Elementary Pre-service Teachers' Perceptions of Educational Robotics: A Case Study of a Situated Learning Experience

by

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Abstract

We live in a digital age where technology plays a pivotal role and can significantly transform education. In recent years, educational robotics has become an innovative resource for classroom learning. However, educators must have technical, pedagogical, and content knowledge to use educational robotics effectively. This dissertation investigates pre-service teachers' perceptions before and after a 10-week situated learning experience. The situated learning experience featured a robotics workshop, in-class activities, and a one-week summer camp with elementary students guided by a mentor teacher. In this qualitative case study, pre-service teachers responded to a pre-survey at the beginning of the semester, a mid-survey after a robotics workshop, and a post-survey at the end of the semester. Three pre-service teachers also participated in a semi-structured interview at the end of the semester to reflect on their experiences. The open-ended surveys were analyzed using the Technological Pedagogical Content Knowledge (TPACK) framework and thematic analysis. The open-ended interviews were also analyzed thematically. The analysis identified five key themes, highlighting a noticeable shift in perceptions. This research indicates a need for pre-service teachers to have a hands-on, authentic experience with educational robotics.

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List of Abbreviations

CK	Content Knowledge
CoP	Community of Practice
ER	Educational Robotics
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
PST	Pre-Service Teacher
STEM	Science, Technology, Engineering, and Math
TCK	Technological Content Knowledge
TK	Technological Knowledge
TPK	Technological Pedagogical Knowledge
TPACK	Technological Pedagogical Content Knowledge

Chapter I. Introduction

Today, robots permeate society in everything we do, from automated transportation, restaurants, and the medical fields to robots in grocery stores and homes. When I first heard the phrase "robots are our future," I immediately thought of Rosie from *The Jetsons*. This connection seemed like a far-fetched idea; however, it is more mainstream today. Marina Bill, President of the International Federation of Robotics, stated, "In 2023, the industrial robot market is expected to grow by 7% to more than 590,000 units worldwide" (IFR International Federation of Robotics, n.d.). In the United States, the number of robotics installations in industry was up 10% from 2022 and will continue to rise in the foreseeable future (IFR International Federation of Robotics, n.d.). Our technology-driven society is only becoming more dependent on automation and robotics.

With the rise of robotics and other technology, there is a lack of qualified professionals to fill the increase in science, technology, engineering, and mathematics (STEM) careers (Fayer et al., 2017; Lee, 2015). The National Science Foundation (2019) has reported a significant shortage of qualified STEM professionals ready to meet the demands of career positions, particularly in computer science and engineering. One way to meet this need for skilled STEM professionals is kindergarten through twelfth (K-12) STEM education reform (Banks & Barlex, 2014).

Integrating robotics education has become a strategy to help increase STEM motivation and achievement (Ouyang & Xu, 2024) Kucuk and Sisman (2017) found that educational robotics (ER) are more common and potentially impact students' learning. Mosley et al.'s (2016) research involved an experimental and control group of sixth-grade students who took pre-and post-tests to measure cognitive skills and STEM interests. The experimental group used robotics

in cooperative learning, while the control group did not use robotics. The experimental group showed increased STEM and cognitive skills after a year-long robotics course (Mosley et al., 2016). With the increase of ER, Anwar et al. (2019) reviewed research to determine the benefits. They found that research suggests robotics education 1) positively impacts overall educational experience, 2) increases the construction of new knowledge, 3) improves motivation and creativity, 4) broadens the involvement of underrepresented groups, including females and minority students, and 5) utilize professional development effectively using ER for teachers to be successful.

Computer science is "the study of computers and algorithmic processes, including their principles, their hardware and software designs, their [implementation], and their impact on society" (Tucker, 2003, p. 6). Computer science is integrated into many classrooms in schools in the United States (Code.org, 2022). In 2022, Code.org reported that 43 states created initiatives or passed laws to support K-12 computer science in the past three years (Code.org, 2022). Schools require kindergarten through sixth-grade generalist teachers to integrate computer science into their classrooms; however, they need more knowledge and experience with computer science competencies, like decomposition, algorithms, and computational thinking (Burke et al., 2016; Mannila et al., 2014).

The use of ER in K-6 classrooms has gained momentum as teachers increasingly view them as a less intimidating tool to teach programming and computer science (Kim et al., 2015). Physical robots can help relieve apprehension of computer science and programming concepts (Kim et al., 2015). As more schools embrace using ER and the demand for teaching computer science standards increases, we must adequately prepare our pre-service teachers (PST) before

they enter the classroom. The success of integrating robotics education predominately depends on teachers (Ortiz et al., 2015).

As the use of ER grows, well-prepared teachers can significantly impact their students' learning (Kucuk & Sisman, 2017). Using ER as an educational tool is an effective teaching method, especially within the STEM classroom (Anwar et al., 2019). Students are engaged, having fun, and learning the content.

According to the 2022 State of Computer Science Education document, 43 states either have K-12 computer science standards or are in development, and 27 states require schools to teach computer science (Code.org et al., 2022). For example, in 2018, Alabama released the Digital Literacy and Computer Science course of study for K-12 students (Alabama State Department of Education, 2018). These standards include using/developing algorithms, programming, various systems, and design thinking at varying stages/competency levels as the student progresses through grade levels. Due to the nature of these standards and the impact of COVID-19, schools implemented the standards by grade bands, with all schools required to adopt them by the 2021-22 academic year. ER is a tool all teachers can use to address these standards; however, we must prepare educators to integrate robotics into their classrooms.

Statement of Problem

Perceptions impact how teachers teach, including their perceptions about STEM (Bell, 2016; Bruce-Davis et al., 2014; Herro & Quigley, 2016). Perceptions of ER as a part of STEM are essential, and this situated learning experience, where PSTs construct knowledge in an authentic context, could provide them with a positive experience. Since little research has focused on PSTs and their use of robotics (Kucuk & Sisman, 2018), this study will fill in some

gaps. With a positive experience in ER, PSTs may alter their perceptions, making them more likely to use ER in their classrooms.

Purpose of Study

This qualitative study examined elementary PSTs' perceptions of ER and how those perceptions evolved following a 10-week situated learning experience. The PSTs participated in a situated learning summer semester (10 weeks), including in-class activities, direct robotics professional development, and a one-week robotics summer camp with elementary students. PSTs completed open-ended surveys and semi-structured interviews and worked with a licensed teacher during a summer camp that uses robotics. I examined and found patterns in the data using thematic analysis (Braun & Clarke, 2006).

This research attempts to address the gap in research on robotics education in K-6 teacher preparation programs by examining a cohort of 24 elementary PSTs at a mid-sized public university in the southeastern United States. I recruited participants from a math and science methods course in the university's elementary (K-6) education degree program. All twenty-four students agreed to participate in the study by filling out open-ended pre-, mid-, and post-surveys, and three agreed to participate in the semi-structured interviews.

Theoretical Framework

This dissertation draws on theoretical frameworks and ideas from several disciplines, including constructivism theory, situated learning, and Technological Pedagogical Content Knowledge (TPACK). Constructivism is the theory developed by Jean Piaget, which states that learners construct their knowledge based on their experiences, and the overarching theory encompasses my research. Situated learning is the theory that learning occurs in real-life contexts within a community of practice and requires collaboration (Bloch et al., 1994). TPACK

is a framework that explains the knowledge that teachers need to integrate technology into their classrooms (Mishra & Koelher, 2006). My dissertation, which incorporates robotics, situated learning, and TPACK, is grounded in the theory that knowledge is constructed.

Lave and Wenger (1991) propose that learning is a process of participation in communities of practice, starting with legitimate peripheral participation and gradually increasing engagement and complexity. A Community of Practice (CoP) embodies this approach by fostering learning through engagement in social practices (Wenger, 1998).

A CoP is distinguished from other professional groups by three core elements: domain, community, and practice (Wenger-Trayner & Wenger-Trayner, 2015). The domain represents a shared common interest, which in this dissertation is robotics in the classroom. The community aspect involves members engaging in activities, discussions, and mutual support while sharing information. Interaction and collaboration are essential for a CoP. In this study, pre-service teachers (PSTs) worked together through professional development and the camp experience, embodying the community and practice aspect of a CoP.

Wenger-Trayner and Wenger-Trayner (2015) describe CoP members as active practitioners who develop a shared repertoire of resources—such as experiences, stories, tools, and problem-solving methods—through sustained interaction over time. Unlike casual interest groups, CoPs involve a shared practice that evolves from ongoing collaboration. Throughout the 10-week experience, PSTs collaborated in professional development partner groups and planned camp activities involving ER. CoPs enable teachers to support each other, take risks, and adopt new practices, fostering a culture of collaboration and innovation in teaching (Beddoes et al., 2019; Goodyear & Casey, 2015).

Pre-service teachers (PST) worked in pairs in a summer classroom with certified teachers using robotics to teach math and science concepts. The summer classroom experience provided the situated learning context for the research. The PSTs actively engaged in collaborative problem-solving within the robotics classroom, allowing them to develop the necessary skills and understanding of using ER.

Research Questions

1. What are elementary pre-service teachers' perceptions toward educational robotics before participating in a 10-week situated learning experience?
2. How does participation in a situated learning experience impact elementary pre-service teachers' perception?

Significance of the Study

Understanding preservice teachers' perceptions of robotics education is crucial for several reasons. First, preservice teachers represent the next generation of educators who will shape the learning experiences of countless students. The perceptions of PSTs towards robotics education can significantly influence whether they integrate them into classrooms. Margot and Kettler's (2019) literature review of STEM integration underscores the importance of preservice teachers' perceptions, revealing that these perceptions directly impact their willingness to implement STEM activities in their classrooms. By exploring and addressing any barriers or concerns preservice teachers hold, educators can better prepare them to integrate robotics education into their teaching practice confidently.

Moreover, investigating preservice teachers' perceptions of robotics education provides insights into the effectiveness of teacher preparation programs. These programs play a pivotal role in equipping future educators with the knowledge, skills, and attitudes necessary to meet the

evolving demands of 21st-century classrooms. Kim et al.'s (2015) research highlights the significance of effectively preparing preservice teachers to integrate robotics into STEM education. By identifying gaps or misconceptions in preservice teachers' understanding of robotics education, teacher preparation programs can tailor their curriculum to address the needs of aspiring educators better, ultimately enhancing the quality of instruction in robotics and related fields.

Furthermore, the findings of this study on preservice teachers' perceptions of robotics education could inform policy decisions and curriculum development initiatives to promote STEM literacy and prepare students for future workforce demands. As robotics technology advances and becomes increasingly integrated into various industries, ensuring that educators are adequately prepared to teach robotics is essential for fostering a skilled workforce capable of thriving in a technology-driven society. Alqahtani et al. (2021) emphasize that the role of robotics in a pre-service teacher preparation course increases their intentions of integrating robotics in their future classrooms. This supports the need for PSTs to have opportunities to explore and ponder new technologies' potential within their preparation programs (Hall, 2018).

By examining preservice teachers' attitudes toward robotics education, policymakers and curriculum developers can develop targeted strategies to support the integration of robotics into educational settings. This will enhance students' STEM proficiency and prepare them for success in the digital age.

Definitions of Key Terms

Constructivism. "An approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner" (Elliott et al., 2000, p. 256)

Educational Robotics. Educational Robotics is a "learning tool" (Eteokleous et al., 2013, p. 274).

Perception. "Cognitive, emotional, and attitudinal perspectives and beliefs held by educators regarding various aspects of their professional roles, the teaching and learning process, and the educational environment." (Demirdağ & Efe, 2023)

Situated Learning. A learning experience occurs in an authentic context in a collaborative setting with real-life activities (Lave & Wenger, 1994).

STEM. An acronym for the study of science, technology, engineering, and math in an interdisciplinary approach. "An interdisciplinary approach to teaching science, technology, engineering, and math, STEM instruction integrates key concepts between two or more STEM disciplines as students apply the practices of science and engineering to real-world problems" (*STEM | NSTA*, n.d.).

Technological Pedagogical Content Knowledge (TPACK). TPACK is a framework of technology integration in teaching and learning that says that the knowledge of content, pedagogy, and technology is important, but also important is the interweaving of all those knowledge bases (Mishra & Koehler, 2006)

Summary

The introductory chapter highlights the increasing presence of robotics in our society, reflecting a growing reliance on technology. The industrial robot market will expand significantly, increasing the demand for qualified STEM professionals, particularly in computer science and engineering. Introducing robotics education in K-12 settings emerges as a strategy to address this gap, aiming to boost STEM motivation and achievement among students.

This qualitative study explores elementary PSTs' perceptions of ER and how those perceptions evolve following a 10-week situated learning experience, focusing on potential shifts in their perceptions following that experience. Situated learning theory forms the theoretical foundation for this research, emphasizing learning within authentic contexts through collaboration. The study's significance lies in its potential to inform teacher preparation programs and policy decisions regarding integrating robotics education into curricula, enhancing students' STEM proficiency, and preparing them for future workforce demands.

Understanding preservice teachers' perceptions of robotics education holds important implications for shaping the attitudes and beliefs of future educators toward integrating robotics into classrooms. By addressing any barriers or concerns held by preservice teachers, educators can better equip them to confidently incorporate robotics education into their teaching practice, ultimately fostering a skilled workforce capable of thriving in a technology-driven society. Additionally, insights from this study can inform policy decisions and curriculum development initiatives to promote STEM literacy and prepare students for success in the digital age.

Overview of Chapters

In the following chapters, I share my research study in an elementary math methods course, a required educational course for preservice teachers in their junior or senior year. In Chapter 2, I review pertinent literature and research related to educational robotics in the elementary classroom. Topics include the role of robotics, its history, the importance of inclusion in the classroom, the frameworks that guided this research, the Technological, Pedagogical, and Content Knowledge (TPACK) framework, and Situated Learning. In Chapter 3, I describe the research study's methodology, methods, and analytical steps. In Chapter 4, I present my research findings, including using TPACK as deductive coding for the survey

responses and inductive coding for the semi-structured interviews and survey responses, which led to codes and themes. In Chapter 5, I share the conclusions of this study, including an overview of my findings and implications for pre-service teacher education programs, and conclude with limitations and ideas for future research.

Chapter 2: Literature Review

Science, Technology, Engineering, and Math (STEM) careers have increased rapidly over the last ten years and will continue to increase (*Employment in STEM Occupations: U.S. Bureau of Labor Statistics*, 2022). In 2015, there were about 8.6 million STEM jobs in the United States, a 10.5 percent increase from 2009 (Watson, 2017). In 2019, that number increased to 9.3 million STEM jobs, an 8% growth in four years. The United States Bureau of Labor Statistics predicts that between 2021 and 2031, STEM jobs will increase by 10.8%, which is a higher rate than non-STEM jobs (*Employment in STEM Occupations: U.S. Bureau of Labor Statistics*, 2022). While this sounds promising for job growth, the jobs are unfilled due to students not being prepared for STEM careers (O'Rourke, 2021). To be prepared for STEM careers, students need proper training, which begins with STEM education.

However, STEM education faces several challenges. Among these challenges are teachers' unfamiliarity with STEM content, difficulty integrating STEM into the current curriculum, and lack of structure in learning activities that promote STEM (Darmawansah et al., 2023). STEM education aims to integrate the four subjects, not teach each of the four subjects in isolation, which can be challenging for educators (Kelley & Knowles, 2016). One potential solution to these challenges is the integration of educational robotics in STEM (Chalmers, 2017). Educational robotics (ER) in STEM education can promote STEM disciplines such as engineering, science, mathematics, and technology by allowing students to see the correlation of these fields practically and interactively (Okita, 2013). Robotics in STEM education is becoming more common and has the potential to impact students' learning (Kucuk & Sisman, 2017). This interdisciplinary approach is important because it mirrors the real-world application of STEM skills, where multiple fields must collaborate to solve complex problems.

The increasing affordability and availability of robotic platforms partly drive the growing use of robotics in STEM education. Exposure to STEM is necessary from elementary through high school as research shows that waiting until undergraduate or graduate studies might be too late (Myers & Pavel, 2011). Despite these advances, teacher readiness remains a critical barrier to integrating robotics into STEM curricula. Many educators lack the training or confidence to effectively use robotic platforms in their classrooms, often due to inadequate professional development opportunities (Bers, 2020).

This chapter examines existing literature surrounding the theoretical frameworks used, perceptions, and robotics education. First, the chapter will describe the theoretical frameworks used in the research. Then, the chapter will define and explain the history of ER and current platforms, including the ones used in this study. Next, the chapter will explain why ER is important in the K-12 general classroom and the skills it teaches. Finally, the chapter will explore teacher perceptions and their impact on our teaching.

Theoretical Frameworks

The three theoretical frameworks used in this research were constructivist theory, situated learning theory, and Technological Pedagogical Content Knowledge (TPACK). This research is founded on constructivist theory, as the principles of constructivism underpin both situated learning theory and TPACK.

Constructivist

The foundational framework of this research is grounded in constructivism. Constructivist theory of learning, primarily associated with Jean Piaget (1968) and Lev Vygotsky (1934, 1978), theorizes that learners construct their understanding and knowledge of the world through experiences and reflection on those experiences. This theory suggests that learning is an

active process of constructing knowledge rather than passively receiving information. Students use their prior knowledge as a foundation and build upon it by interacting with new information. This theory contrasts with traditional views of education, which often depict knowledge as something teachers transmit to students.

Piaget's theory focuses on the individual being at the center of the learning process, where they create knowledge through their experiences and ideas. According to Piaget, learners pass through various stages of cognitive development marked by different ways of thinking and understanding the world. Piaget emphasizes the importance of opportunities to engage with materials and ideas to help students develop a deeper understanding. This form of learning is particularly relevant in STEM and ER, where students engage in hands-on problem-solving to learn.

Vygotsky's theory also revolves around the construction of knowledge; however, it includes the crucial role of interacting with others. According to Vygotsky, learning is a social process, and working with others creates shared meaning with peers. Working with others allows students to share knowledge and perspectives, which allows them to reach higher levels of understanding than they could on their own. In a collaborative environment, students can benefit from each other's strengths.

The role of the teacher in a constructivist classroom shifts dramatically from being a transmitter of knowledge to a facilitator of learning. In a constructivist classroom, teachers provide students with opportunities to explore, ask questions, and engage in problem-solving activities that are meaningful to them (Keiler, 2018). This approach encourages learners to take responsibility for their learning, fostering critical thinking and independent inquiry. By creating learning environments rich in opportunities for exploration and interaction, constructivist

educators aim to develop students' ability to think creatively, apply knowledge in real-world situations, and continue learning throughout their lives (Keiler, 2018). Constructivist teaching methods often involve more project-based learning, collaborative problem-solving, and real-world contexts. These methods align with STEM and ER as students working with robotics do not usually follow predefined instructions but are experimenting, troubleshooting, and refining based on their experiences (Jaipal-Jamani, 2024).

Situated Learning

The theoretical framework underlying the 10-week summer program was situated learning. Situated learning is a theoretical model within constructivist theory. It explains how learning occurs in a community of practice within a real-life context and requires collaboration (Lave & Wenger, 1994). From a situated learning perspective, teachers and learners need to engage directly within the contexts where they work to foster meaningful learning (Lave & Wenger, 1991; Wenger, 1999). Lave and Wenger (1991) propose that learning is a process of participation in communities of practice. They start by participating in simple, less central tasks within the group. Over time, as they gain experience and knowledge, their involvement becomes more profound and complex, leading to full participation in the community's practices (Lave & Wenger, 1991). This model emphasizes learning as a social process driven by collaboration and engagement in real-world activities.

A Community of Practice (CoP) is a social learning system that embodies the principles of situated learning (Wenger, 1999). A CoP is distinguished from other professional groups by three core elements: domain, community, and practice (Wenger-Trayner & Wenger-Trayner, 2015). The domain represents a shared common interest, which in this dissertation is robotics in the classroom. The community aspect involves members engaging in activities, discussions, and

mutual support while sharing information. Interaction and collaboration are essential for a CoP. In this study, pre-service teachers (PSTs) participated in a CoP through professional development activities and their collaborative experiences in a 10-week summer program.

Wenger-Trayner and Wenger-Trayner (2015) describe CoP members as active practitioners who develop a shared repertoire of resources—such as experiences, stories, tools, and problem-solving methods—through sustained interaction over time. Unlike casual interest groups, CoPs involve a shared practice that evolves from ongoing collaboration. Throughout the 10-week experience, PSTs collaborated in professional development partner groups and planned camp activities involving ER. CoPs enable teachers to support each other, take risks, and adopt new practices, fostering a culture of collaboration and innovation in teaching (Beddoes et al., 2019; Goodyear & Casey, 2015).

Pre-service teachers (PST) worked in pairs in a summer classroom with certified teachers using robotics to teach K-6 elementary content standards. The summer classroom experience provided the situated learning context for the research. The PSTs actively engaged in collaborative problem-solving within the robotics classroom, allowing them to develop the necessary skills and understanding of using ER.

Situated learning theory has been used in several STEM and robotics-related research (Kelley & Knowles, 2016; Maiorca & Mohr-Schroeder, 2020; Roberts et al., 2018; W. Wang et al., 2021). W. Wang et al. (2021) examined the role of situated learning in developing computer science teachers' understanding of robotics education. Similarly, Kelley and Knowles (2016) used situated learning theory to explore how pre-service teachers' experiences in informal learning environments influenced their perceptions of STEM education. Roberts et al. (2018) also highlighted the importance of situated learning in fostering meaningful engagement with

STEM content through real-world, hands-on experiences. Maiorca and Mohr-Schroeder (2020) examined how situated learning in informal environments influenced pre-service teachers' perceptions and attitudes toward STEM education.

The situated learning theoretical framework, developed by Lave & Wenger in 1991, emphasizes learning within a community of practice in real-life contexts, often through collaborative experiences like student teaching internships. While research on ER and situated learning is limited, studies on situated learning with technology show its potential to enhance PSTs' problem-solving and critical-thinking skills. Kelley and Knowles (2016) introduced a framework for integrated STEM education based on situated learning theory, highlighting the importance of the practical application of knowledge and skills.

TPACK

Mishra and Koehler (2006) developed the Technological Pedagogical Content Knowledge (TPACK) framework. This framework, known as TPACK, is a comprehensive model that describes the types of knowledge vital to teachers' successful and effective integration of technology into their classrooms (Warr & Mishra, 2022). It helps researchers and others to examine the complex nature of teaching with technology and the various knowledge domains that are needed, along with the ability to weave these knowledge domains together for effective instruction. The overarching theme of TPACK is that integrating technology into the classroom requires the integration of the four TPACK knowledge domains, offering a rich and multifaceted approach to technology integration in education (Warr & Mishra, 2022). This framework builds on Shulman's (1986, 1987) work on Pedagogical Content Knowledge (PCK), which states that teachers’ knowledge goes beyond simply knowing content and pedagogy in isolation. Shulman proposed that combining content and pedagogy informs a teacher’s ability to teach effectively.

This framework extends Shulman's (1986) concept of pedagogical content knowledge (PCK) by incorporating knowledge of technology.

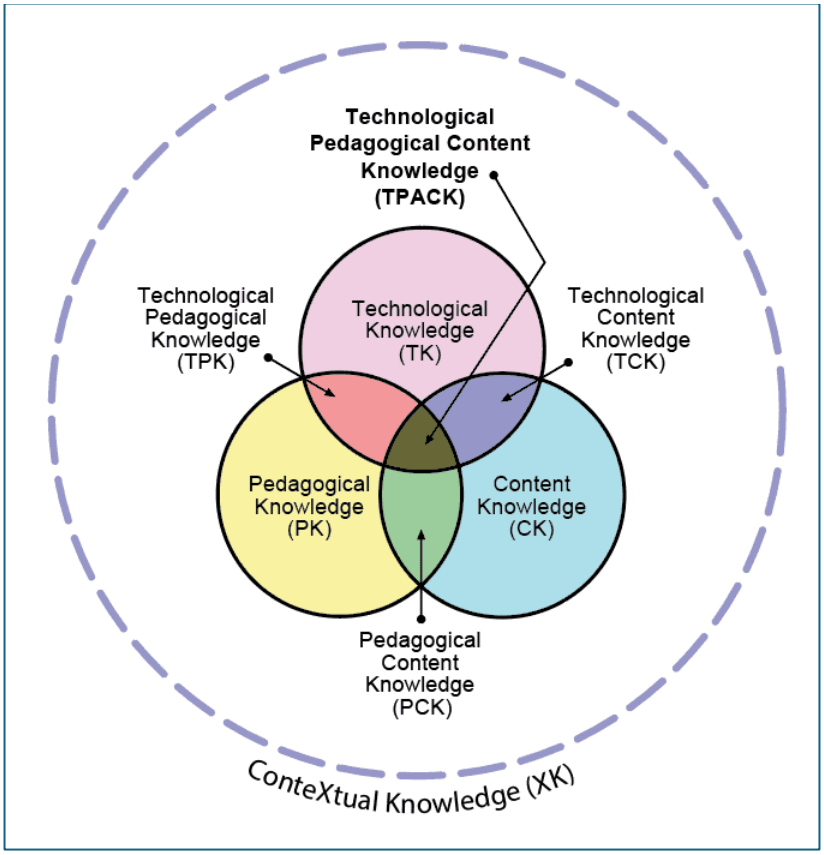
In the TPACK model, content knowledge (CK) refers to teachers' understanding of the subject matter, including the state standards they must follow. Teachers must have a deep understanding of the content they are responsible for teaching to students. Pedagogical knowledge (PK) is knowledge about the methods and strategies of teaching and learning. PK includes knowledge about instructional methods, assessment techniques, classroom management, and how students learn in different contexts. Technological knowledge (TK) is the knowledge of the tools, platforms, and digital technologies used in education. TK involves knowing what technology exists, how to use the tool, and how to use technology to enhance learning.

Fundamental to the TPACK framework is the merging of the knowledge fields (Mishra & Koehler, 2009). The three correlated knowledge bases lead to four additional knowledge constructs: pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK), which together make the Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2009). Pedagogical content knowledge (PCK) is understanding the best practices for teaching specific content to students. PCK involves identifying the best approaches for presenting content to students. Technological content knowledge (TCK) is knowing how the technology tools you have access to can enhance the content you are teaching. Teachers need to know which digital tools best fit into the content to facilitate learning. Technological pedagogical knowledge (TPK) aligns with how technology can impact student learning when combined with specific pedagogical strategies. TPK involves recognizing how digital tools can be integrated into different teaching methods to improve student engagement and learning. Technological Pedagogical Content Knowledge (TPACK) is

understanding how the three core components, technology, pedagogy, and content, intersect and merge (Koehler & Mishra, 2009). Teachers with a strong TPACK are skilled at using technology to support their teaching content and pedagogical strategies. Figure 1 shows the three sets of knowledge and how they interact with each other to create new types of knowledge.

Figure 1

The Technological Pedagogical Content Knowledge (TPACK) Framework



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Educational Robotics

When we mention the word "robot," many pictures come to mind. Some of us think of Rosie from *The Jetsons* cartoon, a humanoid machine-like C-3PO from *Star Wars*, or even everyday devices like a Roomba vacuum cleaner or a self-driving car. While all these are robots, the robots used in education look and operate differently. In education, robots facilitate learning through hands-on, problem-solving tasks. It is important to understand what ER is, its history, and the types of robotic platforms commonly used in education. Understanding the platform is essential because the learning outcomes associated with ER depend on the platform used (Kyprianou et al., 2023).

Definition of Educational Robotics

ER has many definitions. Angel-Fernandez and Vincze (2018) defined ER as "a field of study that aims to improve the learning experience of people through the creation and implementation of activities, technologies, and artifacts, where robots play an active role" (p. 41). This definition explains robots' active role in education by engaging students through hands-on activities. According to new research (*Do You Know How Educational Robots Can Help Your Children to Develop?*, 2021), ER is defined as "a discipline designed to introduce students to robotics and programming interactively from a very early age" (para 4). Another definition of ER says it is a "teaching tool" (Sánchez et al., 2019, p. 26) or a "learning tool" (Eteokleous et al., 2013).

For this research, I defined ER as a learning tool coined by Eteokleous et al. (2013). This tool can be used in an educational setting to help achieve specific learning objectives by integrating them into the subject matter. ER helps students learn about the tool (robot), including

programming, computational thinking, and soft skills. Soft skills, also known as interpersonal skills or people skills, are non-technical skills that relate to how individuals interact.

History

Robotics originated from constructivist educational theories, emphasizing learning through engagement and experimentation. Seymour Papert, a pioneer in technology-based education, suggests that we build our understanding and "construct" our understanding rather than learning by absorbing or being told (Papert, 1980; Papert, 2020). He developed the constructionism theory that says children work best using technology-based learning tools, taking active roles as designers and builders, and doing so in a social setting (Harel, 2018). Numerous studies in ER cite Papert's seminal work as a motivator to use ER in today's classrooms (Benitti, 2012; Julià & Antolí, 2015; Kucuk & Sisman, 2017; Saez-Lopez et al., 2019). Papert's ideas laid the foundation for the modern integration of robotics in education. ER is a tool that lends itself to students learning by doing. To better understand ER as a "learning tool," examining the various kinds of robots used to support learning is essential.

Educational Robotics Learning Tools

Robots used in education can be virtual or physical robots. Virtual robots are software-based with an emphasis on programming in a simulation environment. Physical robots have physical forms, can be touched, and provide an increase in interaction (Pei & Nie, 2018). Their appearances, hardware, software, and functions describe physical robots and determine how educators use them in the classroom (Jung & Won, 2018). Table 1 provides an overview of the various physical robot platforms used in education, including those featured in this study. I organized the table as follows: column one lists the robot's name, column two specifies whether

the robot is buildable or ready to use out of the box, column three indicates the programming language, and column four displays the manufacturer's recommended age range.

Table 1

Examples of robotics platforms, types, programming languages, and age range

Robot Name	Type (buildable or out-of-the-box)	Programming Language	Age Range
LEGO Spike	Buildable	Visual blocks: Scratch	6+ years
LEGO Spike Prime	Buildable	Scratch	10+ years
mBot	Buildable – sensors connect to a base	Scratch	8+ years
Dash Robot	Out-of-the-box	Blockly	6+ years
Blue-Bot	Out-of-the-box	Physical programming- buttons on the bot and picture blocks	3+ years
Ozobot Evo	Out-of-the-box	Physical; Blockly	5+ years
Sphero Bolt	Out-of-the-box	Blockly; Java Script	8+ years
Edison Robot	Out-of-the-box	Blockly; Scratch; Python	4-16 years
VEX GO	Buildable	Blockly	7+ years
VEX 123	Out-of-the-box	Physical; Blockly	4+ years
VEX IQ	Buildable	Blockly	10+ years

ER has come a long way over the years, as companies are designing robots for classroom use. Many educational robot platforms over the past 15-20 years were initially designed as home-use toys (Alvarez, 2014; Create & Learn Team, 2022). However, a wide variety of robots are also available for classroom use. ER has a place in the classroom that is more than just novelty. ER has been used as a tool to teach content standards (Chang et al., 2010), to increase student achievement (Chin et al., 2014), to learn about the world around them (Kuleto & Ilić, 2022), and to integrate STEM (Şişman et al., 2020).

The current study used the VEX 123 and VEX GO platforms in the pre-service teacher professional development training. Some of the summer camp experiences used these platforms as well. VEX 123 is a physical robot that can be programmed using physical touch, a coder device and cards, and drag-and-drop block coding on a website. The platform offers a simplified entry point for programming and coding by providing pre-built tools, and touch coding provides students with a foundational introduction to programming. The VEX GO platform is a buildable platform where students use plastic pieces that snap together to construct robots and other educational tools such as simple machines, a rubber-band powered car, and a math tool that illustrates equivalent fractions. The VEX GO uses drag-and-drop block coding similar to the VEX 123 software.

Why use Educational Robotics?

Research shows ER is being used in the K-12 classroom for numerous reasons, such as to motivate students to pursue STEM careers (Aris & Orcos, 2019; Witherspoon et al., 2016), to increase engagement, learn concepts and subject area content, and the development of skills (Benitti, 2012; Evripidou et al., 2020; Bartholomew & Furse, 2015), to teach soft skills (Alimisis et al., 2019; Kaloti-Hallak et al. 2019), and to teach programming skills (Strawhacker & Bers,

2015; Barker & Ansorge, 2007). Interest in robotics has increased over the years and offers benefits in education at all levels (Johnson, 2003). The research shows the benefits of using ER in the K-12 classroom; however, research also shows that there is a gap between available technology and its effective use in the classroom (Merc, 2015; Tassell et al., 2019)

Engagement

ER allows children to play, encouraging and motivating them (Ryan & Deci, 2000; Sapounidis & Demetriadis, 2013). Incorporating robots into STEM-focused courses can enhance students' cognitive and social skills, boost their interest in learning, and support their understanding of innovative technologies (Anwar et al., 2019; Sapounidis & Alimisis, 2020; Chin et al., 2014). Chin et al. (2014) used ER with a group of primary school students to study the impact on their learning performance and motivation. The participants were 52 first graders in two different homerooms, one being the control group and the experimental group. Comparing the pre-and post-performance tests, the experimental group scored higher ($t=2.493$, $p<.05$), and using a motivational survey, the students were highly motivated when using ER (Chin et al., 2014). In a meta-analysis of ER, Ouyang & Xu's (2024) findings show that learning and engagement improved.

Concepts and Content

Over 50 countries have adopted computer science plans or policies since 2013 (Code.org, 2020). The countries leading the way in computer science in K-12 education are China, Russia, Poland, Switzerland, and Hungary (*Coding Games from Beginner to Professional Level | RoboGarden*, n.d.). According to the 2022 State of Computer Science Education document in the United States, 43 states either have K-12 computer science standards or are in development, and 27 states require schools to teach computer science (Code.org et al., 2022). For example, in

2018, Alabama released the Digital Literacy and Computer Science course of study for K-12 students (Alabama State Department of Education, 2018). These standards encompass applying and developing algorithms, programming, various systems, and design thinking, adapted to different stages and skill levels as students advance through the grade levels. Grade bands implemented all standards, and all schools had to adopt the standards by 2021-22. There are many ways to teach computer science standards, including websites, unplugged activities, coding games, and physical devices. Educational Robotics (ER) is a tool teachers can use to address these standards as it provides a physical solution to what is often seen as an abstract concept, making those concepts more concrete (Chevalier et al., 2020).

Dorotea et al. (2021) examined computer science teachers' knowledge, interest, and confidence in using learning robots. They found that teachers' knowledge, interest, and self-efficacy in using learning robots for teaching are very positive. The results also highlight teachers' interest in using robotics and supporting their students in such learning activities.

While ER can teach programming and computer science skills, it can also teach other content in math, science, and literature (Valenzuela, 2021). A study conducted by Zhang et al. (202) demonstrates that employing robotics in STEM education to teach mathematical concepts can be successful without compromising the integrity of mathematical topics. In research by Coşkunserçe (2021), he found that using robotics in science improved students' motivation and their science skills. Using robotics with storytelling and drama in the classroom improved attention and motivation. The robots' behaviors helped students form mental representations of abstract concepts and foster connections (Bravo et al., 2021).

Development of Skills

The US Army termed “soft skills” to refer to interpersonal skills that do not require the use of machinery. Soft skills, also known as interpersonal skills or people skills, are non-technical skills that relate to how individuals interact with others and navigate their environment. In 2009, Google worked on Project Oxygen, which showed that problem-solving, communication, teamwork, and listening are integral to a company's success (Bryant, 2013). Since 1997, 21st Century Skills have infiltrated education as a set of common skills that all students should acquire to be successful (Kennedy & Sundberg, 2020). The term 21st Century Skills refers to a group of skills believed to be important to be successful in today's world. Some skills listed include critical thinking, problem-solving, creativity, and innovation, which are also soft skills.

ER is considered a tool that can be used to teach soft skills (Rubinacci et al., 2017). Research shows ER can teach soft skills such as problem-solving (Turner & Hill, 2007; Castledine & Chalmers, 2011; Gratani et al., 2021), creativity (Yang et al., 2020; Badeleh, 2021), and collaboration (Gueorguiev et al., 2018). Gratani and Giannandrea (2022) found that while ER did teach concepts like renewable energy, students also learned soft skills such as problem-solving, creativity, and collaboration. Research by Román-González et al. (2017) emphasizes the role of ER in cultivating students' critical thinking, problem-solving, and collaboration skills. Collaborative robotics activities help develop multiple perspectives and ideas from their peers (Yuen et al., 2014).

Pre-Service Teachers Perceptions

Understanding PST’s perceptions is essential for shaping their future teaching practices, especially in STEM education and ER (Margot & Kettler, 2019). Demirdağ and Efe (2023)

define teacher perceptions as “cognitive, emotional, and attitudinal perspectives and beliefs held by educators regarding various aspects of their professional roles, the teaching and learning process, and the educational environment” (p. 304). Teacher perceptions are subjective and are shaped based on their background, life experiences, and mindsets (Jaafar et al., 2021; Mozafari & Wray, 2015; Papadakis & Kalogiannakis, 2020). As a result, teacher perceptions also influence teaching practices and the learning environments they create (Chaya, 2023; Margot & Kettler, 2019; Stubbs & Myers, 2016). There is a strong relationship between a teacher’s perceptions, educational beliefs, and teaching practices in multiple subjects such as science, math, and STEM (Burton, 2022; Jones & Leagon, 2014; Pajares, 1992; McMullin & Reeve, 2014). These perceptions can influence how they develop their understanding of the subject and, in turn, impact how they teach it. While there is a lack of research regarding PSTs' perceptions of using ER in the classroom, we draw on research of perceptions of other subject areas closely tied to ER, such as STEM and technology education.

A substantial body of research indicates that teachers’ perceptions of technology significantly influence their willingness to integrate technology tools into their classrooms (Dinc, 2019; Papadakis et al., 2021; Wang, 2023). Papadakis et al. (2021) found that teachers’ perceptions of the value and efficacy of technology directly affected its use in educational settings. Wang’s (2023) study on PST’s perceptions of integrating technology in the classroom indicated that two key factors influencing in-service teachers' integration of technology are (1) perceived usefulness and (2) their value beliefs regarding teaching. Dinc (2019) found that PST’s perceptions of technology integration included emphasizing effective use, curriculum inclusion, and enhanced engagement, and significant barriers like lack of equipment and ability could hinder their willingness to integrate technology into their classrooms.

In a systemic literature review, Margot and Kettler (2019) found that teachers value STEM, but some barriers include a lack of teacher support, pedagogical, curriculum, and structural challenges; however, those perceptions give insights into how they will implement STEM in their classrooms. Preservice teachers begin to develop conceptions of STEM-based teaching in line with their perceptions and experiences (Mafugu et al., 2023).

A teacher's decisions about what and how to teach often stem from their identity, skills, motivation, and constraints, all of which largely reflect their perceptions (Belland et al., 2023). A study by Blackwell et al. (2014) surveyed 1,234 U.S. early childhood educators about access to and use of technologies in the classroom, their attitude toward technology, and their perceived level of support. Findings indicated that attitude had the most significant effect on technology use, followed by perceived support and confidence (Blackwell et al., 2014). In another study, PSTs' experience with technology and proficiency in using the technology were strong indicators of technology integration (Farjon et al., 2019). Teachers may shy away from including robotics and computer science in their classrooms due to the lack of women in computer science and other STEM fields and not having role models for the teachers (Belland et al., 2023). Teachers may associate technical fields like computer science as masculine, being hard, and one that you do for long hours on your own (Cheryan & Markus, 2020). These biases can make women (teachers) feel they do not belong in computer science, which may keep them from introducing it in their classrooms (Belland et al., 2023).

In a study by Pimthong and Williams (2018) in Thailand, the participating preservice teachers defined STEM education as integrating science, technology, engineering, and mathematics. However, they needed help explaining how to integrate disciplines in their classrooms (Pimthong & Williams, 2018). Introducing ER during pre-service training has

increased teacher self-efficacy, content knowledge, and computational thinking skills (Jaipal-Jamani & Angeli, 2017). However, it is not enough to introduce ER; they need to see how it connects to content (Kucuk, 2018).

Teachers' perceptions of STEM, ER, and TPACK can influence how they design and implement learning activities. In a case study of three teachers, their perceptions of STEM integration strongly influenced how they designed their STEM integration unit (Wang et al., 2011). Researchers must examine teachers' perceptions of ER to seek ways to positively impact the design and implementation of ER in the classroom. Some theoretical and qualitative research results have indicated that educators may have resistance to using robots due to perceived conflicts with their existing teaching and learning practices (Khanlari, 2014; Ensign, 2017; Karypi, 2018) and low levels of perceived usefulness (Lei et al., 2022). Teachers and pre-service teachers' perceptions of their TPACK, their knowledge related to teaching with technology, and their perceived competence also influence their uses of technology (Polly et al., 2022).

Despite these challenges, research shows teachers' perceptions can change with appropriate support and professional development (Alqahtani et al., 2021; Belland et al., 2023; Berlin & White, 2012; Mason & Rich, 2019; Gibson, 2017). Belland et al. (2023) analyzed five studies, revealing that factors like time, prior experience with robot programming, and the perceived value of coding significantly influenced attitudes toward coding. Alqahtani et al. (2021) found that PST perceptions of ER changed after being given adequate time to explore and experience robots and increased their intentions to integrate robotics into their teaching. Mason and Rich (2019) conducted a literature review of twenty-one studies, and the findings suggest that training that includes hands-on approaches can improve teachers' perceptions.

Pre-service Teachers and Educational Robotics

As educational policies evolve to meet the demands of a digital world, computer science, and robotics are becoming essential components of K-12 education. In the United States, for example, Alabama's Digital Literacy and Computer Science Standards are now mandatory in K-12 schools, and 43 states have adopted computer science initiatives or laws (Code.org, 2022). Beyond the United States, over 50 countries have added computer science policies or plans, emphasizing the global shift toward integrating digital literacy into schools. Educational Robotics (ER) offers a versatile and engaging tool to address these standards. By implementing STEM-based units with ER, educators can create lessons that integrate technology with subjects like math, science, and engineering. However, despite the increasing emphasis on computer science in education, many teachers face challenges in implementing ER due to a lack of training. According to Batko (2018), teachers who do not receive sufficient training in ER are less likely to use these tools in their classrooms.

PSTs are digital natives, and many assume they would feel comfortable teaching with technology; however, research shows otherwise. The American Library Association defines digital natives as individuals born and raised in the digital era (post-1980). According to Prensky (2001), digital natives process information differently from previous generations due to growing up immersed in technology like computers, video games, and cell phones. Those not growing up in this environment are digital immigrants (Prensky, 2001). Although Prensky suggests digital natives are more likely to use digital tools in their professional lives, there is no evidence that being a digital native guarantees the use of such tools in the classroom (Milutinović, 2022). Despite pre-service teachers being part of the digital native generation, they may still face challenges when using technology for learning (Huang et al., 2021; Teo, 2016; Milutinović,

2022). Moreover, technological proficiency does not necessarily mean using technology critically or meaningfully, as many in the digital generation lack a deep understanding of digital media (Heverly, 2007).

Teachers expected to teach using robotics need a solid foundation in technical aspects and pedagogical strategies. Research has shown that providing teachers with targeted training in these areas can increase their robotics self-efficacy and the likelihood of using the tools correctly in the classroom (Anwar et al., 2019; Chalmers, 2017). Training on building, programming, and troubleshooting robots is essential for teachers to feel confident using robotics in their classrooms (Anwar et al., 2019). Training should include using the engineering design process, which guides students through problem-solving by having them build, program, and test a robot (Batko, 2017; Chalmers, 2017). McDonald and Howell (2012) argue that ER is particularly effective when grounded in constructivist learning theories, which encourage active participation and problem-solving. This approach enables students to engage and explore technology, aligning with the hands-on nature of robotics, where students learn through direct involvement in building and interacting with robotic systems.

A growing amount of research reveals that some teacher education programs integrate STEM, robotics, and computer science into their undergraduate programs (Chalmers & Macbeth, 2013; Kucuk & Sisman, 2018; Ortiz et al., 2015). Chalmers & Macbeth (2013) found that integrating robotics into teacher preparation programs helps teachers use these technologies in their classrooms, positively impacting both teachers and students. Kucuk and Sisman, 2018, worked with 15 PSTs for four hours per week for 13 weeks with robotics and programming. The PSTs reported that working with robotics positively influenced their attitude toward robotics. In Kaya et al.'s (2017) study, PSTs were part of a 15-week course that included three weeks of

robotics training where they planned, designed, built, and programmed a robot to perform numerous tasks. This research showed that the PSTs improved their perception of their efficacy in using ER (Kaya et al., 2017).

Summary

The increase in STEM jobs over the past decade, accompanied by projections of further growth, creates a challenge as there is a gap between the number of jobs available and the students qualified to fill them. As the United States continues to look for professionals to fill open STEM positions, the push for STEM in the K-12 classroom will persist. With this comes the integration of ER. Robotics is an engaging platform that increases motivation and interest in STEM fields of study. Another theme throughout the research is that ER teaches soft skills such as teamwork, critical thinking, and problem-solving.

STEM education does have challenges, including the difficulty integrating the subjects into existing curricula, teacher perception of STEM, and unfamiliarity with the content. Educational Robotics (ER) is a potential solution to address these challenges, promote STEM, and enhance student learning. ER can extend beyond programming and computer science and integrate science, technology, engineering, and math. By providing a hands-on, constructivist solution, ER makes learning more accessible and engaging for students. Additionally, ER helps develop essential soft and workforce development skills such as teamwork, critical thinking, and problem-solving.

Teacher perceptions of ER play a crucial role in shaping teacher practices and the learning environment, highlighting the need for adequate training and support to implement ER. Training that includes using the robotic platforms and the pedagogy behind using ER is imperative to making teachers feel confident when using ER in the classroom. Teachers must be

familiar with the various ER platforms to discern which is most appropriate in their classrooms based on their specific learning goals, including ways specific ER platforms can enhance student learning and problem-solving in various content areas. Teachers also need specialized TPACK training to support their planning and implementation of ER in their classrooms. Pre-service teacher training programs are beginning to incorporate STEM, ER, and computer science education to equip future educators with the skills and knowledge necessary to integrate robotics into their teaching practices (Zhang & Zhu, 2023).

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Chapter 3: Methods

This research examines PSTs' perceptions of using robotics in the elementary education classroom and whether those perceptions change after a situated learning experience. When looking at how perceptions of teachers influence what they do in their classrooms and how perceptions can change, this study hopes to deepen the knowledge base about how a situated learning experience changes PST perceptions.

Method

This single case study utilized a situated learning experience with elementary PSTs enrolled in a summer cohort experience. This experience included learning to use educational robotics (ER) through professional development, coursework, and an embedded field experience with elementary students during a summer camp. A case study provides an in-depth analysis of the subject while identifying relevant themes (Creswell, 2014; Yin, 2009). I conducted a case study for this research, as the 10-week semester timeframe provided a suitable boundary for the study's scope.

Situated learning is a theoretical framework that states that learning occurs in a community of practice within a specific real-life context (Lave & Wenger, 1994). Situated learning theory has been widely applied in various STEM and robotics-related research contexts (Kelley & Knowles, 2016; Fraihat et al., 2022; Roberts et al., 2018). This framework is particularly valuable for my research because it emphasizes learning as a social process within authentic, real-world contexts. In STEM education, situated learning highlights the importance of contextualized learning environments that allow students to engage with content in a meaningful way. For instance, situated learning has been used to explore preservice teachers' perceptions of STEM in informal learning settings, illustrating how learning in these environments promotes more profound engagement with STEM concepts (Maiorca & Mohr-Schroeder, 2020).

Additionally, Kelley and Knowles (2016) utilized a situated learning experience framework and found that preservice teachers' involvement in an informal STEM learning experience positively influenced their perceptions of STEM. These findings reinforce the importance of hands-on, collaborative learning activities in shaping attitudes and understanding. By employing situated learning as a theoretical framework, my research aims to explore how these principles can enhance exploring and utilizing ER in elementary education through immersive, real-world experiences.

Researcher Positionality

My interest in the preparation of teachers and PSTs to incorporate robotics into their classrooms stems from the increasing technological skills facing all professions, the adoption of the computer science standards across the United States for K-12, the need for additional STEM personnel in the workforce, and a personal connection to ER through my oldest son. I have 20 years of teaching experience and 14 years of ER experience. I have witnessed firsthand the speed at which technology continues to develop and the skills students will need to adapt to these changes successfully. I am drawing on the guidelines set by state standards on technology instruction. As I have provided professional development to teachers on ER for the past six years, I have seen apprehension due to a lack of knowledge and feeling unprepared. Therefore, PSTs could benefit from ER experiences and instruction. From my experience, higher education institutes must add robotics/computer science/programming classes to PSTs' undergraduate studies and robotic educator certificates. I am embarking on this research to see if the data also show this need.

Pilot Study

In the summer of 2022, I conducted a 10-week situated learning pilot study involving 25 pre-service teachers (PSTs). This experience for PSTs included a professional development

program on using ER and a robotics camp experience with students entering grades K-6. At both the beginning and end of the experience, the PSTs completed open-ended pre- and post-surveys. The pilot study was instrumental in refining the research methods and survey questions. For instance, an initial question asked, “What is your comfort level with using educational robotics in your classroom? Explain.” The responses varied significantly due to inconsistent self-assessment scales, making comparisons challenging, which led me to rephrase the survey questions. Another modification was administering the survey at three different points: before the training, after the training, and after the experience. This approach helped identify changes in the PSTs' perspectives based on their experiences throughout the 10-week semester. The pilot study revealed that most PSTs had little to no knowledge of ER and expressed significant apprehension about integrating robotics into an elementary classroom. This pilot study enhanced my desire and highlighted the need to explore this more deeply.

Research Questions

As teachers, our perceptions impact how we teach, including our perceptions about STEM (Bell, 2015). Perceptions of ER may be seen as a subset of STEM. Examining perceptions of ER is essential, and these perceptions within specific situated learning experiences could be especially useful in examining if the experience is positive and impactful for PSTs. With a positive experience in ER, PSTs may alter their perceptions, making them more likely to use ER in their classrooms.

1. What are elementary pre-service teachers’ perceptions toward educational robotics before participating in a 10-week situated learning experience?
2. How does participation in a situated learning experience impact elementary pre-service teachers’ perceptions toward educational robotics?

Setting and Participants

The participants include 24 undergraduate preservice teachers (PST) in the elementary education (K-6) teacher certification degree program of a mid-size public university in the Southeastern United States. The PSTs were enrolled in mathematics and science methods courses and classified as either juniors or seniors. The elementary education program offers courses for students within a cohort of learners, which means the students took classes together during the last four semesters of their program. The program offered the science and mathematics methods courses in the second of the four enrollment semesters. Students also enrolled in a language and literacy course and a classroom management course. This experience was their first field placement, which involved teaching a class of learners. PSTs enrolled in foundational courses the previous semester, including (a) Introduction to Elementary Education, (b) Elementary Mathematics Assessment, (c) Child Development, Learning and Assessment, and (d) Foundations in Literacy Instruction. These courses laid the groundwork for their development in teaching practices and subject-specific instruction. The literacy and child development course included opportunities to interact with young learners in a one-on-one setting. However, this semester did not involve experiences working with students in a whole class or group experience.

I invited all PSTs enrolled in these cohort courses to participate in the study. The coursework included the surveys as reflective opportunities. However, participation in the research study was optional and did not impact their success in the coursework. Prior to posting grades, the instructor did not know who consented or did not consent to participate. During week one of the situated learning experience, PSTs who chose to participate in the study signed an informed consent document as approved by the Institutional Review Board (Appendix A). All PSTs were able to respond to the survey as a reflective opportunity. Twenty-four PSTs signed

the informed consent form. All PSTs identified as female. Twenty-two reported their race as white, one reported their race as Black, and one reported their race as Persian. Table 2 outlines PST demographics.

Table 2

Pre-serve Teacher Demographics

		Count
Gender	Female	24
	Male	0
Race	White	22
	Black	1
	Persian	1

Data Collection

I collected several data sources, including open-ended pre-, mid-, and post-surveys (Appendix C) and interviews (Appendix E) to gather evidence about preservice teacher perception throughout the situated learning experience. In addition, during the data collection and coding process, I made observational notes about the interpretations and insights I had seen in the data. For example, pre-, mid-, and post-survey data observations influenced questions in the semi-structured interviews.

The 24 PSTs were invited to complete an open-ended pre-, mid-, and post-survey to inquire about their prior experience of using ER, perceptions of using ER, the possible benefits and challenges of using ER, and the types of skills/content standards they think ER will teach. Twenty-four PSTs completed the pre-survey to assess their perception and experiences with educational robotics before the 10-week situated learning experience.

In the second week of the situated learning experience, PSTs participated in a four-hour workshop introducing ER, ER types, ER platforms (VEX 123 and VEX GO), and hands-on opportunities to explore and use ER. PSTs also completed sample elementary classroom activities using robotics with math, science, and language arts connections. After the workshop, PSTs were encouraged to complete the online open-ended survey as a reflective experience. Twenty-two PSTs completed this mid-survey. In weeks three through ten, each PST spent one week at a robotics-themed summer camp with certified elementary teachers and one week at a summer camp that did not involve robotics. During the robotics-themed camps, PSTs worked with elementary students to teach content using ER. In week 10, 21 PSTs completed the post-survey about their experience and to note their perceptions at that time.

The pre-survey had 24 responses, the mid-survey had 22 responses, and the post-survey had 21 responses. There are two possible explanations for the attrition in the PST survey responses. First, I administered the pre-survey at the beginning of the robotics workshop, with all the PSTs present in person, and then the workshop began once they completed the survey. Having a designated time for PSTs to complete the initial survey versus the other surveys that were part of their independent tasks to complete in their learning management system may explain the larger response rate. Secondly, PSTs became busier with more coursework obligations throughout the semester, and those obligations may have impacted their decisions to complete the ungraded reflective opportunities the surveys provided.

At the conclusion of the 10-week situated learning experience, I emailed all the PSTs to ask for volunteers to participate in a semi-structured interview, and three PSTs agreed to participate. After the experience, I interviewed three PSTs using a semi-structured interview. I amended the interview questions based on my initial reactions from examining the data collected. I conducted and recorded the interviews using a video conferencing platform. This

platform created an initial transcription of the interviews. I then listened to the interviews to clean up the initial transcriptions and note any body language that might be important but would not be included on the transcript. I removed identifying information from the transcripts, condensed the separated lines to one speaker for readability, cleaned up any wording the platform misunderstood in the transcription, and added tags to identify when the speaker used non-verbal cues, laughter, and other expressions. Table 3 outlines the research questions and explains how the data collection and analysis align with each question.

Table 3

RQ, Data Collection, and Analysis

Research Question	Data Collection	Data Analysis
RQ1: What are elementary pre-service teachers' perceptions toward educational robotics before participating in a 10-week situated learning experience?	Pre-Survey Mid-Survey Post-Survey Semi-Structured Interview	A priori codes from TPACK framework and Thematic Analysis
RQ2: How does participation in a situated learning experience impact elementary pre-service teachers' perceptions toward educational robotics?	Pre-Survey Mid-Survey Post-Survey Semi-Structured Interview	A priori codes from TPACK framework and Thematic Analysis

Data Analysis

My original data analysis plan was to use inductive analysis for both the open-ended surveys and the semi-structured interviews. However, after my initial surface analysis of the surveys, I saw the themes of technology, content, and pedagogical knowledge in their responses. This initial analysis illuminated that the Technological Pedagogical and Content Knowledge (TPACK) framework would be an informative tool to organize and analyze portions of the data. Therefore, I analyzed the open-ended surveys deductively using the Technological Pedagogical and Content Knowledge (TPACK) framework. I also analyzed the open-ended surveys inductively with a thematic analysis approach. I analyzed the interviews with an inductive approach, looking for similar themes using a thematic analysis approach.

Deductive, or a priori coding, involves having the codes before data analysis from literature, a theory, organizational categories, or categories from literature or a theory. (Bingham, 2023). Using the TPACK, I reviewed the survey responses and categorized them based on where they would fit within the TPACK framework. I analyzed the pre-, mid-, and post-surveys during the same session to ensure similar responses were categorized appropriately. I printed all survey responses, cut them out, and attached them to a sheet of paper for the specific knowledge category. For example, if a pre-service teacher (PST) said teachers need to know "how the robotics work," I placed this on the Technological Knowledge category sheet. I looked at all seven knowledge categories for each survey: pre-, mid-, and post. See Table 4 for brief descriptions of each category.

Table 4

Technological Pedagogical Content Knowledge (TPACK) Definitions

TPACK Knowledge Categories	Definition
Technological Knowledge (TK)	Knowledge of technologies used in education
Content Knowledge (CK)	Knowledge about the content, including state standards
Pedagogical Knowledge (PK)	Knowledge about the teaching methods and practices
Technological Content Knowledge (TCK)	Knowledge of how technology tools enhance the content
Pedagogical Content Knowledge (PCK)	Knowledge of the best practices for teaching specific content
Technological Pedagogical Knowledge (TPK)	Knowledge of how technology can impact learning with specific pedagogical strategies
Technological Pedagogical Content Knowledge (TPACK)	Knowledge of how all these categories intersect and merge to effectively use technology tools in content areas and with particular pedagogy

Since the decision to use the TPACK framework occurred in the analysis phase rather than before the data was collected, a few survey questions and responses did not align with the framework. For example, the question, "Using a scale of 1-5, with 1 being not at all and 5 being daily, how often would you like to use educational robotics in the general K-5 classroom?" relates to the research question, but not directly to TPACK, which assesses knowledge rather than desire to use the technology. Out of a total of 225 responses, 35 did not fit into the TPACK

framework. I removed the responses that did not fit into the TPACK from the analysis using that framework; however, I did look at those responses in the thematic analysis of the open-ended surveys.

Thematic Analysis is a way to identify patterns of meaning across a data set that provide an answer to one of the research questions and is a method for identifying, analyzing, organizing, describing, and reporting themes found within a data set (Braun & Clarke, 2006). Patterns are determined through rigorous data familiarization, data coding, theme development, and revision (Braun & Clarke, 2006). Thematic Analysis involves a six-phase process for conducting analysis, which is sequential and builds on each other. The six phases are familiarizing with the data, coding, generating initial themes, reviewing, defining, naming, and writing. I reviewed the open-ended surveys and semi-structured interviews using thematic analysis for familiarization and assigned codes to similar texts. Then, I searched for themes, reviewed themes to verify they were present across the entire data set, and named and defined themes (Braun & Clarke, 2006).

I also used inductive, or open coding, when analyzing the surveys. In reviewing the surveys, I analyzed the data within sets. I looked at all the pre-survey data together to identify codes and themes. I used the same process when reviewing the mid- and post-survey data. I also analyzed the data across all surveys to identify changes or growth over time. Finally, I analyzed the data by person to review how the pre-service teacher (PST) responded to all surveys. Table 5 shows how I analyzed the data I collected.

Table 5

Data Analysis

Data Collection	*Analysis*	*Analyzed Responses within sets*	*Analyzed Responses across sets*	*Analyzed Responses by individual*
Pre-Survey	*A priori codes from TPACK Framework*	*X*	*X*	*X*
	Inductive using thematic analysis			
Mid-Survey	*A priori codes from TPACK Framework*	*X*	*X*	*X*
	Inductive using thematic analysis			
Post-Survey	*A priori codes from TPACK Framework*	*X*	*X*	*X*
	Inductive using thematic analysis			
Semi-Structured Interview	*Inductive using thematic analysis*	*NA*	*X*	*X*

Note – "X" indicates I analyzed the responses for that data set, and NA indicates it was not applicable to analyze the data in that way

As noted earlier, there was a decline in the number of PSTs who completed the surveys. In analyzing the data, I used all available responses when examining the pre-, mid-, and post-survey data separately and in aggregate. This approach allowed for a comprehensive view of the overall survey results. However, when analyzing data by individuals, I focused only on the 21

PSTs who completed all three surveys. This was necessary to assess their consistency and growth, as complete data from all survey phases was required to provide a complete picture.

I analyzed the data within three significant timeframes in the study: before the 10-week experience, during the 10-week experience, and after the 10-week experience. When looking at the data sets of the surveys from each of the three timeframes and examining changes by individuals across these three timeframes, situated learning theory was foundational in considering how the data varied throughout these situated experiences. In reviewing the data sets in this way, I identified five themes. I used the timeframes to investigate how the situated learning experience influenced the pre-service teacher's perceptions of educational robotics. The semi-structured interview themes that emerged were hesitation, challenges, student engagement, educational value, and confidence.

Credibility and Trustworthiness

Establishing credibility and trustworthiness is vital for qualitative research to be deemed responsible and accurate and for the research to be fully understood. Researchers can show credibility and trustworthiness in multiple ways to cross-check and ensure well-supported findings. In my research, I used an audit trail, triangulation, member checking, and peer debriefing to show credibility and trustworthiness.

An audit trail provides readers with evidence of the researcher's decisions and choices throughout the research process (Koch, 2004). Keeping a self-critical account of the research process is central to the audit trail (Nowell et al., 2017). I made observational notes of data throughout the research study, starting with the pilot study. After the pilot study, I changed the wording throughout the open-ended survey questions, added a mid-survey after the robotics training, and reworded some interview questions. Throughout the research and writing, I wove in evidence of the decisions and choices made along the way, including incorporating the

Technological Pedagogical and Content Knowledge (TPACK) framework after collecting and reviewing all the data to show transparency in my thoughts and motivations.

Triangulation combines two or more theories, data sources, and research methods to study a singular phenomenon (Denzin, 1970). Data triangulation uses multiple sources to develop a comprehensive understanding (Carter et al., 2014). According to Banik (1993), one of the most significant benefits of theoretical triangulation is its ability to provide a broader and deeper analysis of findings. I used data triangulation to compare surveys and interviews and look for consistency. I looked for themes and commonalities between the surveys and interviews. I also used theory triangulation in using multiple frameworks (Denzin, 1970). My research analyzed data using the situated learning theory and Technological Pedagogical Content Knowledge.

Observational notes from the pre-, mid-, and post-surveys were utilized to identify areas requiring clarification, enhancing the credibility and trustworthiness of the data. These notes played a critical role in refining the research process by highlighting ambiguities or inconsistencies in PST responses. This allowed for a more focused approach during the semi-structured interviews, as the insights gained from the observations helped shape the interview questions, ensuring they addressed areas of concern. The observational notes supported the data analysis and informed the structure and direction of the semi-structured interviews. For example, based on the information gained from the surveys, I asked questions about their experiences with the robotics workshop and the camp in the interviews. Because the interviews happened after the post-survey, they provided me a way to clarify, and the patterns and themes across all data held greater weight.

Member checking is a technique for participants to verify and confirm their meaning in a research setting. This process aims to provide credibility to the data (Elo et al., 2014). During

the interviews, member checking helped clarify and confirm understanding. When the PSTs responded to a question, I followed up with a clarifying statement before moving on to the next question. For example, when Jan was responding to a question about how she felt about robotics before the semester, she responded, “Honestly, confused. I was intrigued, but robotics always seemed like this subset category, maybe like an elective, like music or art, like something students who are interested in do. So I was interested to see how we would use it.” I responded, “So, if I understand correctly, you were confused but intrigued about robotics in education before the semester (Jan nodded). So, what about now? What do you think now? What is your comfort level with robotics?”.

After analyzing all surveys deductively with the TPACK framework and coding the semi-structured interviews inductively using thematic analysis, I contacted another researcher to serve as a peer debriefer. Peer debriefing is used in research when a colleague provides an external evaluation or perspective of the data analysis (Lincoln & Guba, 1985; Onwuegbuzie & Leech, 2006). A colleague who recently graduated with a doctoral degree in elementary education agreed to review portions of my data analysis for trustworthiness. When reviewing the pre-surveys using the TPACK framework, the peer debriefer identified three comments out of 225 that she needed clarification regarding whether they fit into the most appropriate knowledge category I assigned. While reviewing one of the semi-structured interviews and the codebook, she agreed with how I developed the codes and themes.

Summary

This chapter presents the methodology and design employed in this study, which aimed to explore PSTs' perceptions regarding integrating robotics in elementary education classrooms and the potential changes in these perceptions following a situated learning experience. The

research adopts a single case study approach, focusing on a cohort of 24 PSTs enrolled in a 10-week summer situated learning experience. This program includes professional development, coursework, and field experiences with elementary students, aiming to immerse PSTs in a situated learning environment. The choice of a case study is deliberate, aligning with the timeframe, location (a mid-size university in the southeastern United States), and participants (PSTs in the Elementary Education program) involved in the study.

Research questions focused on understanding PSTs' perceptions of ER and how these perceptions may evolve through participation in the situated learning experience. Data collection methods included open-ended surveys and interviews gathered throughout the program. I analyzed the data using thematic analysis to identify patterns and themes, focusing on ensuring credibility and trustworthiness through triangulation of data sources and member checking during interviews.

Chapter 4: Findings

This case study examined elementary preservice (PST) perceptions of educational robotics (ER) and how those perceptions evolved following a 10-week situated learning experience. I collected qualitative data through open-ended surveys and semi-structured interviews between May 2023 and August 2023. Pseudonyms are used throughout the dissertation when referring to PSTs. Through the data, I sought to answer the following research questions:

1. What are elementary pre-service teachers' perceptions toward educational robotics before participating in a 10-week situated learning experience?
2. How does participation in a situated learning experience impact elementary pre-service teachers' perceptions toward educational robotics?

Findings

In this section, I will present the findings from the collected data. I will begin by sharing the results from the open-ended survey, using the Technological Pedagogical Content Knowledge (TPACK) framework to categorize the responses deductively. Next, I will discuss the results of the thematic analysis of these surveys. Following that, I will explore the emerging themes from the semi-structured interviews. Finally, I will integrate the findings from open-ended surveys and semi-structured interviews to provide a comprehensive view.

Open-ended Surveys

I administered an open-ended survey (Appendix C) to participants three times during the research. A pre-survey examined research question one, while the mid- and post-surveys examined research question two. The pre-survey was given to 24 elementary PSTs before they

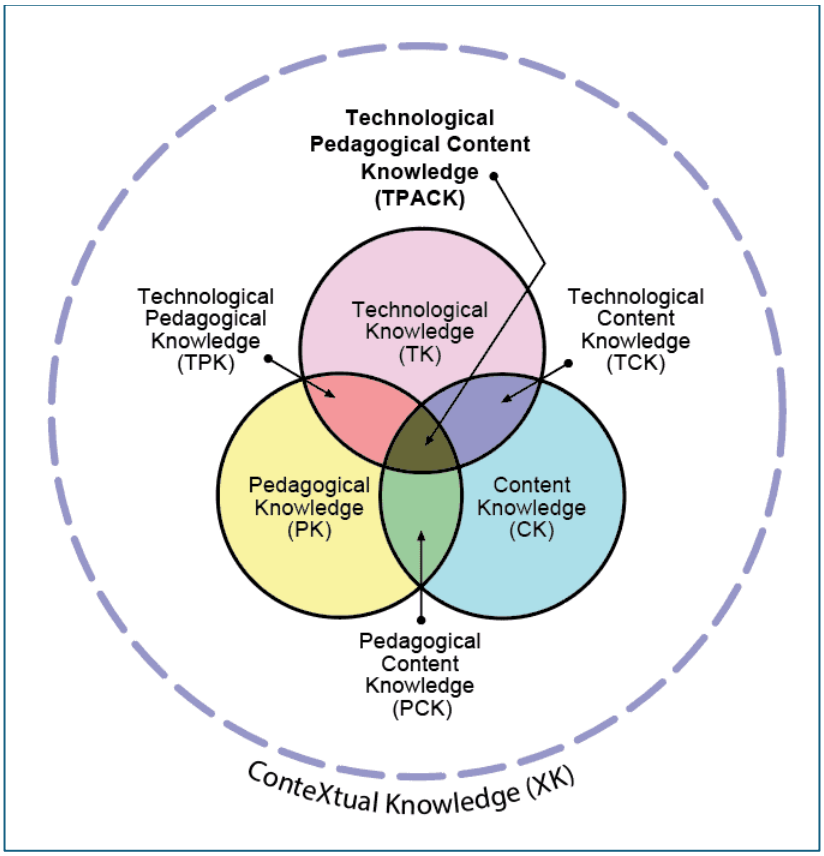
participated in the ER workshop to understand their knowledge and perceptions of the ER at the onset of the experience. At the end of the four-hour workshop, 22 PSTs chose to complete a mid-survey to gauge the change in knowledge and perceptions after a hands-on experience with the technology and among peers. Twenty-one PSTs completed the post-survey after they spent time in a summer camp with elementary students and cooperating teachers, which was the final part of their 10-week situated learning experience.

TPACK Framework

The analysis of the three surveys revealed patterns and themes that warranted using the Technological Pedagogical and Content Knowledge (TPACK) framework to analyze surveys deductively, which provided helpful information about my questions. I used deductive coding with a priori codes from the TPACK. TPACK, as explained in Chapter 2, describes the types of knowledge teachers need to successfully and effectively integrate technology into their classrooms. Technological knowledge (TK) is the knowledge of the technologies used in education and the ability to use those technologies for learning and organization. Content knowledge (CK) involves understanding the subject matter that teachers instruct. Pedagogical knowledge (PK) is the knowledge about the methods used to teach students. Figure 2, initially presented in Chapter 2, shows how the TPACK knowledge bases interact.

Figure 2

The Technological Pedagogical Content Knowledge (TPACK) Framework



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The other four pieces of knowledge that emerge from the combination of the three primary knowledge bases are Pedagogical content knowledge (PCK), Technological content knowledge (TCK), Technological pedagogical knowledge (TPK), and Technological pedagogical content knowledge (TPACK). PCK describes teachers' understanding of the best teaching practices for their content. TCK is the knowledge of how technology tools can enhance and transform the content with students. TPK describes how technology tools can impact students' learning when combined with specific pedagogical methods. The TPACK framework explains what knowledge teachers must have to integrate technology and helps teachers

purposefully and successfully integrate technology into their classrooms. TPACK can provide insight into teacher perceptions of using technology in the classroom. Table 6, initially presented in Chapter 3, defines the TPACK knowledge bases.

Table 6

Technological Pedagogical Content Knowledge (TPACK) Definitions

TPACK Knowledge Categories	Definition
Technological Knowledge (TK)	Knowledge of technologies used in education
Content Knowledge (CK)	Knowledge about the content, including state standards
Pedagogical Knowledge (PK)	Knowledge about the teaching methods and practices
Technological Content Knowledge (TCK)	Knowledge of how technology tools enhance the content
Pedagogical Content Knowledge (PCK)	Knowledge of the best practices for teaching specific content
Technological Pedagogical Knowledge (TPK)	Knowledge of how technology can impact learning with specific pedagogical strategies
Technological Pedagogical Content Knowledge (TPACK)	Knowledge of how all these categories intersect and merge to effectively use technology tools in content areas and with particular pedagogy

I designed the open-ended survey to address the research questions and planned to use thematic analysis; therefore, my questions did not directly address the PST's TPACK knowledge. However, the survey asked questions about their experiences, prompting PSTs to refer to the knowledge bases in TPACK. Data analysis revealed that using the TPACK framework would allow me to evaluate their initial perceptions within a well-established framework that explored their TPACK knowledge bases and track how these evolve throughout the situated learning experience. Using the TPACK framework for the pre-survey helped me examine research question one, and I used the data provided by the mid- and post-surveys to examine research question two.

Technological Knowledge (TK)

TK is the knowledge of the tools, platforms, and digital technologies used in the classroom. It includes knowing what technology exists, how to use the tool, and how to use technology to enhance learning. The open-ended survey did not ask specific questions regarding the PST's technological knowledge; however, several questions about their experiences prompted the pre-service teachers (PST) to emphasize the importance of robotics knowledge in their responses. For example, the question asked, “What does a teacher need to know to use educational robotics in the general K-5 classroom effectively?” Many wrote about needing to know what robotics is, how to use robots, how to program robots, and how to troubleshoot and fix common issues, all of which show that technology knowledge is imperative for teachers to use ER effectively. For example, in the pre-survey, Amy said, “Teachers need to have a basic understanding of design and operation of robots,” Carol said, “A teacher should have a thorough understanding of technology and robotics.” In the pre-survey for these questions, 23 out of 24

PSTs included the importance of technology knowledge in their responses, which made it clear they knew technological knowledge (TK) was essential to using ER in the classroom.

Another survey question that prompted PSTs to respond about technology knowledge was, “What are the challenges of using educational robotics in the classroom?”. PSTs identified challenges such as teachers not knowing how to use robotics and concerns about cost and difficulty level. Again, these challenges relate to the importance of the teacher having technological knowledge. In the pre-survey, Dee said, “The challenges of using educational robotics are that many teachers have never been instructed in robotics, and therefore facilitating it can be difficult.”

As the study progressed from the pre-survey to the mid-survey and post-survey stages and while examining the data from PSTs over time, responses became less focused on the challenges of TK in using robotics in the classroom. In the pre-survey, six PSTs identified technological knowledge as a challenge. The challenge was mainly related to teachers not knowing about ER. Olivia said, “It would be hard for educators to teach students something that they know nothing about themselves,” Sandy said, “The biggest challenge is to understand robotics.” This number increased from six to seven in the mid-survey but dropped to only two in the post-survey. The challenge of TK in the beginning was the challenge of not knowing about ER. In the post-survey, the challenges related to technology knowledge were issues that could arise when using robotics, such as the need to fix the robot, rather than the earlier general comments about being unfamiliar with ER. Olivia said,

> “As with all technology, sometimes robots just do not work the way they are intended. It could be because of a dead battery, or a button breaks, but unexpected

problems can come up. Because many teachers do not know how to troubleshoot robots, it would be hard to solve these problems on the spot."

Content Knowledge (CK)

CK is the teacher's understanding of the subject they are teaching, including state standards. Three survey questions prompted the PSTs to refer to content knowledge for subjects taught in elementary school: "What are some content standards that educational robotics could support for learners in the general education classroom?" "If educational robotics is used in a general education classroom, what subjects would be most appropriate and why?" and "What types of skills do you think educational robotics could teach?"

For the question about content standards, PST's answers ranged from listing specific course of study objectives, subjects, or skills in the pre-, mid-, and post-surveys. Some PSTs listed specific grade and subject-level content standards from the Alabama Course of Study Objectives. For example, Sandy listed a third-grade science standard in the pre-survey,

"3. 1. Plan and carry out an experiment to determine the effects of balanced and unbalanced forces on the motion of an object using one variable at a time, including number, size, direction, speed, position, friction, or air resistance (e.g., balanced forces pushing from both sides on an object, such as a box, producing no motion; unbalanced force on one side of an object, such as a ball, producing motion), and communicate these findings graphically."
Also, in the pre-survey, Dee responded, "Science and math content standards could align with robotics." In the mid-survey, Ann said, "Estimation, measurement, addition, subtraction, skip counting, story sequencing."

In the survey question about the subject area where somebody could use ER, PSTs listed specific subjects. For example, in the pre-survey, Melissa responded, "Science and math

because that is what I think is involved the most in robotics," Lisa said, "In my mind, education robotics would be best taught during the science and math subjects." While math and science were the most common responses in the pre-survey, 24 stated math or science; this changed in the mid-and post-surveys, with more PSTs responding to additional subjects. In the mid-survey, Melissa replied, "All subjects! I learned today you can use it for sequencing in a story! I thought it was just for math and science, but it's not!" and Amy said, "It could be paired with math, science, or language arts." Table 7 shows the subject areas a teacher could use ER in the PSTs listed from the pre-, mid-, and post-survey.

Table 7

The number of responses for each subject from survey question eight, "If educational robotics is used in a general education classroom, what subjects would be most appropriate and why?"

Subject	Pre-Survey	Mid-Survey	Post-Survey
Math	**13**	**13**	**14**
Science	**11**	**8**	**7**
English/Language Arts	**3**	**2**	**3**
Technology	**1**	**1**	**4**
History/Social Studies	**1**	**0**	**0**
All Subjects	**0**	**9**	**8**
Other	**5**	**6**	**0**

The types of content changed from the pre-, mid-, and post-surveys. In the pre-survey, PSTs responded mainly to math and science, meaning ER is most appropriate in those subjects. As Table 7 shows, 24 participants stated that robotics could teach math or science content in the

pre-survey, and no PSTs believed it could be used in all subjects. In the mid-survey, twenty-one PSTs specifically mentioned math and/or science, while nine indicated that robotics could be integrated into all subjects The post-survey still had the highest responses in math and science, with eight saying all subjects. It is important to note that the number of PSTs that said ER could be used in all subject areas and science dropped from mid- to post-survey; however, the decline in the number of participants who responded to the survey could have affected this response, or it could be as they switched to all subjects, they no longer included individual subjects. In the post-survey, more PSTs listed technology as a subject. Technology content was missing from the reactions from the first survey but included in the other two surveys. A few PSTs listed skills like critical thinking, following directions, or sequencing instead of subjects, and I included those in the table as "other."

Pedagogical Knowledge (PK)

PK is the knowledge about the methods and strategies of teaching and learning. This includes knowledge about instructional methods, assessment techniques, classroom management, and how students learn in different contexts. While there were no survey questions directly related to pedagogy, a few responses fit into this category. In the pre-survey, seven responses related to pedagogical knowledge; in the mid-survey, there were eight; and in the post-survey, there were 14 responses. The data showed an increase in knowledge that the teaching method, lesson plan development, and classroom management were necessary even though pedagogy was not directly mentioned in the robotics workshop. It is important to note that none of the responses included the word "pedagogy." For example, Christine said a challenge was "organizing and relaying all procedures," Julie said, "Teachers need to know how to keep their students on task to be effective at using educational robotics." Ann said, "Some challenges may

be that some students won't be interested in it or that it may be too hard," which are all examples of pedagogy or note the importance of pedagogy to connect with learners.

Technological Content Knowledge (TCK)

TCK involves understanding the relationship between technology and content areas and how adding technology can transform the content of a lesson. Significantly few responses included technological content knowledge (TCK). In the pre-survey, six comments related to TCK, ten in the mid-survey, and five in the post-survey. While there were no specific questions in the survey about TCK, PSTs responded to the challenges of using ER in the classroom by listing difficulties integrating technology into content. For example, in the pre-survey, Rebecca said a challenge would be "relating the robotics to standards for younger grades." Ann said, "Another challenge is that an educator may have difficulty integrating into their curriculum" in the mid-survey.

Pedagogical Content Knowledge (PCK)

PCK is understanding how pedagogy relates to the specific content that teachers instruct. None of the survey responses mentioned how pedagogy connects to subject content. However, in the pre-survey, Dana responded to the benefit of using robotics, "I think there are several benefits to using educational robotics. It allows students to have more hands-on experiences." In the mid-survey, five PSTs stated that using robotics provided hands-on or interactive teaching methods. These all relate to the pedagogy of teaching robotics (TPK) but not necessarily the pedagogy of a specific content area.

Technological Pedagogical Knowledge (TPK)

TPK involves understanding how technology can change teaching methods, including the available tools and the ability to choose the tools that best suit specific pedagogical practices.

Several questions in the survey, including “What are the benefits of using educational robotics in the classroom?”, “What types of skills do you think educational robotics could teach?” and “What are the challenges of using educational robotics in the classroom?” prompted PSTs to discuss how educational robotics transforms teaching. In the pre-survey, PSTs said integrating educational robotics into the classroom encourages collaboration with technology, problem-solving, and teaching skills like critical thinking and teamwork. In the pre-survey, Kim said, “It can educate students on working together.” PSTs in the pre-survey said that challenges would include teachers not knowing how to use the robots in the classroom, it being difficult for students not to be interested, it being too hard, causing frustration and confusion in students, and it being a distraction. Ann said, “Some challenges may be that some students won’t be interested in it or may be too hard.” The quote above, in the PCK section, could also fall under this area of TPK.

After the robotics workshop, the mid-survey responses primarily focused on the benefits and skills ER could teach. Only three PSTs listed a challenge related to TPK. Julie said, “Educational robotics may take up too much instruction time. I would fear that a lesson might get away from me if I didn’t allow the right amount of time.” Jessica responded, “Sometimes they might not work, or sometimes they might be too difficult for some students.” Oliva said, “Students may be distracted because it is like a game.” The other connections to TPK included that when robotics are used, it could teach teamwork, communication, perseverance, and differentiation. Nicole said the skills ER could teach are “patience, teamwork, and strategy.” Christine said a benefit of using ER in the classroom was to “provide differentiation, enhancing material, and incorporating technology.” Lucy said ER could teach skills like “teamwork,

communication, and failure." Eight PSTs mentioned perseverance in what skills ER could teach or how ER could benefit students.

In the post-survey, PSTs continued to mention TPK in response to the benefits and skills of using ER, while TPK decreased in terms of challenges. Kim was the only PST to mention TPK as a challenge: "Some students may not like using that much technology or robot-related stuff, so it might be difficult to keep some kids engaged if it is too hard for them to manage their robot."

Technological Pedagogical Content Knowledge (TPACK)

TPACK is a comprehensive model that combines all the knowledge domains mentioned above: TK, PK, CK, TCK, TPK, and PCK. By integrating these domains, educators can create and apply instructional strategies that blend technology, pedagogy, and content knowledge. However, no PST responses included all the knowledge domains in TPACK. The survey was developed to examine PST perceptions of ER without a specific focus on TPACK. Therefore, the absence of TPACK in the responses may be due to the questions asked.

Outliers and Inductive Coding

First, I examined the open-ended surveys through inductive, thematic coding. As I made my initial passes to become familiar with data, coding, and generating initial themes, I realized the connection to some of the knowledge domains in TPACK. This realization shifted my data analysis to a more deductive approach using the TPACK framework. However, since some survey questions did not align with TPACK, I continued to look at those inductively.

Three questions did not fit into the TPACK framework anywhere: "Using a scale of 1-5, with 1 being not at all and 5 being daily, how often would you like to use educational robotics in the general K-5 classroom?". Table 8 illustrates how responses about the frequency of ER use in

the classroom changed across the pre-, mid-, and post-surveys. For example, with the three being in the middle of the scale, three PSTs responded with three in the pre-survey. There were 17 that responded with three in the mid-survey and 13 with three in the post-survey.

Table 8

Responses from survey question four, "Using a scale of 1-5, with 1 being not at all and 5 being daily, how often would you like to use educational robotics in the general K-5 classroom?"

Survey	Not at all (1)	2	3	4	Daily (5)
Pre	**1**	**12**	**10**	**0**	**1**
Mid	**0**	**2**	**17**	**2**	**1**
Post	**0**	**6**	**13**	**1**	**1**

Overall, there were few changes in the PST responses to this question. However, there were changes in the number of PSTS that responded with a two on the scale. This number dropped from the pre- to mid-survey, then went back up post-survey. It is important to note that the PSTs took the pre-survey before gaining any experience with the ER in a room where they knew they were about to participate in an ER workshop, which may have impacted their openness to using them. The PSTs completed the mid-survey after the robotics workshop. This decrease from pre- to mid-survey could be the PSTs seeing the possibility of using ER in all subject areas and their increase in confidence. Again, it is important to note that the PSTs took the post-survey after their classroom experience with ER. This increase from mid- to post-survey could have been due to their classroom experiences. PSTs recognized the benefits of using ER but realized that they might not need to use it as frequently. It is also interesting that the one response from each survey, that responded with a "5" for daily use was from the same PST.

The second question that did not fit into the TPACK framework was, “Should educational robotics be utilized in the general K-5 classroom? Why or why not?”. In the pre-survey, 22 PSTs said yes, and two said they didn’t know; in the mid-survey, 22 PSTs said yes, and 21 PSTs said yes in the post-survey. Due to the attrition in survey responses, this question essentially showed no change over the three surveys.

The third question that did not fit into the TPACK framework was, “Describe any experiences you have had with educational robotics. If you have not had any experiences, please state that.” This question is important to assess their initial perceptions. Knowing if the PSTs have any experience in ER helps illuminate their initial perceptions, which correlates to research question one. If a PST came in with previous experience with ER, their perceptions might not change through the experience, as they might feel more familiar with the concepts and tools. In general, PSTs responded to this question based on their experience at that moment in time. Table 9 shows how the PSTs responded to this question from the pre-, mid-, and post-surveys.

Table 9

Responses from survey question one, "Describe any experiences you have had with educational robotics. If you have not had any experiences, please state that."

Survey	No Experience	Exposure to Robotics through sibling or friend	Experience in Technology Class	Robotics Workshop Experience	Camp Experience
Pre	**18**	**3**	**3**	**0**	**0**
Mid	**0**	**1**	**2**	**21**	**0**
Post	**1**	**1**	**0**	**9**	**21**

From this question, Ann's responses from all three surveys were: pre-survey - "I have not had any experience with educational robotics"; mid-survey - "I took a robotics class with Mrs. X today, so I have knowledge working with robots and coding" and post-survey - "I took a training with Mrs. X and attended a week-long robotics camp." This example shows that PSTs referred to their most recent experience. There was one PST, Melissa, whose responses did not line up with her experiences from the situated learning experience, as she said she had no experience on the pre-survey; on the mid-survey, she said, "I just did a whole class on robotics!! We coded and built a robot! I also drove the robot!", and in the post-survey, she again said she did not have any experience. It is also important to note that the number of PSTs who recognized all the activities from the situated learning experience was low, as only seven PSTs in the post-survey listed all their robotics experience.

While certain survey questions gave information that wouldn't fall clearly in the TPACK framework, throughout the survey, there were also responses to other questions from PSTs that did not fit into the TPACK framework anywhere. Some of these responses were when a PST said they were "unsure" in response to a survey question or when they were not specific, like "The benefits they have for students." Out of 225 responses, 35 did not fit into the TPACK framework. I analyzed those responses that did not fit in the thematic analysis of the surveys.

Semi-structured Interviews

I asked all pre-service teachers (PSTs) to participate in a semi-structured interview about their experiences in the 10-week situated learning experience. Three PSTs agreed to participate. I conducted the interviews online using Zoom's cloud-based video platform. The questions in Appendix F guided the interview, and I added some questions based on the PST responses.

All three PSTs interviewed were juniors who identified as women; two reported their race as white, and one as black. I interviewed all three PSTs after the 10-week situated learning experience, and the interviews averaged about 30 minutes in length. I assigned pseudonyms to ensure confidentiality.

The Situated Learning Theory provided the framework for the semi-structured interview questions about the PST's perceptions about the 10-week experience and ER. I formed the questions around the three identified time frames: before the 10-week experience, during the 10-week experience, and after the 10-week experience. I integrated constructivist and situated learning theories into the data collection and analysis process by collecting opinions and personal accounts of PST's experiences during the 10-week experience. I examined research question two using Situated Learning Theory and semi-structured interviews.

Pre-Service Teachers' Background Information

The pseudonyms for the three pre-service teachers (PSTs) I interviewed were Lucy, Olivia, and Jan. I asked about their K-12 educational backgrounds to better understand their perceptions and experiences with robotics. All three participants had limited technology experiences, impacting their perceptions of classroom robotics. I am sharing the background information for the three PSTs to show that although they grew up in different towns and had different schooling experiences, the limited use of technology was a common thread. The details of the PSTs' backgrounds offer insights into their personal lives, including their K-12 education and experiences with ER and technology. This background serves as the foundation for their initial perceptions of ER.

Lucy

Lucy grew up in the same town where she went to college. She explained that she was familiar with the area, which kept her there for college, "I've always lived here, so it was just familiar." Lucy described her educational background as a good experience with the teachers who became the support system she did not have at home. "I didn't have a support system at home. So I really found that at school with a few teachers". Lucy also explained that these same teachers were part of why she wanted to become a teacher, as she wanted to provide that same support to other students. "I want to be able to provide that love and support to a student." Lucy attended the local public school system from K-12, which has a very high reputation. Lucy described her technology use in K-12 as limited to using a SMARTBoard as a presentation tool, laptops and iPads in junior high and high school for assessments, and the occasional slide show presentation. "Honestly, it wasn't until I was older that we really started using technology

because growing up, it was really just SMART Boards." She was not exposed to robotics at all in K-12.

Olivia

Olivia grew up in a small town in the same state where she later attended college. She chose that college because her father was an alumnus. "My dad went to XXX, so that's a big reason why I went there, just because I always knew it was good." During her K-12 education, Olivia attended an elementary magnet school and was homeschooled for middle and high school. While homeschooled, she enrolled in a junior college for dual enrollment during high school. "In elementary school, I went to a magnet school, and then once I got to middle school, we moved, and my parents didn't want to put me in the school system there, so I was homeschooled," Olivia explained that her desire to become a teacher stemmed from her lifelong love of school. Technology usage for Olivia was limited and included slide show presentations, an interactive whiteboard in elementary school, and computers for online programs in high school. "When I was in elementary school, we had PowerPoint display, like the SMART Board where you touch it and everything. When I was homeschooled, we did an online program. So did use a computer. But other than that, we didn't really use much technology. I'm really not great with technology."

Jan

Jan was the only PST interviewed who did not grow up in the same state where she attended college. She also had no personal connection to the college but chose it because it felt like home when she toured. "I knew I wanted to go out of state for college. The schools in my area were not the culture and community I want to surround myself with, so I toured around, and like X just felt right, like I just felt at home." Like Olivia, Jan's K-12 experiences varied from private school from kindergarten to first grade, charter schools from second grade to fifth grade,

homeschooled from sixth through eighth grade, and then returned to private school for high school. Jan was interested in elementary education because of her teachers throughout her K-12 career. She wanted to mentor children to "break the cycle of brokenness" because education can "play a really big role" for those in "poverty." Another common thread between Oliva and Lucy was their experiences with technology: an interactive whiteboard, iPads, and computers. Although Jan had similar technology experiences, her forensic class in high school exposed her to 3D printing. Jan also mentioned a large STEM lab at high school that she was not permitted to go into because she did not take any of those classes.

" We did use a SMART Board. I know we had iPads that we would use and computers in high school. My high school had a large STEM room and 3D printing. I never took any of those classes, so I never got to go there. We did one thing in forensics, which was a 3D printing thing, for our project, which was so fun and cool. But the basic things in school is the technology that I used."

Themes

I analyzed the data with specific attention to responses during three major time frames that coincide with their introduction to educational robotics and the situated learning theory: before the 10-week experience, during the 10-week experience, and after the 10-week experience. In my first pass with the data, I read through the interviews multiple times to become familiar with the data. Once familiar with it, I began reading through the data and assigning first-round codes. Some of my initial codes were technology, before perceptions, after perceptions, and background. Upon subsequent rounds with the data, more specific codes were developed, such as uncertainty, challenges, and positives of using ER. In the final steps, I combined similar codes into themes. Within each time frame, I identified themes that reflect

how the PSTs responded to questions from the semi-structured interviews. It is important to note that my codes are not mutually exclusive, meaning that data can be assigned to multiple codes simultaneously, and therefore, themes can overlap. For example, when looking at student engagement and educational value, some of the quotes could fall into both themes.

Before the 10-week Experience

In the semi-structured interview protocol (Appendix F), several questions prompted PSTs to describe their background, including their prior experience with technology and educational robotics. In their background, Lucy, Olivia, and Jan described a positive experience in their K-12 education with limited technology use. All three mentioned using a Smart Board and computer, while Jan and Lucy also used iPads. Jan's iPad use was occasional in her K-12 experience; however, Lucy had a one-to-one iPad experience from 10th to 12th grade. Through these experiences, all three PSTs were about using ER and thought they would need a lot of support.

Hesitation

Overall, the interviewed PSTs were reluctant to use educational robotics due to their lack of experience. They all came into the experience with no knowledge of educational robotics and perceptions about needing to be qualified to use it. There were comments of being confused and uncomfortable. At the beginning of the 10-week learning experience, when asked if her prior experience helped prepare her for the classroom of today and how she felt about robotics coming in, Jan said,

> "I definitely did not like robotics coming in. I had no idea how to work anything like that. I feel I can somewhat work on an iPad, a computer, and a SMART Board, so I feel prepared. Honestly, I was kind of a little bit confused. I was intrigued, but I was

like, robotics always seems like this subset category, maybe like an elective, like music or art, like something for students who are interested. So I was like, how does that work?"

Lucy described her comfort level with technology as "pretty comfortable just because I've grown up in a society where we rely on it every day, but then doing robotics things and taking the technology classes, I'm really not that comfortable." When asked about her experience with robotics before the semester, Lucy said, "Honestly, nothing. This was the first for me."

Olivia admitted that she struggled with technology: "I'm really not great with technology." She also mentioned her lack of experience with robotics: "I didn't have any robotics experience growing up in the classroom."

Part of their hesitation was also related to the support they believed they would need to support the use of ER in their classrooms. Lucy said, "I definitely need training or a course on that to be familiar with and implement it because I wasn't exposed to it. While Olivia focused more on not knowing about the different types of available ER and needing support that way, "I don't know what all the options are." Jan would rely on her own research to gather more information about robotics, "I would do more research, but I feel like I could." While this theme of hesitation was prevalent throughout the semi-structured interviews, it was reduced once the situated learning experience began.

During the 10-week Experience

In the semi-structured interview (Appendix F), PSTs discussed their involvement in the robotics workshop and the summer classroom experience, working alongside a master teacher and elementary-aged students. These activities were integral to the teachers' situated learning environment. I focused on their reflections over the ten weeks to understand how their

perceptions evolved. This focus aligns with my research questions, which explore how perceptions shift during a situated learning experience.

Challenges

During the experience, the PSTs noted challenges associated with using ER. Occasionally, there were technology issues with the robots, like something not working correctly and not being able to clearly explain why. They described scenarios of attempting to troubleshoot a problem and being unable to help the students. Another challenge was keeping students on task and managing the robots in the classroom.

Lucy felt a challenge was being unable to help, "I wasn't able to help much because I wasn't exposed to it. I felt uncomfortable. I want to feel confident if I were to implement in my classroom". Similarly, Jan mentioned challenges with the class, "It was a hard class" and "If that was my first experience teaching, I would be very concerned." While Olivia felt the challenges were more of the troubleshooting,

> "Well, for teachers, it's kind of intimidating because, like with technology, you don't know what will go wrong. And I know when I did a robotics station, we had a lot of problems with the robots; half of them just would not work. And that was an obstacle like trying to go around and not let the students get discouraged."

Olivia also mentioned the challenge of students staying on task, noting the positives and negatives,

> "Some of the students looked at it like too much of a game almost, like they wanted to play with their robots and race them down the hall, so they kind of got out of hand with that. But, I mean, there's a good thing to that, too. They were interested and wanted to see how the robots worked.

Student Engagement

They all noticed increased student engagement when using the robot during specific times. For example, Jan noticed that a few students who struggled sitting still and listening to a read-aloud would quickly become engaged with the hands-on robotics portions of the class, which she mentioned when describing a challenge of the "hard class."

> "It was kind of sweet even to see, like the way that when you add robots in, like the kids, that they would not sit and listen to a book, but if they like could get to engage with and use their robots for an activity at the end, that like made them a lot more engaged and want to pay attention. So it was cool to see, like, the impact that adding robots into the classroom actually helps a great deal with classroom management."

Olivia also spoke about student engagement,

> "You can use it in so many different subjects that make school not boring because I know we did robotics to help students learn even and odd numbers. And, like, to some, that really would seem like a boring concept to kids. But just using that to make the learning process more engaging and fun, I feel like you'd help them remember it more, rather than just giving a lecture on even and odd numbers like they're going to remember."

Lucy discussed the students' excitement and realized teachers could add these tools to the classroom.

> "Students were definitely excited about it. And so that was cool. They liked the freedom. It helps me to keep in mind that, like, I can teach and stay on curriculum and the standards that I want them to get from that, but they still have the freedom to bring in their interest to the classroom".

After the 10-week Experience

In the semi-structured interview (Appendix F), I asked questions about their future use of robotics in the classroom and asked them to describe what "teaching with robotics" means to them. These questions were important to learn more about the lasting effects of the situated learning experience, as the interviews took place afterward. I focused on their reflections after the experience to understand how their perceptions evolved from beginning to end. Again, this focus aligns with my research questions, which explore how perceptions shift during a situated learning experience.

Educational Value

All three PSTs identified robotics as having solid educational value when used in the classroom. They discussed using ER in all subject areas, helping teach soft skills like teamwork, and seeing how excited the students got. Lucy talked about student excitement with ER, "Students were definitely excited about it. And they were able to design things they were interested in. It wasn't like, you have to make this the way I wanted them to. And so they liked that freedom". She also talked about ER helping teach soft skills,

> "It also gives them the opportunity to work with other people. I realized that other students are scared to ask teachers questions but feel more comfortable asking their friends. We learn a lot in classroom management, and it is not just about teacher and student interactions; student and student interactions are just as important, and I feel like I have to give them opportunities to do that."

Olivia had some of the same thoughts about the educational value.

> "They all got to, like, choose their plan for, like, which robot they wanted to build, and they got to choose the process of how they wanted to build it and how they

wanted to work in their teams and stuff. So it had a lot of creativity, and they weren't closed into a box. In school, it feels like you have to do this step, then this step, and this step, and it's the only way you can do it, or you're wrong. But they had a lot of creativity and had to use their own minds. I think that made it fun for them."

Olivia mentioned all the different subjects on which you could use ER, including using it to teach soft skills and student engagement.

"It allows the students to look at school in a fun way. I think. As I said earlier, you could use it in many different subjects that make school not boring. It makes the learning process more engaging and fun, and I feel like you'd help them remember it more, too, rather than just like you giving a lecture. Then, it helps them like and think critically about stuff. They worked a lot on communications throughout the week. We had a few that struggled to be around each other, but by the end of the week, they learned how to say, I disagree with you respectfully, because they learned how to communicate and solve those issues."

Jan also shared her thoughts on the educational value of ER.

"The idea of using technology like robotics to create a classroom space where students are more readily engaged. You can integrate technology into different content areas. And I just like how it all helps students understand the content easier. It helps with classroom management, all the things."

Jan made a connection between robotics and failure,

" I feel like it helps with the things you can't teach, like teamwork, like you have to learn how to work in a team, and creativity. Or, like, in robotics, you're bound to fail. And I feel like at least that was my experience. I did not know how to deal with failure at

all, growing up. I was such a perfectionist. And it was crippling where it's like, if I were to have had an experience with something where it's like normalized to fail, what it's like to fail that helps set you up for success, kind of realizing this is a normal thing. It's like those lessons that I feel robotics teaches that you don't learn in school."

Confidence

All three commented that their confidence in the ER increased after the experience. Olivia commented that she was ready to use the ER in her classroom,

> "I would love to use robotics. I didn't have any robotics experience growing up in the classroom, but after getting experience with the camp, I realized that it was so fun, and the students loved it. So I would definitely use them."

Jan said she could use the robot she used during the experience, but she would need additional support if it were a new robot.

> "I would say, the basic robots; having the experience at camp with the VEX 123, I'm an expert on those things now, and I could definitely do it. I would do more research if we decided to step it up a bit. But I feel like I could. There are different ways to integrate robotics in the classroom that I'd feel comfortable with."

Olivia appreciated the experience, which gave her some knowledge of ER and confidence in using them, " If you asked me that before camp, I probably wouldn't have known." When asked about her thoughts or feelings about using ER in the classroom, Olivia said, "I want to." Still, she expressed concerns about not being well prepared, "I'm nervous, honestly, because we only had one EDMD class that helped us a little bit, but even then, I feel like maybe there should be an additional course."

The PSTs also wanted to expand their use of all technology in their classrooms beyond what they had experienced. When asked if she thought she'd use technology in her classroom, Olivia said,

> "I'd like to expand on what I used, not just to use the SMART Board, but maybe build more. I would love to use robotics. We also learned about all the different subjects you can use it in; it's not just a technology thing. You can also use it in math, language, and reading. I think it just makes school more fun. So I would definitely love to use that."

Olivia also said, "I definitely could teach robotics at this point. I feel like I could go into a classroom and do it." Lucy shared her thoughts after the introduction to robotics,

> "Honestly, excited, because, first being able to do it and learning what it looks like, you make us do it. That helped. But also, I saw the different ways it can be used, not only for math, which I thought it could only be used for, but for literacy, learning how to spell, and stuff like that. So it was really cool to experience and learn more about it."

Surveys and Semi-Structured Interviews: A Combined Approach

As noted earlier, I analyzed the survey data using the TPACK framework and thematic analysis. My thematic analysis confirmed the themes identified through the semi-structured interviews and introduced two additional themes. Thematic analysis of the pre-survey, before the 10-week situated learning experience, examines research question one. Thematic analysis of the mid-survey, after the ER workshop, examines research question two. Finally, at the end of the situated learning experience, thematic analysis of the post-survey examines research question two.

Much like the semi-structured interviews, the theme of hesitation was evident in the pre-survey from PSTs from their responses. For example, on the pre-survey, 18 PSTs said they had no experience with robotics, three said they had some exposure from a sibling or student, and three said they had some exposure in a college class. This lack of experience led them to answer the question about what subjects would be most appropriate for ER, and they overwhelmingly responded with math and science (Table 7). Also, the challenges PSTs noted in the pre-survey were that teachers didn't know about robots, that robots were too hard for students, and that robots cause confusion and stress. Jessica said, "Some challenges could be that some students aren't ready for it, and it just makes them more confused and stressed." From Dawn, "It may be very challenging or confusing for students whose minds do not think in that capacity. Tracey said, "I do not know much about robotics, but I feel as though if I were given just basic instructions on how to best instruct my students, I would be an effective robotics teacher." On the question about how often ER should be used in the classroom (Table 8), 13 of the students believed it should be on the lower end of the scale, and this number changed by the post-survey to six.

The theme of challenges was also seen in the surveys and semi-structured interviews. On the mid-survey, PSTs noted challenges with using ER with their knowledge acquired from participating in the workshop. The PSTs listed fourteen different challenges. For example, PSTs said money, time, teacher knowledge, teacher resources, students may not like them, and more. Similar challenges also appeared in the post-survey. PSTs again mentioned time, money, teacher knowledge, teacher resources, and students may not like them. However, they also listed new challenges that developed after their classroom experience with ER. Two new challenges were aligning ER to standards and students arguing. Another challenge that was similar to the semi-

structured interviews was technology issues. In the mid-survey, one PST only listed the technology issue PST; however, in the post-survey, four PSTs mentioned technology issues or troubleshooting problems with ER. Olivia talked about technology issues in both the semi-structured interview and the post-survey. In the semi-structured interview, she said, "When I did a robotics station, we had a lot of problems with the robots, like half of them just like, would not work. And so that was an obstacle." In the post-survey, she said a challenge was, "As with all technology, sometimes robots just do not work they way they are intended. Unexpected problems can come up. Because many teachers do not know how to troubleshoot robots, it would be hard to solve these problems on the spot". These challenges were not present in the pre-survey due to the lack of experience the PSTs had with ER.

The themes of student engagement and educational value were evident across both data sets. On the mid- and post-survey, PSTs included student engagement and educational value in their responses, correlating to semi-structured interviews. Their responses to the question about which subject areas would be most appropriate for ER highlighted its educational value. In the pre-survey, 24 responses mentioned math and/or science, and none suggested all subjects. In the mid-and post-surveys, math and science remained the most frequently mentioned subjects; however, nine mid-survey students and eight post-surveys indicated that ER could be suitable for all subjects. PSTs also included engagement and educational value in describing the benefits of ER and the skills ER can teach. PSTs said ER makes learning fun, is interactive, teaches critical thinking and problem-solving, and fosters an interest in STEM.

Confidence was also seen in the survey responses, specifically when looking at the growth in their TPACK and in the additional questions. The growth in TPACK happened across multiple knowledge domains, including TK and PK. Responses evolved from surface-level to

more detailed responses after the PSTs had experiences with ER. In the question regarding how often they would like to use ER in the classroom, there was a shift from the pre-survey to the post-survey, with more PSTs saying they would use it at level two or three.

The two additional themes evident across all the data sources were curiosity and optimism. In the pre-survey, PSTs noted that benefits to educational robotics could be things like Dana saying, "hands-on experience," Michelle said, "It will teach children how to problem solve." Lisa said, "encourages creativity." While PSTs did not know about ER, they were optimistic about its use in the classroom. The other theme was curiosity. In the interviews, Jan said, "intrigued," and Lucy said, "excited" about learning about ER. In the pre-survey question that asked if ER should be used in the elementary classroom, most of them said yes, even without experience with ER. However, why they said yes, leads to optimism. In the pre-survey, Lucy said, "Yes, educational robotics should be utilized in the classroom. Although I do not have much experience with robotics, I can see how it could push students to think critically.". Ann said, "I believe it could be a great way to get students interested in real world careers and new topics". Melissa shared, "I honestly do not know enough information about robotics, but I think it would be helpful in schools because it introduces students to a new skill.".

It is important to note that the interviewed PSTs, Lucy, Olivia, and Jan, also responded to the surveys. While their survey responses are included, other PSTs also provided input. For example, Jan and Lucy did not mention critical thinking in the surveys. However, Olivia did list critical thinking as a skill you could teach with ER. Also, five other PSTs listed critical thinking.

Summary

This research study explores how a 10-week situated learning experience influenced elementary preservice teachers (PSTs) perceptions of educational robotics (ER). By integrating

ER into their training, the study aimed to enhance PSTs' understanding and comfort with these tools, which are increasingly relevant in today's classrooms. The study utilized open-ended surveys and semi-structured interviews to capture how PSTs' knowledge and confidence in ER evolved. By analyzing the open-ended surveys through thematic analysis and using the TPACK framework, I could glean insight into their perceptions of ER before, during, and after the situated learning experience, which aids in addressing the research questions in this study.

I used the Technological Pedagogical and Content Knowledge (TPACK) framework to analyze these changes in the surveys. This approach allowed me to examine how PSTs' understanding grew across three domains: technological, pedagogical, and content knowledge. The findings indicated a notable improvement in the PSTs' ability to integrate technology with effective teaching strategies and subject-specific content. I analyzed the semi-structured interviews inductively, developing themes. The thematic analysis developed five themes within the three different time frames. Before the 10-week experience, PSTs were hesitant about robotics. During the 10-week experience, they noticed there would be challenges to using ER, but there was also increased student engagement. After the 10-week experience, their confidence with ER increased, as did their realization of the educational value of using ER. I also used thematic analysis for the surveys, which provided supplemental data to support the themes from the semi-structured interviews and confirmed two additional themes, optimism and curiosity.

Initially, many PSTs were hesitant about using ER, mainly due to their lack of prior experience with such technology. This initial uncertainty was rooted in their unfamiliarity with the technology and concerns about their robotics teaching capabilities. Despite these reservations, the PSTs reported that this 10-week program provided a supportive environment for PSTs to explore ER through hands-on activities, workshops, and collaborative learning

experiences. Over time, these experiences gradually shifted their perceptions. The study found that PSTs recognized the educational value of ER, noting its potential for enhancing student learning and engagement. By the end of the experience, most PSTs reported feeling significantly more confident incorporating ER into their teaching practices. In Chapter 5, I will discuss the implications of these findings, the limitations of this study, and recommendations for future research.

Chapter 5: Discussion and Implications

In recent years, the increasing use of educational robotics (ER) in the elementary classroom has garnered attention (Ouyang & Xu, 2024). While the increased use of ER is evident, pre-service teachers (PST) face challenges that hinder them from using this new technology tool, and one of those challenges is perceptions (Papadakis et al., 2021). Research suggests that teachers' perceptions of technology impact their willingness to integrate tools, like ER, into their classrooms (Dinc, 2019; Papadakis et al., 2021; Wang, 2023). This case study aimed to understand pre-service teachers' (PSTs) perceptions of ER and how those perceptions evolve after a 10-week situated learning experience. The research questions guiding the study were:

1. What are elementary pre-service teachers' perceptions toward educational robotics before participating in a 10-week situated learning experience?
2. How does participation in a situated learning experience impact elementary pre-service teachers' perceptions toward educational robotics?

Pre-service teachers (PSTs) participated in a workshop on educational robotics and their application in classroom settings. Following the workshop, they collaborated with a mentor teacher and participated in a week-long robotics summer camp for elementary students, where they also delivered a lesson incorporating ER. An open-ended pre-survey was administered to the PSTs before the workshop, a mid-survey was conducted after the workshop and before the summer camp, and a post-survey was given after the ten-week program. Three PSTs were interviewed using semi-structured interviews to learn more about their perceptions and

experiences with educational robotics. This chapter reviews the data presented in Chapter 4 and offers implications and recommendations for future research.

Discussion

Qualitative data were collected using open-ended surveys and semi-structured interviews. The open-ended surveys were analyzed through thematic analysis and deductive coding using the Technological Pedagogical Content Knowledge (TPACK) framework. The semi-structured interviews were analyzed through thematic analysis. The data were analyzed to examine PST perceptions about the use of educational robotics in elementary classrooms, and five major themes emerged. These results help provide evidence to address the research questions and connect the outcomes to the existing literature.

Research Question 1

The first research question that guided the study was, “What are elementary pre-service teachers’ perceptions toward educational robotics before participating in a 10-week situated learning experience?”. Teacher perceptions are naturally subjective, shaped by their backgrounds, life experiences, and mindsets (Jaafar et al., 2021; Mozafari & Wray, 2015; Papadakis & Kalogiannakis, 2020).). In this study, PST's backgrounds, life experiences, and mindsets about ER provided insight into their perceptions of using ER in the elementary classroom.

Examining PST perceptions is essential as it can shape their future teaching practices, especially in STEM and ER (Margot & Kettler, 2019). The PSTs in this study reported a perception of optimism but also very little experience with ER before this situated learning experience. This is highlighted by the themes of hesitancy and curiosity that emerged through thematic analysis of the interview and initial survey data. Dinc (2019) found challenges such as

limited access to equipment and a lack of necessary skills can discourage PSTs from implementing technology in their classrooms, even though they value it.

Hesitancy and Lack of Knowledge and Experience

The theme of hesitancy that emerged in the thematic data also connects to findings from the pre-survey using the TPACK framework. The PSTs perception of their lack of background knowledge and experiences related to ER help explain their hesitancy. They perceived they had limited technological knowledge (TK) and technological content knowledge (TCK) related to ER before participating in the 10-week situated learning experience. This perception of limited knowledge parallels other research findings (Chai et al., 2013; Y. Wang et al., 2020). Low TK significantly impacts their ability to integrate technology into their teaching (Dewi et al., 2021; Diamah et al., 2022). There was also a lack of TK in the interviews. Jan said, "doing like robotics things and taking the technology classes. Like I'm really not that comfortable, but I think it's only when like I'm tasked to, you know, use a new program that I've never used before. Or like if there's an error or crash, like I wouldn't know how to fix that."

Teachers need to know how the technology works (TK) and how to integrate these tools to enhance teaching and learning (PK) (Dewi et al., 2021; Irwanto, 2021). Similarly, the PSTs in this study shared their perception that for a teacher to use ER successfully, they first need to know about ER. The PSTs perception that they lacked knowledge could explain their hesitancy in using ER in the classroom. Research highlights that TK needs to move beyond basic tool proficiency to encompass confidence in implementing technology to enhance learning outcomes (Tondeur et al., 2019).

Teachers' gaps in knowledge and understanding can limit students' learning opportunities (McMullin & Reeve, 2014). PSTs in the pre-survey said that teachers do not know

how to use robots in the classroom, it is difficult for students, it is too hard, causing frustration and confusion, and it is a distraction. Ann said, “Some challenges may be that some students won’t be interested in it or may be too hard.” This gap extends beyond the basic familiarity with digital tools to a lack of a deeper understanding of using technology for pedagogical purposes. Dinc (2019) found that pre-service teachers recognize and value that using technology can engage students. This study found that initially, PSTs didn’t have that same expectation. Instead, they were hesitant to engage students out of concern for the frustrations and challenges students might experience. The elementary students' challenges allow for perseverance and productive struggle that are part of the math and science standards (CK) which is neglected in this reflection by PSTs.

There wasn’t much exploration into subject-specific content knowledge (CK) or (PCK) of PSTs, because this study examined ERs across content areas. However, PSTs initially perceived that ERs wouldn’t be useful in all subjects but instead mainly in STEM fields. Twenty-three PSTs initially noted that ER could be used in math and science, which is positive; however, they were limited in seeing its use in other subjects. This was expected, as research shows ER is most frequently used in subjects related to science, technology, engineering, and mathematics (STEM) (Bano et al., 2023). This narrow focus may restrict the integration of ER in other subject areas, like language arts, social studies, or creative subjects, like art. Expanding ER beyond STEM could encourage a more interdisciplinary approach, fostering creativity and critical thinking in many other subjects (Sullivan & Bers, 2015). In the camp experience, Jan noted a student who was not engaged during a read-aloud became engaged once the robot was introduced,

> "It was kind of sweet even to see, like the way that when you add robots in, like the kids, that they would not sit and listen to a book, but if they like could get to engage with and use their robots for an activity at the end, that like made them a lore more engaged and want to pay attention."

This hesitancy to use ER across disciplines could be due to a lack of CK or PCK but could more likely be explained by a lack of TPACK, where they recognize the intersections of content, pedagogy, and technology to enhance learning.

The PSTs listed very few responses related to pedagogical knowledge (PK) and technological pedagogical knowledge (TPK) in the pre-survey, only seven, demonstrating their need for knowledge about ER pedagogy. Pedagogical knowledge helps teachers overcome barriers to technology integration, and by understanding these effective teaching strategies, teachers can more confidently incorporate technology into their classrooms (Adipat, 2021). For teachers, it is vital to identify teaching strategies aligned with ER (TPK) to be successful with their use in the classroom (Weyers et al., 2024).

PSTs need adequate TK, along with their CK and PK, to effectively address learners' needs (Casler-Failing, 2021). In addition, they need to know how these intersect to create TPACK which enables them to plan technology rich instruction that benefits the learner In this study, PSTs noted that a challenge of using ER in the classroom was that teachers did not know how to use it. In a study with 156 teachers at a Greek primary school, a challenge for teachers was that they felt unprepared due to the lack of training and professional development

opportunities (Tzagaraki et al., 2022). PSTs in this study expressed that same challenge at the beginning of the study before the 10-week situated learning experience.

PSTs conveyed a perception that ER causes challenges in the classroom due to a lack of teacher knowledge, ER is too hard for elementary students, or there is a lack of vision for how this could support learning. These negative perceptions signal a need for more precise guidance on integrating ER into the curriculum and developing a stronger understanding of its educational value to foster teacher confidence and student engagement. Sixteen PSTs in the pre-survey thought a challenge of ER was the teacher's lack of knowledge about robotics and that using ER may be too hard for elementary students. This aligns with other studies that found teachers identified challenges in using ER, for example, their own lack of technical skills and training to implement robotics (Alimisis, 2013; Ateş & Gündüzalp, 2023; Khanlari, 2015; Screpanti et al., 2021). However, no substantial evidence supports the idea that ER is too complex for elementary students. In fact, some studies show the opposite (Bers et al., 2019; Burleson et al., 2018). Pugnali et al.'s (2017) study used a robot to investigate four to seven-year-olds computational thinking skills. Their research found that using a robotic platform versus on-screen block coding was helpful to students in developing computational thinking skills, communication, and teamwork. This perception of robotics being complex initially stems from the PSTs' lack of experience with ER and possibly their lack of experience in a classroom with elementary students, as this was their first field placement in a classroom.

Despite being considered digital natives, PSTs hesitated to integrate ER into their teaching. The American Library Association defines digital natives as individuals born and raised during the digital era (post-1980). Marc Prensky (2001) suggests that digital natives process information differently due to constant exposure to technology such as computers, video games, and cell phones. While Prensky suggests that digital natives are more likely to use digital tools in their careers, Milutinović (2022) found no conclusive evidence that simply being a digital native ensures successful integration of such tools in the classroom. The PSTs had experiences in technology, but the experiences in educational technology were limited, and only three had limited experience with ER (two through a sibling and one through a friend). PSTs felt comfortable with technology they had been exposed to and were used to using (computer, phone, SMART Board, etc.). The notion of new technology, like ER, or how to use technology as a creation tool was intimidating to the PSTs. Lucy's response about using technology in the classroom was, "Pretty comfortable... but then doing robotics things, I'm not really that comfortable." This hesitation is not unique to this group as it reflects a broader trend in the literature. It is a common thought that digital natives feel comfortable teaching with technology. However, research indicates this is only sometimes the case. This is echoed by studies showing that despite PSTs' familiarity with technology, they often face challenges in applying it effectively for educational purposes (Huang et al., 2021; Prensky, 2001; Teo, 2016; Milutinović, 2022).

Optimistic

Building on these findings, it becomes clear that PSTs may initially view educational robotics with hesitation due to their perceived lack of experience and knowledge (TPACK). However, their perceptions are not entirely negative. In the pre-survey, eighteen PSTs indicated they had no prior experience with ER, which likely shaped their initial apprehensions. Research supports that teachers with limited exposure to technology can often have a negative outlook, leading to reluctance in adopting new tools (Akram et al., 2022; Dinc, 2019). Despite minimal background knowledge, PSTs recognized several advantages of ER, such as enhancing problem-solving skills, fostering creativity, and promoting collaboration among students. This dual perspective acknowledges the challenges outlined in the previous chapter, emphasizing that perceptions of ER are complex and multifaceted. PSTs may approach ER cautiously, but their awareness of its potential benefits signals an openness to learning and adapting, underscoring the importance of targeted support and training in teacher preparation programs (Román-Graván et al., 2020). This balance of caution and optimism is crucial for developing well-rounded educators who can navigate challenges and harness educational robotics opportunities.

In the semi-structured interview, PSTs were asked to reflect on their thoughts about ER before the semester. Upon reflection in the semi-structured interviews, the PSTs, Jan, Lucy, and Olivia, were hesitant at the beginning of the semester. They were reluctant to use ER because they lacked experience with the tools. While they all had experience with other technology tools in their educational background, they did not feel that gave them the knowledge they needed to

work with ER. All three PSTs stated they did not have any prior experience with ER. They said their initial thoughts about ER were “uncomfortable,” “confused,” and “intimidating.”

Curiosity

When putting the open-ended pre-surveys and reflections from the semi-structured interviews in conversation with each other, initial perceptions of ER of the PSTs were that they felt uncertain and needed training, but they were curious. They said things like, “I was confused,” “I had no idea how to work them,” and “I didn’t have any robotics experience.” They also said, “I need training,” and “I only had one technology class.” However, they were open to the idea by saying, “I was intrigued” and “Excited” at the prospect of trying ER in the workshop. Other research supports these conflicting perceptions of apprehension but curiosity (Fegely et al., 2023; Román-Graván et al., 2020). In a study of pre-service teacher perceptions in Spain, García-Valcárcel-Muñoz-Repiso et al. (2013) found that PSTs recognized a positive impact of technology; however, they expressed concerns over their lack of knowledge and training about integrating technology into the classroom.

Research Question 2

The second research question that guided the study was, “How does participation in a situated learning experience impact elementary pre-service teachers’ perceptions toward educational robotics?”. Alqahtani et al. (2021) found that PST perceptions of ER changed after being given time to explore and experience robots. This finding supports the current study’s situated learning experience, which also increased PSTs’ reported intentions to integrate robotics

into their teaching. It is important in this study to look at how perceptions changed from the beginning to the end and from the pre-survey to the mid-survey, from the mid-survey to the post-survey, and from the pre-survey to the post-survey. In this analysis, one can look specifically at how the ER workshop may have impacted perceptions, how the camp impacted their perceptions, and how they were impacted over the 10-week situated learning experience. During and following the situated learning experience, the notions of ER being challenging yet seeing increased student engagement, as well as increased confidence and educational value, were revealed.

Challenging

While some PSTs' perceptions of ER changed over the 10-week situated learning experience in this study, which aligns with Alqahtani et al. (2021), the changes weren't unanimous, and the changes PSTs noted varied. PSTs started to feel more comfortable with robotics after the professional development; however, they still expressed concerns, like troubleshooting the ER and knowing what to do when they don't work. Margot and Kettler (2019) discuss the importance of professional development in STEM but also note that even after professional development, some teachers are still uncomfortable with STEM. This was also seen in this study, in the mid-survey, as the PSTs still had questions about using ER in a classroom setting. Some questions were about integrating ER into content areas for different grade levels, hesitancy in planning instruction with ER, and concerns over the possible technical issues they might face. Banas and York's (2014) research study examined how professional development

workshops impact teachers' understanding of technology integration. They found that teachers initially have a general view of technology use. Still, as they participate in technology professional development, they see how it can be intermingled, leading to more detailed knowledge. In the current study, PSTs demonstrated this movement from a general view of technology to a more detailed knowledge. This shift also made them aware of challenges beyond knowing how to use ER, including managing the class, troubleshooting, and integrating ER into content areas. Another study highlights how professional development can enhance teachers' understanding of content, pedagogy, and technology, which helps move them from a surface-level awareness to a deeper, more integrated approach (Gess-Newsome et al., 2017). Surface-level awareness in the PSTs gave them surface-level challenges; however, the deeper, more integrated awareness caused their challenges to be more specific and based on professional development and classroom experiences. While there were some shifts in this seen in the perceptions reported by PSTs in surveys and interviews, there was still much room for growth. This study provided professional development and opportunity for implementation practice, this was very limited in time and opportunity for the PSTs.

Research shows that teachers in a situated learning experience, with a community of practice, could better integrate technology in their classrooms and move from a general understanding of technology to more context-specific technology uses (Prestridge, 2017). Teachers are more likely to utilize technologies like ER when they receive support within their learning community (Ateş & Gündüzalp, 2023). The PSTs received direct support through

the workshop and had a mentor teacher in the summer camp experience; however, the mentor teachers were not part of the community of practice in the workshop. When PSTs were in their summer camp experience, they were in very small community groups. This meant there was no opportunity to plan, implement, and discuss reflections on communal implementation experiences, which did compromise some of the community of practice within the situated learning experience.

Student Engagement

The semi-structured interviews also showed evidence of PSTs' evolving perceptions. Based on their experiences with ER from the workshop and classroom, the PSTs realized their challenges were related to not knowing about ER, feeling intimidated, and being unable to help. Research has shown that collaborative teacher training, which spans an extended period and includes coaching support, improves educators' skills more effectively than traditional, shorter training (Murphy, 2015). While some PSTs noted potential student engagement in the pre-survey, they witnessed increased student engagement in the summer camps when using ER. Olivia talked about student engagement, "But just using that to make the learning process more engaging and fun, I feel like you'd help them remember it more, rather than just giving a lecture on even and odd numbers like they're going to remember." This shows growth in their initial perceptions that ER could be too difficult for some students or that students might not be interested. Studies suggest ER can spark student motivation, driving curiosity and active participation (Eguchi, 2014; Kim et al., 2015). This aligns with the PSTs' observations that ER

appeared to facilitate deeper student engagement, particularly with students who might struggle with traditional teaching methods.

Specifically, using hands-on tools to help students learn, students learning collaboration and teamwork through ER, increased student engagement when using ER, and helping students learn content better. ER has been shown to increase student engagement and motivation, positively impacting student behavior and problem-solving skills (Grubišić & Crnokić, 2024; K. Wang et al., 2023). Studies suggest ER can spark student motivation, driving curiosity and active participation (Eguchi, 2014; Kim et al., 2015). This aligns with the PST observations that ER appeared to facilitate deeper student engagement, particularly with students who might struggle with traditional teaching methods. Although there were some changes in PSTs' perceptions, it is evident that additional support is necessary. PSTs continued to express concerns about the difficulties of integrating ER into classroom instruction. Offering more chances to learn and apply ER in natural classroom environments could enhance their confidence and increase the likelihood of effective use in their future teaching.

Confidence

PSTs mentioned needing to know how robots work 27 times in the pre-survey, which aligns with technological knowledge (TK). In the mid-survey, given after the ER workshop, PSTs mentioned TK 14 times. And in the post-survey, PSTs mentioned TK eight times. However, in the post-survey, when TK was discussed, it was focused more on the need to understand specific aspects of ER, like how to troubleshoot the robot, code the robot, or practice

with the materials, than their initial perception of needing to know about ER in general. After the 10-week experience, PSTs were knowledgeable enough about ER to suggest other TK essential to integrating ER in the classroom. This highlights the progression of PSTs from a broad understanding to a more practical one (Banas & York, 2014).

In the semi-structured interviews, all three PSTs commented that their confidence in ER increased. Olivia said she was ready to use robotics in her classroom and credited the camp experience. Lucy also mentioned that the robotics workshop and camp experience helped her see all how ER could be used in her classroom. Situated learning experiences can improve confidence in PSTs (Meyers & Lester, 2013).

Educational Value

A systematic review of ER studies suggests that educational robots can enhance students' skills in writing, reading, collaboration, and communication (Anwar et al., 2019). In the pre-survey, PSTs mainly listed math and science as the subjects in which ER would be integrated. In the mid-survey, PSTs included math and science; however, nine expanded their answer to all subjects. In the post-survey, PSTs again said math and science, but four also included technology as a subject, and eight said all subjects. Research shows that ER is most frequently used in STEM-related subjects (Bano et al., 2023). However, research shows that ER can also be effective in other subject areas (Bers, 2008; Bravo et al., 2021). In a case study on using ER to teach history and art, Mantzanidou (2019) highlights the integration into the curriculum to enhance traditional learning experiences. ER does connect well with math and

science and in STEM; however, it is also important to note that it can go beyond those subjects. During the situated learning experience, PSTs completed activities incorporating ER into various subject areas, which helped them understand how ER can be applied across all content areas. This shows a shift in their perception that ER is best used in math and science to consider ER could be used in more subject areas.

PST's pedagogical knowledge (PK) also increased over the experience. They included more specific responses about PK in the post-survey based on their experiences. PSTs thought ER could help students learn through productive struggle, how to keep students on task with ER, and increase student engagement when using ER. Teachers view struggle and failure as integral parts of STEM education (Dare et al., 2014). In the semi-structured interview, Jan talked about failure,

> "Or, like, in robotics, you're bound to fail. And I feel like at least that was my experience. I did not know how to deal with failure at all growing up. I was such a perfectionist. And it was crippling where it is like, if I were to have had an experience with something where it's like normalized to fail, what it's like to fail that helps set you up for success, realizing this is a normal thing. It's like those lessons that I feel robotics teaches that you don't learn in school."

Bers (2017) explains that failure is integral to learning, particularly for young students. She describes a classroom where teachers use constructivist practices with ER to create an environment that encourages failure to learn. This aligns with Jan's comment about her

experience with robotics creating a safe place for failure. This environment of using failure to learn, also known as productive struggle, allows students to learn problem-solving skills and perseverance. Productive struggle is a Standard of Math Practice (National Council of Teachers of Mathematics, 2014). Casler-Failing et al. (2022) note that most research on productive struggle has been in math; however, it should be in all content areas. This cross-cutting concept helps bridge connections to content areas, which in turn helps students build problem-solving skills (Andrade, 2020). In this way, teachers create a safe learning environment for students to solve problems while constructing their knowledge. Again, Jan talked about how using robotics in the classroom created a way to normalize failure. The use of ER can provide teachers the opportunity to practice productive struggle in all subject areas.

All three PSTs interviewed found an educational value in using ER that they had yet to consider before the 10-week experience, and this increased their confidence when using ER. Jan talked about what teaching with robotics means to her,

> "Robotics is more than just technology because it involves so much more. We did a lot with coding, which wasn't just robotics—the idea of using technology like robotics to create a classroom space where students are more readily engaged. You can integrate technology into different content areas. And I like how it all helps students understand the content easier. It helps with classroom management and all the things."

Exceptions

One question from the open-ended survey showed little change. The question asked how often the PSTs thought ER should be used in the classroom on a scale of 1-5 (1 being never, 5 being daily). In the pre-survey, ten thought they should be used at level three. In the mid-survey, 17 said level three. Furthermore, in the post-survey, 13 said level three. The pre-survey responses do not correlate to their initial perceptions of robotics. In the pre-survey, the PSTs may have responded with the higher levels based on what they felt might be the "correct" answer or chosen answer "3" as it was in the middle. Also, the pre-survey was taken in the classroom where the PSTs were about to participate in a robotics workshop with their peers. In the mid-survey, the increase to 17 suggests that the hands-on experience from the workshop might have given a sense of confidence in using ER. In the post-survey, 13 responding at a level "3" could suggest a more thorough understanding of ER practical application. Some PSTs may have realized that despite the benefits of ER, it may not be practical for daily use.

Study Limitations

In this study, my role with the pre-service teachers posed a limitation due to their potential perception of me as an authority figure. Being the subject matter expert in educational robotics, this dynamic could have led to response biases, with the pre-service teachers adjusting their answers to match perceived expectations or presenting themselves in a more favorable light.

Implications for Teacher Preparation Programs

The findings of this study illuminate the importance of exposing PSTs to ER in their teacher preparation programs. This exposure develops their ER knowledge and provides authentic situated learning experiences for PSTs. Pre-service teachers need more than opportunities to learn how to use various tools, as is often the case in the stand-alone technology

course (Lambert & Gong, 2010). Giving PSTs authentic situated learning experiences that include new technologies enables them to develop and practice teaching with those technologies in real-world contexts (Hall, 2018).

Teachers and researchers widely use the TPACK framework for technology integration. Incorporating this framework into teacher preparation programs will guide PSTs in all knowledge domains and help them effectively orient their knowledge to use all technology, not just ER. In this research (and pilot study), none of the PSTs had experience with ER, which limited their TK and PK with ER. Research has found a connection between using the TPACK and helping PST connect technology tools to their teaching practices (Bate et al., 2013; Thomas et al., 2013).

Despite being generally comfortable with technology, PSTs initially found ER intimidating or difficult. More hands-on experience with ER gives PSTs confidence to use it in their classrooms. Chand et al.'s (2020) research highlights the importance of teacher training with technology to improve their confidence in using it in their classrooms. After being given time to explore and experience robotics in an immersive environment, like a situated learning environment, PSTs gain pedagogical knowledge of integrating robotics into the classroom (Alqahtani et al., 2021). This study supports the research regarding PSTs who engaged in technology integration activities during methods courses or K-12 field experiences often reported more positive attitudes toward technology integration (Polly et al., 2009).

Pre-service teachers should have comprehensive training in ER, not only in STEM but all subject areas. Seeing other teachers integrate ER into other subject areas allows PSTs to see how ER can be integrated. Offering hands-on experiences over multiple semesters will provide PSTs with extended exposure to ER, enhancing their TPACK and increasing the likelihood that

they will incorporate it into their future classrooms. Also, offering opportunities for PSTs to observe in elementary classrooms where in-service teachers are effectively using ER, where they can practice their newly learned ER skills, and a community of practice where they can reflect and debrief about their experiences would provide PSTs with the technical and pedagogy skills need for ER. By considering these implications, teacher preparation programs can better equip PSTs to confidently incorporate educational robotics into their lessons, increasing student engagement, enhancing learning outcomes, and fostering the development of critical 21st-century skills.

Recommendations for Future Research

I see several recommendations for future research to enhance the understanding of PSTs' perceptions of ER. First, integrating the Technological Pedagogical Content Knowledge (TPACK) into developing the open-ended survey questions and structuring the workshop using the TPACK framework could provide valuable insights and guide the ER workshop. This would also enable researchers to compare the pre-, mid-, and post-survey results more effectively. Research about using the TPACK in the teacher preparation content courses would be beneficial. Through this, PSTs would get experience from the content experts who would model how they use the TPACK to integrate technology into their content areas.

Another recommendation would be conducting a similar study within a 15-week semester class, where students have formal classroom placements, could provide a more realistic context than the informal camp setting used in this study. In addition, implementing a longitudinal study that tracks PSTs after graduation as they begin teaching in classrooms could provide insight into the long-term effects of ER experiences gained during their teacher preparation programs. Research that includes more intentional reflection, discussion, and support during

field experiences, including planning, conversations, and debriefing related to the use of educational robotics.

To further examine ways to support PSTs' changes in perceptions about ER, I suggest creating a community of practice where PSTs are involved in professional development and implementation alongside a group of mentor teachers. By including the mentor teachers in the PD and group discussions about ER, they become members of the community of practice with a shared experience. PSTs and mentor teachers would complete surveys to examine their perceptions as they begin and complete the experience.

Finally, a future recommendation would be to conduct a study that includes observations of the PSTs and their integration into ER. This would further explore how the introduction of ER impacts their practice. Conducting open-ended surveys throughout this time would also provide the opportunity to see how practice and perception are connected, which could yield valuable insights.

Conclusion

This study investigated pre-service teachers' (PSTs) perceptions of educational robotics and how those perceptions change after a 10-week situated learning experience. Three frameworks underpinned the entire study: Constructivism (Piaget, 1968), Technological Pedagogical Content Knowledge (Mishra & Koehler, 2009), and Situated Learning Theory (Lave & Wenger, 1994). PSTs provided details about their background with educational robotics (ER), their ideas of how ER could be used in the classroom, and how those initial ideas and thoughts changed after their situated learning experience.

The initial perceptions of ER reflected apprehension due to a lack of exposure and limited understanding of how ER could be integrated into the classroom. In the early stages of the study, PSTs TK, CK, and PK about ER were minimal, which aligns with previous research. However, the PSTs were curious and open to learning more about ER and its possibilities. Throughout the 10-week situated learning experience, PSTs participated in a workshop and a week-long summer robotics camp, allowing them to engage with ER in a controlled and real-world classroom environment. This situated learning experience contributed to a noticeable shift in their perceptions. The data showed a progression from general knowledge to a more detailed understanding of ER, including how it could enhance student engagement, develop problem-solving skills, and foster collaborative learning. There was also noticeable growth from their initial perception that ER was best suited for STEM-related subjects to recognizing it could be integrated into other subjects beyond STEM. The situated learning experience also allowed the PSTs to view ER in a tool that could facilitate more profound learning experiences. ER can support productive struggle, encourage persistence, and engage students struggling with traditional teaching methods.

This case study demonstrates the importance of incorporating ER into teacher training, not merely as a standalone technology course but as an integral part of authentic, situated learning experiences. Such experiences give PSTs the skills, confidence, and pedagogical strategies needed to integrate ER successfully into their classrooms.

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Appendix A

Informed Consent for Research Study

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CURRICULUM & TEACHING

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMED CONSENT
for a Research Study entitled
Elementary pre-service teachers' perceptions of educational robotics: a situated learning experience case study

You are invited to participate in a research study to *examine how elementary pre-service teachers perceive the role of educational robotics in a general K-5 classrooms and how that changes after a situated learning experience.* The study is being conducted by Jennifer Spencer, doctoral candidate, under the direction of Dr. Megan Burton, Associate Professor, in the Auburn University Department of Curriculum and Teaching. You were selected as a possible participant because you are an elementary education student, enrolled in mathematics and science methods courses, and are age 19 or older.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to share classroom assignments (open-ended surveys, journal responses, and lesson plans) with me to know what your perceptions of educational robotics are and how those change throughout the semester. Your total time commitment will be approximately six hours.

Are there any risks or discomforts? The risks associated with participating in this study are minimal. To minimize these risks, we will use pseudonyms to maintain anonymity.

Are there any benefits to yourself or others? Participants will not directly benefit from participation. If you participate in this study, you can expect to better understand your perceptions about educational robotics. I cannot promise that you will receive any or all of the benefits described. However, you will be contributing to the knowledge base about teacher perceptions.

Are there any costs? If you decide to participate, you will not incur any costs.

Will you receive compensation for participation? You will not be compensated for participation.

5040 HALEY CENTER
AUBURN, AL 36849-5212

TELEPHONE:
334-844-4434

FAX:
334-844-6789

www.auburn.edu

Participant's initials _____

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If you change your mind about participating, you can withdraw at any time during the study by telling the researcher you wish to withdraw or by emailing Jennifer Spencer at jss0007@auburn.edu. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University or the Department of Education.

Your privacy will be protected. Any information obtained in connection with this study will remain confidential. Information obtained through your participation may be to complete an education requirement, published in a professional journal, or presented at a professional conference.

If you have questions about this study, *please ask them now or* contact Jennifer Spencer at jss0007@auburn.edu or Dr. Megan Burton at meb0042@auburn.edu. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

_____	_____
Participant's signature Date	Investigator obtaining consent Date
_____	_____
Printed Name	Printed Name

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Version Date: April 24, 2023 | Page 2 of 2

Appendix B

Recruitment Script

Recruitment Script

This will be read aloud by myself, Jennifer Spencer, on the first day of class for Summer 2023 semester in the Elementary Math Methods course. The professor of the course, Dr. Megan Burton, will not be present in the room when this is read nor when consent documents are signed.

To the class:

Hi everyone, my name is Jennifer Spencer, and I am an Elementary Education Ph.D. candidate in the College of Education. My research focuses on elementary education pre-service teacher's perceptions of educational robotics in the general K-5 classroom and how those change after a situated learning experience. I am beginning my dissertation data collection this semester and I would like to have permission from all of you to view assignments from this course as part of my data.

During this semester, you will be completing course assignments, such as journal entries, and I am asking permission to view your responses and completed course assignments. I will not have access to your grades. I will be present throughout the semester in varying roles, including working with you in this class and observing at the summer camps as I am a camp organizer. However, I am not in a position of power or authority over your grades or day-to-day camp experience.

In addition to course assignments, I may ask a few of you to talk with me about your experience this semester, but that will be later and will include a separate consent form.

I am going to pass out the consent form to you now. Again, you are consenting to allowing me to view your completed course assignments. Dr. Burton will not be aware of who is participating in this research and whether you participate will have no bearing on your grade or your future relations with myself, Auburn University, or the College of Education.

I will pass around an envelope for you to return your forms.

If you have any questions, please feel free to ask them now.

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Appendix C

Open-ended Survey Questions

Open-ended Survey Questions

1. Describe any experiences you have had with educational robotics. If you have not had any experiences, please state that.
2. Should educational robotics be utilized in the general K-5 classroom? Why or why not?
3. What types of skills do you think educational robotics could teach?
4. Using a scale of 1-5, with 1 being not at all and 5 being daily, how often would you like to use educational robotics in the general K-5 classroom?
5. If educational robotics is used in a general education classroom, what subjects would be most appropriate and why?
6. What are the benefits of using educational robotics in the classroom?
7. What are the challenges of using educational robotics in the classroom?
8. What are some content standards that educational robotics could support for learners in the general education classroom?
9. What does a teacher need to know to use educational robotics in the general K-5 classroom effectively?

Appendix D

Informed Consent for Semi-Structured Interview

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INFORMED CONSENT
for a Research Study entitled
"Elementary pre-service teachers' perceptions of educational robotics: a situated learning experience case study"

You are invited to participate in a research study to *examine how elementary pre-service teachers perceive the role of educational robotics in a general K-5 classroom and how that changes after a situated learning experience.* The study is being conducted by Jennifer Spencer, doctoral candidate, under the direction of Dr. Megan Burton, Associate Professor, in the Auburn University Department of Curriculum and Teaching. You were selected as a possible participant because you are an elementary education student, enrolled in mathematics and science methods courses, and are age 19 or older.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to participate in a semi-structured interview which will be recorded and transcribed. Your total time commitment will be approximately one hour.

Are there any risks or discomforts? The risks associated with participating in this study are minimal. To minimize these risks, we will use pseudonyms to maintain anonymity.

Are there any benefits to yourself or others? Participants will not directly benefit from participation.

Are there any costs? If you decide to participate, you will not incur any costs.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University or the Department of Education.

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Participant's initials _____

Your privacy will be protected. Any information obtained in connection with this study will remain confidential. Information obtained through your participation may be used to complete an education requirement, published in a professional journal, or presented at a professional conference.

If you have questions about this study, *please ask them now or* contact Jennifer Spencer at jss0007@auburn.edu or Dr. Megan Burton at meb0042@auburn.edu. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

_____	_____
Participant's signature Date	Investigator obtaining consent Date
_____	_____
Printed Name	Printed Name

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Appendix E

Recruitment Script for Semi-Structured Interview

Recruitment Script for Semi-Structured Interview

My name is Jennifer Spencer, and I am an Elementary Education Ph.D. candidate in the College of Education. My research focuses on elementary education pre-service teacher's perceptions of educational robotics in the general K-5 classroom and how those change after a situated learning experience. I am beginning my dissertation data collection this semester and I would like for you to participate in a semi-structured interview with me.

The interview is anticipated to take no more than one hour and will be audio-taped for transcription.

Participation in this interview is voluntary. Your identity as a participant will remain confidential during and after the study. Pseudonyms will be used.

I am going to give you the consent form now. Again, you are consenting to participating in a semi-structured interview with me. Dr. Burton will not be aware of who is participating in this research and whether you participate will have no bearing on your grade or your future relations with myself, Auburn University, or the College of Education.

If you have questions please contact me at jss0007@auburn.edu.

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Appendix F

Semi-Structured Interview Protocol

Semi-Structured Interview Protocol

Below is a list of preliminary questions for the interview. Other questions will be developed in response to class occurrences and as follow-up questions.

Interview questions:

1. Please tell me a little bit about your background, like where you grew up, and how you chose Auburn University.
2. Tell me about how/why you chose elementary education as a career.
    a. Tell me about your educational background. For example, favorite subjects or teachers, or activities?
3. When you were in school, grades K-12, what kinds of activities involving technology did you do? What types of technology did you use?
4. What are your thoughts about using robots in the classroom?
5. Tell me about your comfort level with using technology in the classroom.
    a. What forms of technology are you comfortable using? Teaching students to use?
6. How has the workshop we had impacted the way you see robotics in education?
7. Describe what "teaching with robotics" means to you.
8. What do you feel could be obstacles to using robotics to teach?
9. Is there anything else you would like to share with me about using robotics as a teaching tool?

Other question ideas:

1. Are you good with technology? Tell me why or why not.
2. How do you feel about computers?
3. What do you spend the most time doing on a computer?
4. Do you have a computer at home?
5. What do you do if something on your computer does not work?

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