author.

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by The Golden LEAF Foundation.

The framework for part of this survey was developed from the following sources: Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teachers science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi: 10.1002/sce.3730740605

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DIRECTIONS:

For each of the following statements, please indicate the degree to which you agree or disagree.

Even though some statements are very similar, please answer each statement. There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help make your choice.

Science Teaching Efficacy and Beliefs

Directions: Please respond to these questions regarding your feelings about ***your own*** teaching.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am continually improving my science teaching practice.	O	O	O	O	O
2. I know the steps necessary to teach science effectively.	O	O	O	O	O
3. I am confident that I can explain to students why science experiments work.	O	O	O	O	O
4. I am confident that I can teach science effectively.	O	O	O	O	O
5. I wonder if I have the necessary skills to teach science.	O	O	O	O	O
6. I understand science concepts well enough to be effective in teaching science.	O	O	O	O	O
7. Given a choice, I would invite a colleague to evaluate my science teaching.	O	O	O	O	O
8. I am confident that I can answer students' science questions.	O	O	O	O	O
9. When a student has difficulty understanding a science concept, I am confident that I know how to help the student understand it better.	O	O	O	O	O
10. When teaching science, I am confident enough to welcome student questions.	O	O	O	O	O
11. I know what to do to increase student interest in science.	O	O	O	O	O

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Science Teaching Outcome Expectancy

Directions: The following questions ask about your feelings about teaching ***in general***. Please respond accordingly.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	O	O	O	O	O
2. The inadequacy of a student's science background can be overcome by good teaching.	O	O	O	O	O
3. When a student's learning in science is greater than expected, it is most often due to their teacher having found a more effective teaching approach.	O	O	O	O	O
4. The teacher is generally responsible for students' learning in science.	O	O	O	O	O
5. If students' learning in science is less than expected, it is most likely due to ineffective science teaching.	O	O	O	O	O
6. Students' learning in science is directly realted to their teacher's effectiveness in science teaching.	O	O	O	O	O
7. When a low achieving child progresses more than expected in science, it is usually due to extra attention given by the teacher.	O	O	O	O	O
8. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	O	O	O	O	O
9. Minimal student learning in science can generally be attributed to their teachers.	O	O	O	O	O

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Mathematics Teaching Efficacy and Beliefs

Directions: Please respond to these questions regarding your feelings about ***your own*** teaching.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am continually improving my mathematics teaching practice.	O	O	O	O	O
2. I know the steps necessary to teach mathematics effectively.	O	O	O	O	O
3. I am confident that I can explain to students why mathematics experiments work.	O	O	O	O	O
4. I am confident that I can teach mathematics effectively.	O	O	O	O	O
5. I wonder if I have the necessary skills to teach mathematics.	O	O	O	O	O
6. I understand mathematics concepts well enough to be effective in teaching mathematics.	O	O	O	O	O
7. Given a choice, I would invite a colleague to evaluate my mathematics teaching.	O	O	O	O	O
8. I am confident that I can answer students' mathematics questions.	O	O	O	O	O
9. When a student has difficulty understanding a mathematics concept, I am confident that I know how to help the student understand it better.	O	O	O	O	O
10. When teaching mathematics, I am confident enough to welcome student questions.	O	O	O	O	O
11. I know what to do to increase student interest in mathematics.	O	O	O	O	O

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Mathematics Teaching Outcome Expectancy

Directions: The following questions ask about your feelings about teaching ***in general***. Please respond accordingly.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	O	O	O	O	O
2. The inadequacy of a student's mathematics background can be overcome by good teaching.	O	O	O	O	O
3. When a student's learning in mathematics is greater than expected, it is most often due to their teacher having found a more effective teaching approach.	O	O	O	O	O
4. The teacher is generally responsible for students' learning in mathematics.	O	O	O	O	O
5. If students' learning in mathematics is less than expected, it is most likely due to ineffective mathematics teaching.	O	O	O	O	O
6. Students' learning in mathematics is directly realted to their teacher's effectiveness in mathematics teaching.	O	O	O	O	O
7. When a low achieving child progresses more than expected in mathematics, it is usually due to extra attention given by the teacher.	O	O	O	O	O
8. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	O	O	O	O	O
9. Minimal student learning in mathematics can generally be attributed to their teachers.	O	O	O	O	O

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Student Technology Use

Directions: Please answer the following questions about how often students use technology in settings where you instruct students. If the question is not applicable to your situation, please select "Not Applicable."

During elementary STEM instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.), how often do your students...

	Never	Occasionally	About half the time	Usually	Every time	Not Applicable
1. Use a variety of technologies, e.g. productivity, data visualization, research, and communication tools.	○	○	○	○	○	○
2. Use technology to communicate and collaborate with others, beyond the classroom.	○	○	○	○	○	○
3. Use technology to access online resources and information as a part of activities.	○	○	○	○	○	○
4. Use the same kinds of tools that professional researchers use, e.g. simulations, databases, satellite imagery.	○	○	○	○	○	○
5. Work on technology-enhanced projects that approach real-world applications of technology.	○	○	○	○	○	○
6. Use technology to help solve problems.	○	○	○	○	○	○
7. Use technology to support higher-order thinking, e.g. analysis, synthesis and evaluation of ideas and information.	○	○	○	○	○	○
8. Use technology to create new ideas and representations of information.	○	○	○	○	○	○

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Elementary STEM Instruction

Directions: Please answer the following questions about how often students engage in the following tasks during your instructional time.

During elementary STEM instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.), how often do your students…

	Never	Occasionally	About half the time	Usually	Every time
1. Develop problem-solving skills through investigations (e.g. scientific, design or theoretical investigations).	○	○	○	○	○
2. Work in small groups.	○	○	○	○	○
3. Make predictions that can be tested.	○	○	○	○	○
4. Make careful observations or measurements.	○	○	○	○	○
5. Use tools to gather data (e.g. calculators, computers, computer programs, scales, rulers, compasses, etc.).	○	○	○	○	○
6. Recognize patterns in data.	○	○	○	○	○
7. Create reasonable explanations of results of an experiment or investigation.	○	○	○	○	○
8. Choose the most appropriate methods to express results (e.g.drawings, models, charts, graphs, technical language, etc.).	○	○	○	○	○
9. Complete activities with a real-world context.	○	○	○	○	○
10. Engage in content-driven dialogue.	○	○	○	○	○
11. Reason abstractly.	○	○	○	○	○
12. Reason quantitatively.	○	○	○	○	○
13. Critique the reasoning of others.	○	○	○	○	○
14. Learn about careers related to the instructional content.	○	○	○	○	○

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Science, Technology, Engineering and Mathematics

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21st Century Learning Attitudes

Directions: Please respond to the following questions regarding your feelings about learning ***in general***.

"I think it is important that students have learning opportunities to..."

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Lead others to accomplish a goal.	O	O	O	O	O
2. Encourage others to do their best.	O	O	O	O	O
3. Produce high quality work.	O	O	O	O	O
4. Respect the differences of their peers.	O	O	O	O	O
5. Help their peers.	O	O	O	O	O
6. Include others' perspectives when making decisions.	O	O	O	O	O
7. Make changes when things do not go as planned.	O	O	O	O	O
8. Set their own learning goals.	O	O	O	O	O
9. Manage their time wisely when working on their own.	O	O	O	O	O
10. Choose which assignment out of many needs to be done first.	O	O	O	O	O
11. Work well with students from different backgrounds.	O	O	O	O	O

STEM Career Awareness

Directions: Please respond to the following questions based upon how much you disagree or agree with the statements.

"I know …"

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. About current STEM careers.	O	O	O	O	O
2. Where to go to learn more about STEM careers.	O	O	O	O	O
3. Where to find resources for teaching students about STEM careers.	O	O	O	O	O
4. Where to direct students or parents to find information about STEM careers.	O	O	O	O	O

APPENDIX E

SEMI-STRUCTURED INTERVIEW INITIAL AND FINAL QUESTIONS

Initial Interview Questions

1. Tell me about your experience with computer science.

2. Tell me about your experience with computer science professional development.

3. What are your first impressions about these workshops?

4. In what ways do you want your teaching to be different because of your participation at these workshops?

5. What do you think will be your biggest challenge during these workshops?

Final Interview Questions

1. Think back to when you first became involved with the workshops. What were your first impressions?

2. In what ways have your impressions about computer science changed?

3. In what ways is your teaching different because of your participation in the program?

4. In what ways have you implemented things you learned from the workshops into your classroom?

5. How has these workshops affected your confidence in engaging young students in computer science activities?