EXPLORING PRESERVICE TEACHERS' TECHNOLOGY INTEGRATION REPERTOIRE: A MIXED METHODS STUDY

By

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Abstract: The purpose of this convergent mixed methods study was to explore how an undergraduate educational technology course impacts preservice teachers' TPACK knowledge and how it affects the development of their technology integration repertoire. A total of 14 preservice teachers enrolled in a face-to-face section of an educational technology course in Fall 2021 participated in the study. Quantitative findings indicate the growth of participants' TPACK (self-perceptions and application) over the course of the semester. The qualitative findings suggest that the technology integration repertoire of the participants developed from a tool-based approach to the learner first and then the tool approach that confirms the growth of the TPK. This study is significant to teacher educators by providing an overview of the preservice teachers' decision-making process for using technologies in their lesson plans and their overall growth in technology integration during an educational technology course. The findings of this study could inform teacher preparation programs about the instructional activities that are the most beneficial for preservice teachers to experience for TPACK development.

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CHAPTER I

INTRODUCTION

During my first year teaching educational technologies to preservice teachers, I observed students' growth at the end of each class. Each semester, I encountered a different group of learners who brought their own prior knowledge, beliefs, and attitudes towards technology into the course. Some did not see the value of using technology with early childhood and elementary students. Class discussions provided some insight into the issues students had, such as privacy, cyberbullying, and technology addiction. Other students decided that they were not good at using technologies. Collectively, students who did not see the value in using technology in their future classrooms reported what Ertmer (1999) described as second-order barriers, which include beliefs, attitudes, and willingness to change practices. The more I read, the more I found study after study stating that preservice teachers did not feel well-prepared to teach with technologies after graduating from their teacher preparation programs (Kay, 2006; Polly et al., 2010; Tondeur et al., 2013). These findings made me wonder whether the course prepared students to effectively integrate technology in their future classrooms.

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In 2018, I conducted a qualitative case study to investigate which projects students thought were beneficial and what impact they had on students' understanding of teaching with technology. Additionally, I wanted to assess the course's design to determine if the course was preparing our preservice teachers to integrate technology in the classroom effectively. The study used transformative learning theory (Mezirow, 2000) to understand preservice teachers' experiences. Mezirow (1996) defined transformative learning as "the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experience in order to guide future action" (p. 162). Perspective transformation occurs when students are exposed to new information and there is a change in their beliefs (Cranton, 2017; King, 2003a; Taylor, 2007). According to King (2003a), students experience perspective transformation when new learning activities impact their beliefs and understandings. Examining new information promotes growth and a shift in perspective during the incorporation and revision of the new experiences. The process itself alters their worldview and values by giving students the opportunity to accept or reject the new information presented (Cranton, 2017; Taylor, 2007).

The findings of my study suggested that preservice teachers' perspective transformation (Mezirow, 2000) about teaching with technology changed over the semester. The students developed an understanding of what it means to teach with technology, became confident in their ability to teach with technology, and began valuing the idea of teaching with technology. Overall, the course activities and projects helped students learn what it meant to teach with technology, and both designs of the course promoted student growth over the semester. The findings were different from previous studies, suggesting that an educational technology class was preparing teachers to integrate technology in their future classrooms and easing some of the second-order barriers.

While studying for my qualifying exams, I found a recent study conducted by Ottenbreit-Leftwich et al. (2018), which found that preservice teachers felt prepared to teach with technology after completing an educational technology course. This finding surprised the authors, because they previously described the lack of opportunities preservice teachers had in their programs to integrate technologies (Ertmer & Ottenbreit-Leftwich, 2010). Other factors, such as field placements and mentoring, became more influential in changing their views about integrating technologies to support teaching and learning.

While I initially wanted to research how beginning teachers make decisions about integrating technology, I realized I needed to try to capture a baseline of preservice teachers' preparedness before both student teaching and their first year of teaching. Kopcha et al.'s (2020) Teacher Response Model (TRM) provides a lens for understanding preservice teachers' preparedness to teach with technology. In a vignette illustrating the TRM, Kopcha et al. described a teacher who planned to integrate technology using a digital escape room. During implementation, the teacher realized that students were struggling; quickly, he had to find another strategy to reteach students a concept he assumed they previously mastered before proceeding with the activity. To do this, the teacher retrieved an appropriate instructional strategy from his teaching repertoire, which was influenced by a number of factors (e.g., beliefs, knowledge, experience, perception of context). Darling-Hammond (2006) described the importance of developing a strong teaching repertoire to manage diverse learners in dynamic environments. Teachers' repertoires provide a range of skills and strategies that help them evaluate and adjust their pedagogies in different contexts. The concept of repertoire provides a unique lens for studying the baseline of what preservice teachers know about teaching with technology. What constitutes preservice teachers' technology integration repertoire? What does it look like? The term "teaching repertoire" is used in the literature as the collection of instructional strategies that teachers develop throughout their careers (Darling-Hammond, 2006; Garrett, 2007; Kopcha et al., 2020). The "teaching repertoire" develops during the teacher preparation program through the exposure to a variety of courses (e.g., method courses, technology courses, field placement courses). It continues throughout their inservice careers with the exposure to classroom environments, school environments, curriculum, district policies, and professional development opportunities.

My hypothesis is that preservice teachers' technology integration repertoire will grow after completing the course; however, I cannot begin to conjecture whether the instructional technology strategies remain the same, improve, or diminish before and during the beginning of their inservice journeys. In this context, having a baseline understanding of what their technology integration repertoire looks like will help in understanding the interplay of different milestones on the development of beginning teachers' technology integration repertoire. This dissertation is the beginning of a longitudinal study that I plan to continue after graduating, where I will investigate preservice teachers' technology repertoire during student teaching and the first few years of their teaching journeys.

Background Literature

With the arrival of different media, from audiovisual materials to computers and mobile technologies, researchers and educators have attempted to determine the most effective ways to integrate technology into teacher education and professional development initiatives (Bakir, 2016; Kay, 2006; Lawless & Pellegrino, 2007; Ottenbreit-Leftwich et al., 2010). This journey has been impacted by the constant change of technology tools. The introduction of computers to the classroom created a need for teachers to learn how to use technology tools for teaching purposes (Bakir, 2016). The United States government developed many initiatives (e.g., Preparing Tomorrow's Teachers to use Technology Program; Technology Literacy Fund) throughout the years to support technology integration in public schools, which ranged in focus from computers to internet connectivity (U.S. Department of Education, 2010).

Despite having access to computers and other technologies, most teachers used them occasionally as add-ons or supplements (e.g., word processing; drill and skill practice) when they had extra time and not necessarily to enhance student learning (Cuban et al., 2001). The lack of use by teachers opened a window for new research asking why teachers were not using the technologies if they were available (Cuban, 1993; Cuban et al., 2001; Lim & Chai, 2008; Swallow, 2015). For example, Swallow (2015) found that technologies were not used actively by teachers because of a lack of support from the schools after the initiatives were implemented. These results are similar to findings from Lim and Chai (2008), Lowther et al. (2008), and Ross (2004); all three studies concluded that having access to technologies did not result in an increase of technology integration to support learning in the classroom, because there was a lack of support and the skills needed to integrate technology.

Moreover, research about technology integration in K-12 provides an overview of the complexities of teaching with technology. Some studies focused on understanding the ways teachers used technology in K-12 classrooms (Ertmer et al., 2012; Inan & Lowther, 2010). Other studies looked at the external barriers (i.e., schools, technology support) and internal barriers (i.e., beliefs, attitudes, self-efficacy) that enhanced or interfered in the process of meaningful technology integration (Ertmer, 1999; Ertmer et al., 2012). Furthermore, others looked at teachers' years of experience integrating technology (Inan & Lowther, 2010; Miranda & Russell, 2012). While Miranda and Russell's (2012) analysis of 1,040 elementary teachers found that teaching experience was an important factor for technology integration, Inan and Lowther (2010) found the opposite – experience was a negative factor impeding technology integration. Contradicting these opposing findings, Perrotta (2013) found no relationship between years of experience and technology integration among K-12 teachers. In addition to experience, gender was measured in some of the studies, with mixed results. For example, Tondeur et al. (2008) found that male teachers tended to integrate technology more frequently than female teachers; however, other studies found no relationship between gender and technology integration (Perrotta, 2013; Tweed, 2013).

Recent studies try to understand the technology integration of K-12 teachers (preservice and inservice) depending on the context instead of investigating the barriers or factors hindering technology integration. The classroom is a dynamic learning environment, and teachers must be equipped with a vast number of instructional strategies to meet the needs of diverse groups of learners (Kimmons & Hall, 2016; Kopcha et al., 2020). Kimmons and Hall (2016) acknowledged the importance of understanding the barriers that teachers (preservice and inservice) experience when deciding to implement technologies to support learning or support their teaching; however, looking only at the barriers limits the scope and context in which teaching takes place. This finding aligns with concepts that ground Kopcha et al.'s (2020) TRM; teachers will use technologies for teaching if they see the value of them for their context. In brief, this research suggests multiple variables can affect technology integration in K-12 educational settings.

Teacher Preparation Programs

As Mishra and Koehler (2006) explained, it is important that teachers have "the ability to learn and adapt to new technologies (irrespective of what the specific technologies are)" (p. 1028). Preservice teachers need to learn to teach with technology in ways that can enhance students' learning and assist them in mastering the standards (Nelson & Hawk, 2020; Tondeur et al., 2013). To prepare preservice teachers to teach with technology, teacher preparation programs offer holistic curricula that combines general education, educational methods, domain-specific education, and educational technology courses (Council for the Accreditation of Educator Preparation, 2018; Tondeur et al., 2012). Additionally, preservice teachers must complete field placement training, which includes observations, tutoring, and student-teaching in PK-12 settings.

Current research on preservice teachers suggests that teacher preparation programs are preparing teachers with the technology teaching skills they need to succeed (Nelson & Hawk, 2020; Ottenbreit-Leftwich et al., 2018). Ottenbreit-Leftwich et al. (2018) found that preservice teachers felt well prepared to teach with technology after finishing their teacher preparation programs. Oftentimes, the instructional skills and knowledge gains experienced by preservice teachers are affected by external factors, such as field placements, school sites, and mentoring (Ertmer, 1999, 2005; Ertmer et al., 2010; Ertmer et al., 2012; Nelson & Hawk, 2020); however, little is known about preservice teachers' teaching with technology skills and knowledge before those external factors affect their teaching repertoire. Darling-Hammond

(2006) explained how having a solid teaching repertoire full of strategies will help teachers adapt and identify the appropriate strategies to fulfill the learning goals. Knowing the composition of preservice teachers' technology integration repertoire (Kopcha et al., 2020) could help establish a baseline and determine how their technology repertoire evolves at different stages in their teacher preparation programs and beyond.

TPACK

Mishra and Koehler (2006) developed the Technological Pedagogical Content Knowledge (TPACK) framework to assess what teachers needed to know to integrate technology effectively in their classrooms. The authors extended Schulman's (1986) pedagogical content knowledge (PCK) by adding the technology component to reflect the changes happening in educational settings. The visual framework depicts the interaction between content knowledge, pedagogical knowledge, and technological knowledge that teachers must have to integrate technology. The three components are nested inside a dotted circle representing teachers' contextual knowledge of their context (Mishra, 2019). The TPACK framework has been used in many studies to understand what teachers need to know to teach with technology (e.g., Abbitt, 2011; Chai et al., 2013; Wei et al., 2018; Willermark, 2018; Tseng et al., 2020).

One of the most used TPACK surveys is the one developed by Schmidt et al. (2009) that has been adapted, tested, and validated in many studies (Chai et al., 2011; Young et al., 2019). To address some of the drawbacks of self-reported data, such as participants inflating their performance, Harris et al. (2010) developed the technology assessment rubric (TIAR), which incorporates the components measured in TPACK to assess teaching artifacts (i.e., lesson plans). In an effort to better understand preservice teachers' knowledge of teaching with technology, some scholars have triangulated TPACK teaching artifacts and self-report measures (e.g., Hall, 2018; Hall et al., 2020; Kopcha et al., 2014). Combining these measures also could reveal which components are stronger than others, how the components evolve, and the baseline technology integration repertoire of preservice teachers before they enter student teaching.

Problem Statement

Research analyzing the effectiveness of technology integration in the classroom has primarily relied on self-report data from teachers (Bakir, 2016; Ertmer, 1999; Kay, 2006; Ottenbreit-Leftwich et al., 2010). While the findings of previous studies presented relevant information about teachers' beliefs as well as internal and external barriers that may impede technology integration practices, they often overlook how well-prepared teachers are to teach with technology when they leave their teacher preparation programs (Lawless & Pellegrino, 2007). A recent longitudinal study revealed that preservice teachers felt that their teacher preparation programs prepared them well to teach with technology (Ottenbreit-Leftwich et al., 2018); however, during their student teaching experiences, external factors, such as field experiences, mentorships, and observations, played a role in shaping their pedagogies. Additionally, the participants revealed how external factors, such as the school environment, changed their teaching repertoire during their beginning years as inservice teachers. Nevertheless, when preservice teachers graduate from their preparation programs, little is known about the state of their technology integration repertoire (e.g., How do preservice teachers plan to use technology? What is the quality of technology integration in their lesson plans? Descriptions of their technology integration repertoire). The purpose of this convergent mixed-methods dissertation study is to explore preservice teachers' technology integration repertoire. Using a collective case study design, this dissertation will investigate how an undergraduate educational technology course impacts preservice teachers' knowledge about teaching with technology and how it affects the development of their technology integration repertoire. The research questions guiding this study are:

1. To what extent (if any) do preservice teachers' TPACK self-perceptions and application change over the course of a semester-long educational technology course? (*quantitative*)
2. How do preservice teachers' technology integration repertoires change over the course of the semester? (*qualitative*)
3. How does the convergence of TPACK self-perceptions, TPACK application, and reflections illustrate preservice teachers' technology integration repertoire? (*mixed methods*)

Context of the Study

The educational technology course was designed using Grossman et al. (2009) pedagogies of practice (i.e., representations, decomposition, and approximations) with an emphasis on blended teaching. Neumann et al. (2021) conducted a study to examine the design of the course, and the results indicated significant growth in TPACK at the end of the course. The course provided preservice teachers with scaffolded activities to expose them to a variety of technology tools, modeling effective technology integration, and opportunities for enactment through the design of lesson plans (Neumann et al., 2021). However, the study only focused on the effectiveness of the design to improve TPACK, not on exploring what preservice teachers learned and what skills they developed during the course.

For this collective case study, I will be looking only at preservice teachers who completed the educational technology course, resulting in a focus on preservice teachers' "technology integration repertoire." The term "technology integration repertoire" will be used throughout this dissertation and refers to the instructional technology strategies preservice teachers apply and describe in their lesson plans and reflections. The technology integration repertoire will demonstrate the knowledge preservice teachers have beyond how to use technology. Additionally, the TPACK survey will be used in the dissertation to explore preservice teachers' understanding of technology integration over a semester long-educational technology course. The convergence of the TPACK survey, TPACK application, and reflection will illustrate the technology integration repertoire.

I acknowledge that preservice teachers' technology integration repertoire might be influenced by other factors, such as barriers, self-efficacy, and attitudes towards technology. Additionally, the multidimensionality of the teacher preparation program might influence their technology integration repertoire depending on the courses and experiences the students have had. For this study, I will be looking at one piece of the puzzle. My future goal is to explore how the technology integration repertoire changes at the different stages (i.e., observations, student teaching) of the teacher preparation programs.

Philosophical Framework

Pragmatism is the research paradigm guiding this research. As a pragmatic researcher, I understand that there are multiple views of reality, and my goal is not to find the ultimate truth, because truth is dependent on the situation (ontology). Rather than trying to describe reality or uncover the ultimate truth, pragmatists aim to find practical value (axiology); the goal is to determine how useful the findings will be and whom they will benefit the most (Creswell & Plano-Clark, 2018; Morgan, 2007). Finally, knowledge (epistemology) is created by making sense of the world through previous experiences that can be influenced by culture, the environment, and peers (Creswell & Creswell, 2018; Glesne, 2016; Patton, 2015).

The pragmatic worldview imparts the flexibility to collect different types of data, answering research questions by looking at multiple perspectives and including the subjective and objective views (Creswell & Plano-Clark, 2018). It permits a mix of both qualitative and quantitative methods to explain aspects of a phenomenon. It also presents a complete and holistic picture of the problem that cannot be addressed by implementing only one approach (Creswell & Plano-Clark, 2018; Tashakkori & Teddlie, 1998). Using my pragmatic beliefs, the data collected in this study will guide my research process, allowing me to look at all the possible angles and provide practical solutions by selecting the methods that best align with the lines of inquiry.

Significance of the Study

The study has implications for understanding preservice teachers' technology integration decision-making process during their teacher preparation program and the evolution of their technology integration repertoire. By exploring their TPACK development and assessing the quality of their instructional plans, the findings could provide insight into how preservice teachers will use technology in their future classrooms. Additionally, it could inform teacher preparation programs about the instructional activities that are the most beneficial to experience for preservice teachers learning to teach with technology. Finally, the study could extend Kopcha et al.'s (2020) Teacher Response Model by examining the embedded system that affects what preservice teachers view as possible with technology before they begin teaching.

Definition of Terms

4E framework. The combination of Kolb's (2017) Triple E Framework (enhance, extend, engage) with a fourth E (efficiency) focuses on how teachers use technology. The 4E framework aims at "understanding a teacher's decision to use technology" (Kopcha et al., 2020, p. 740).

Enactivist Theory. A theory of cognition grounded in phenomenology and cognitive sciences that focuses on "understanding how all organisms including human beings, organize themselves, and interact with their environment" (Begg, 2013, p. 81).

Preservice teacher. An undergraduate college student enrolled in a teacher preparation program.

Survey of Preservice Teachers' Knowledge of Teaching and Technology. A TPACK self-report measure that consists of 46-items using a five-point Likert-scale with an internal consistency of reliability (coefficient alpha) ranging from .75 to. 92 (Schmidt et al., 2009).

Technology Integration Assessment Rubric (TIAR). A performance assessment method to assess preservice teachers' TPACK application in teaching artifacts (i.e., lesson plans). The rubric consists of four criteria items with scores from one (lowest) to four (highest). The four criteria include 1) curriculum goals and technologies, 2) instructional strategies and technologies, 3) technology selection(s), and 4) fit (Harris et al., 2010).

Technology integration. The use of technologies to support learning and instructional methods in PK-12 classrooms (Liu et al., 2017).

Technology integration repertoire. A collection of developed technology teaching strategies to support a diverse group of students in a dynamic learning environment (Darling-Hammond, 2006; Garrett, 2007; Kopcha et al., 2020).

Summary

This chapter provides an overview of what this dissertation is about. It includes a brief overview of the research quest to find the problem, the background of the problem, the context of the study, research questions, and the theoretical framework. Additionally, it includes the philosophical assumptions and definitions of key terms that are used throughout the study.

Organization of the Study

The dissertation is organized into five chapters. Chapter 1 introduces the problem and the importance of conducting the research. In Chapter 2, the review of the literature presents previous research in the field of educational technology, a brief history of educational technology, and studies that specifically addressed teacher education and technology integration, including preservice, inservice, and professional development.

Moreover, Chapter 3 describes the methodology of the study and presents the research design, sample techniques, types of data collected, instruments used, methods, and procedures. Next, Chapter 4 shows the results of the analysis conducted. Finally, Chapter 5 presents a discussion of the results, implications, recommendations, and conclusions.

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CHAPTER II

REVIEW OF LITERATURE

The literature review presents a brief overview of educational technologies' history as well as the current landscape of technology integration in PK-12 settings and preparing preservice teachers to teach with technology. Additionally, it describes the theoretical and conceptual frameworks guiding this dissertation study.

Brief History of Educational Technologies

Reiser (2001a, 2001b) provided an overview of the history of instructional media and instructional design, and he defined instructional media as "the physical means, other than the teacher, chalkboard, and textbook, via which instruction is presented to learners" (2001a, p. 55). According to Reiser (2001a), the first instructional media were housed in school museums (i.e., exhibits, slides, films) and viewed as a supplement of instruction, not as a substitute for the teacher or textbook. Reiser (2001a) stressed that teachers were given authority to make decisions according to which instructional media they deem appropriate for their teaching practices. In the 1920s and 1930s, audiovisual materials were implemented in classrooms.

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Tools such as the "stereoscope" and "opaque projectors" were well received, but the novelty faded, and their impact on education practices was limited (Betrus & Molenda, 2002; Reiser 2001a, 2001b). Most of the audiovisual materials were used by teachers to impart instruction with limited use by students (Betrus & Molenda, 2002).

From the 1940s to the 1960s, new technologies emerged, and historical events influenced the field. For instance, the military used training films to educate soldiers for jobs in the military and civilian jobs in industry after the war. Some of the tools used by the military to reinstate soldiers back into the workforce include "slide projectors, which were used in teaching aircraft and ship recognition; audio equipment, which was used in teaching foreign languages; and simulators and training devices, which were employed in flight training" (Reiser, 2001a, p. 57). After the success of the military training programs, studies about media comparison (traditional vs. film, radio, or television) were conducted, revealing that students learned the same regardless of the instructional media and showed no significant differences in learning outcomes (Clark, 1983; Reiser, 2001a). In addition to World War II training, the launch of the first satellite into space (Sputnik) by the former Soviet Union prompted the United States to fund STEM education in the United States, which ultimately influenced formative evaluation of instructional materials (Betrus & Molenda, 2002; Reiser, 2001b). Even though these events advanced the field in many ways, they often did not translate into the educational practices of practitioners.

Most teacher preparation programs have provided preservice teachers with one technology course since the 1920s (Betrus & Molenda, 2002). According to Betrus and Molenda (2002), teacher preparation programs started conversations about the best ways to teach technology to preservice teachers besides the standalone course. The authors explained, "In the late 1960s there was a movement to integrate technology skills in various components of the teacher education program, particularly the 'general methods' course and the 'practice teaching' experiences" (p. 21). In the 1970s, a change in terminology for teacher preparation programs occurred; the term audiovisual media was replaced with educational technology and instructional technology. Theories of communication were used to research instructional media; still, educational practices did not change during that period (Reiser, 2001b).

During the 1980s and 1990s, the introduction of computers became part of the school landscape. Constructivist theory influenced teacher preparation programs and resulted in an emphasis on student-centered experiences in their courses (Betrus & Molenda, 2002; Jonassen, 1991); however, in classroom settings, computers were used for “drill and practice, and at the secondary level, reports indicated that computers were mainly used for teaching computer-related skills, such as word-processing” (Reiser, 2001a, p. 60). Computer and internet accessibility increased in public schools, yet the computer's presence did not change instructional practices (Cuban, 1993; Richey, 2013; Reiser, 2001). Betrus and Molenda (2002) **s**uggested a disconnect between what is taught in educational technology courses and what occurs in classrooms.

In the 2000s, a more critical view of technology was presented. Distancing from McLuhan's view of media as neither good nor bad (as cited in Postman, 2000), Postman suggested looking at media from a humanistic perspective, where the interaction of the natural and media environments is explored for the purpose of analyzing technology within a framework that incurs moral consequences. Within this framework, the evolution of technology can be seen by some as a great endeavor, yet by others as the collapse of time. Postman (2000) explained, "People differ about what is good for them, and what isn't, and second, that changes over time will make us see things differently from the way they might have first appeared" (p. 2). Depending on which part of the spectrum they look at the situation through, media ecology helps examine those differences. Media ecology explores the interaction between these two Postman frameworks, which could explain the reasons for the low use of technologies in the classroom for instructional practices despite teachers using them in their personal time (Cuban et al., 2001).

On the other hand, the technological boom created another perspective about a new generation of students and their relationship with technology influencing instruction design practices. Prensky (2001a, 2001b) published two articles identifying the characteristics of this new generation of learners that grew up interacting with technology tools (i.e., video gaming, text messaging, watching TV). In applying concepts from the neurosciences, the author surmised that exposure to technological tools causes changes in their brain functions (neuroplasticity, malleability), and because of those changes, they process information differently. Prensky (2001a, 2001b) called this group "digital natives."

Prensky's (2001a, 2001b) suggestions were problematic because they provided no empirical evidence to suggest that media consumption is the cause of structural brain changes. In addition, Prensky (2001) generalized by concluding that most teachers are "digital immigrants" who ignore these brain changes when designing lessons. Responding to Prensky's claims, Selwyn (2009) wrote a conceptual piece providing evidence on why the "digital native" or the so-called "net generation" was a myth. The author suggested that this group of students should not be viewed as experts in digital media, and that despite being born at a time where they had access to digital media, "many children and young people will continue to require support in the creation and communication of content, with many still lacking the experience, confidence or motivation to be involved in the process of designing, implementing and evaluating self-created content" (p. 374). Additionally, Thompson (2015) provided empirical evidence that "digital natives" are not a homogenous group as Prensky (2001) suggested, finding the digital native population is very different than what Prensky described.

Currently, organizations, such as the International Society for Technology in Education (ISTE) and Council for the Accreditation Educator Preparation (CAEP), are helping the field by providing guidance in the skills that preservice and inservice teachers need to successfully teach with technology. Bakir (2016) explained that there is an "urgency to prepare teachers who know how to effectively use technology in their teaching" (p. 27). Because having access to technology tools does not translate into proper use of technologies (Selwyn, 2009; Thompson, 2015), it is imperative to prepare future teachers to use technology for instructional purposes.

Definition of Educational Technology

The definition of educational technology has changed throughout history, reflecting the technologies of each period (e.g., information age) and the instructional method (Richey, 2013). Januszewski and Molenda (2008, 2013) presented a definition of educational technology. The authors broke the definition into 12 constructs, describing each construct. The description of each construct presents the evolution and influences that have shaped educational technology from evidence, indicating the benefits of media and technology in instruction to the processes used to improve learning (Januszewski & Molenda, 2008, 2013; Thompson, 2017). The authors explained how the field had been influenced by new technologies and theories from other fields. Januszewski and Molenda (2008, 2013) addressed the importance of merging research and application. This merger acted as a bridge between designing the best instructions using different learning theories (e.g., constructivist, cognitive) to creating the best learning environments. The shift as described in the article "changed the emphasis in the field from teaching to learning " (p. 2).

Educational technology is defined as "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" (Januszewski & Molenda, 2013, p. 1). Thompson (2017) summarizes each construct, interpreting the definition in a practical manner.

As Thompson (2017) explained, "educational technology involves a thoughtful effort to employ the right technologies in the right way to meet learning goals" (p. 1). The 12 constructs described by Januszewski and Molenda (2008) are: 1) study, 2) ethical practice, 3) facilitating, 4) learning, 5) improving, 6) performance, 7) using, 8) managing, 9) appropriate, 10) technological, 11) process, and 12) resources (as cited in Thompson, 2017, p.1).

The Great Media Debate

Known as the Great Media Debate, Clark's (1983, 1991, 1994) and Kozma's (1991, 1994) back-and-forth publications promulgated discussions about the influence of media in learning. As previously discussed, technology has influenced the educational landscape in a number of ways throughout history (Reiser, 2001a, 2001b). Clark's (1983, 1994) argument was framed on the distinction between medium and instructional methods. His 1983 article examined media comparisons meta-analyses and concluded, "It is what the teacher does—the teaching—that influences learning" (p. 456). For Clark (1983), media were "mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 445). He explained that in order to find significant learning variances, researchers must separate the method from the medium because "confounding has contributed to the studies attributing learning benefits to one medium over another" (p. 450). From Clark's (1983) perspective, the separation of medium and method is paramount, because it is not the medium but the design of instruction that actually will motivate and engage students in the classroom; instructional methods are responsible for learning, achievement gains, and motivation.

Kozma (1991) opposed Clark's (1983) perspective and described how learning with media is a process that depends on the relationship between the characteristics of media and learning. He claimed, "Clark [1983] creates an unnecessary schism between medium and method. Medium and method have a more integral relationship" (p. 205). Kozma concluded, "Various aspects of the learning process are influenced by the cognitively relevant characteristics of media: their technologies, symbols systems, and processing capabilities" (p. 205). In other words, there is a relationship between the characteristics of media and learning that can result in learning with media. Clark (1991) disregarded the idea of focusing on characteristics of media because of the similarities in effects that media with different characteristics can have.

Instead of making conclusions about whether media influences learning, Kozma (1994) reframed his position and suggested scholars investigate *how* media affect learning. He rejected the idea of looking at medium from a behavioral perspective – that is, as a "delivery truck" positioning learning and learners as passive receptors of information waiting for an "active stimulus." Kozma (1994) explained that to understand the "relationship between media and learning," we must "consider it as an interaction between cognitive processes and characteristics of the environment" (p. 8). He went on to describe how defining "media in ways that are compatible and complementary with these processes" and researching "the mechanisms by which characteristics of media might interact with and influence these processes" can help scholars understand the influence of media on learning (p. 8).

In rebuttal to Kozma's (1991, 1994) claims, Clark (1994) remained firm in his position, explaining how media is neither sufficient for nor necessary to learning. He concluded, "Only the use of adequate instructional methods will influence learning" (p. 27). While Kozma (1994) was not dismissing Clark's (1983) strong foundations about the importance of instructional methods in design, he was describing the active role of the learner with the medium, the cognitive processes, and in the construction of knowledge. In other words, new technologies need new methods of instruction. Currently, the focus of the media debate is to identify how to integrate technology to support teaching and learning (Sickel, 2019).

Technology Integration in PK-12 Settings

For more than 40 years, researchers have been investigating the impact of computer technology on learning. In 1983, the National Commission on Excellence in

Education issued the first report that addressed the importance of integrating technologies in teaching and learning. As a result of this report, several educational initiatives focused on fostering the integration of technologies to support learning in PK-12 schools in the United States. For instance, in the mid-1980s, Apple Computer funded a nationwide initiative called Apple Classroom of Tomorrow (ACOT), which was a long-term project that explored the learning and teaching changes when using interactive computer technologies (ACOT, 1991; Baker et al., 1993; Dwyer et al., 1994). The program provided teachers and students with two computers: one for the classroom and another for home. ACOT influenced policy by applying a constructivist approach that promoted using computer technologies to foster student-centered environments and changing the teacher's role to a facilitator (ACOT, 1991; Baker et al., 1993; Dwyer, 1994). For example, Baker et al. (1993) conducted a study to explore the effects of ACOT's classroom environment on students, teachers, and parents. The goal was to compare ACOT's student outcomes with the national sample over a long period of time. The data collection consisted of quantitative data (e.g., standardized tests, writing performance) and qualitative data (e.g., students' growth). Findings reported that students' standardized scores did not change over the two years, but secondary students' writing skills (e.g., essays) improved. Additionally, teachers had to adapt their views about learning and increased students' expectations; however, teachers and parents were concerned about not meeting the curriculum standards in the new environment.

Other initiatives, such as the Technology Literacy Challenge Fund (1997) and Preparing Tomorrow's Teachers to Use Technology (PT3) in 1999 (U.S. Department of Education, 2005), also helped PK-12 schools with the acquisition of technologies (i.e., computers and other devices) and teacher training (Brush, 2003). Despite the funding provided by the government and private sectors, the research on these initiatives found that the use of computers for student-centered activities was limited (Bakir, 2016; Schrum, 1999).

Several meta-analyses included studying the use of the word processor in various domains (e.g., language, science) and grade-levels (see Bangert-Drowns, 1993; Goldberg et al., 2003). Other meta-analyses concentrated on studying computer-assisted instruction (see Schenker, 2007 for math; Soe et al., 2000 for ELA). Much of this research was influenced by No Child Left Behind (2001), which relied heavily on standardized testing to measure schools' success (U.S. Department of Education, 2002). Using experimental designs, these studies compared classrooms where students learned from computers (e.g., computer-based instruction, computer-assisted instruction) with classrooms where students did not use any technology (e.g., traditional methods) to discover which approach produced the most gains in student achievement (Ross, 2020; Tamim et al., 2011; Zheng et al., 2016), resulting in research that was centered on Clark's (1983, 1994) views about media. Tamim et al.'s (2011) meta-analysis found, "The average student in a classroom where technology is used will perform 12 percentile points higher than the average student in the traditional setting that does not use technology to enhance the learning process" (p. 17), suggesting that integrating technology in the classroom can support students' achievement efforts. In other words, technology is more than a content delivery tool. Technology can help teachers create new learning environments, where technology can be used to differentiate instruction and provide personalized options for students (Arnesen et al., 2019; Graham et al., 2019b).

One-to-One Initiatives

In the 2000s, states and school districts began implementing their own initiatives to promote technology integration in PK-12 settings. One-to-one initiatives started increasing in popularity, and some states developed state-wide initiatives, such as the Maine Learning Technology Initiative (Silvernail & Lane, 2004; Silvernail & Gritter, 2007; Silvernail et al., 2011), the Texas Technology Immersion Project (Morrison et al., 2016), and Michigan's one-to-one initiatives (Lowther et al., 2003, 2012). Other initiatives occurred at the district level, such as the Littleton Public School District Universal Literacy Framework in Denver, Colorado (Zheng et al., 2014); the Lake School District's (pseudonym) initiative in a rural Midwestern town (Petterson & Scharber, 2014); and Enhancing Education Through Technology in Florida (Dawson et al., 2008).

The initiative from the state of Maine began in the Fall 2002 and collected data from 243 middle schools, specifically from students and teachers in seventh and eighth grades. The program provided Apple iBooks, wireless networking, and internet access. The data collection consisted of online and paper surveys (e.g., teachers, students, parents, principals), site visits (e.g., interviews), classroom observations, and document analysis (e.g., school policies, procedures, lesson plans, student work). Findings during the first two years of implementation demonstrated that teachers used active learning pedagogies to support students' learning (shifting from traditional instruction), and students' productivity, motivation, and engagement increased (Silvernail & Lane, 2004). In 2007, Silvernail and Gritter (2007) assessed the impact of the laptop program on students' learning and standardized scores. Data collected from surveys found that more than 70% of the students perceived that the laptops facilitated their learning, and more than 70% of teachers believed that the use of laptops supported students' learning (Silvernail & Gritter, 2007). To examine the impact of the laptop program on standardized scores, the authors evaluated the Main Educational Assessment (MEA) writing test scores two times – before implementation of the laptop program and five years after. The authors found, "In 2000, 29.1% of the eighth graders met the writing proficiency standard on the MEA, and in 2005, this has increased to 41.4%" (p. 7). The report concluded that the effectiveness of the laptop program in writing was due to how students used the laptops in the writing process. Moreover, teachers' use of the laptops, for both teacher-centered activities and student-centered activities, increased. Approximately 83% of teachers used the laptop to develop instructional materials, 75% used it for classroom instruction, and 58% to support differentiated instruction (Silvernail et al., 2011).

The Texas Technology Immersion Project (TIP) provided one-to-one laptop computers to middle school students (sixth through eighth grades) from low socioeconomic school districts (Morrison et al., 2016; Shapley et al., 2010). TIP's goal was to improve students' state test achievement scores in reading and math. Most of the students participating in TIP increased their state test scores, improved their collaborative learning skills (e.g., small group projects), and improved their technology skills (Morrison et al., 2016; Shapley et al., 2010).

To evaluate the Technology as a Tool program in Detroit, Lowther et al. (2003) collected data from 26 middle school classrooms and found that students in the laptop program performed better on writing projects than students in traditional classrooms. Students in the laptop program also did better than students who had access to desktop computers at school. The Technology as a Tool program findings presented the benefits of one-to-one classrooms for students, suggesting they can increase students' problem-solving, writing, and research skills (Lowther et al., 2003). The Freedom to Learn (FTL) initiative was implemented in middle and high schools across Michigan and aimed to create student-centered learning environments (Lowther et al., 2012). FTL focused on investigating the transformation of classrooms from teacher-centered to student-centered; it did not emphasize test scores. Using surveys, observations, and interviews with teachers and students, Lowther et al. (2012) found transformation was evident in classrooms; they described changes in teachers' pedagogies, which shifted to creating hands-on and project-based learning activities. The change in pedagogy provided students opportunities to create projects (e.g., videos, posters, simulations) with their laptops, and the teacher's role shifted to a facilitator (Lowther et al., 2012).

Zheng et al. (2014) conducted a study to examine fifth, sixth, and ninth grade English language arts students' perceptions of using technology to support their learning. The authors analyzed students' blog post responses to questions about the value of computers in the classroom at three different times over a year (2009-2010). A total of 362 blog posts were analyzed using a combination of qualitative (content analysis) and quantitative (descriptive statistics) methods. Findings demonstrated that the laptop initiative had a positive effect from the students' perspective. The authors reported recurrent themes in the blog posts showing what students felt about the laptop program, which revealed how students believed the laptop program provided them with opportunities for research, improving writing skills, collaboration with peers, and increased productivity.

One-to-one learning environments are becoming more common in the United States (Bethel, 2015). Zheng et al. (2016) conducted a meta-analysis exploring empirical studies focused on one-to-one laptop learning environments in K-12 settings. The authors reviewed 65 journal articles and 13 doctoral dissertations that employed experimental or quasi-experimental methods with control groups. Findings revealed that one-to-one laptop environments "increased academic achievement in math, science, writing, and English" (p. 1075). The meta-analysis described the one-to-one laptop environment as one that "increased technology use for varied learning purposes; more student-centered, individualized, and project-based instruction; enhanced engagement and enthusiasm among student; and improved teacher-student and home-school relationships" (p. 1075).

Blended Learning

As one-to-one computing environments have increased, an understanding of blended teaching and learning has become more important. In 2015, President Obama replaced No Child Left Behind (2001) with the Every Student Succeeds Act (ESSA), a bipartisan effort to strengthen the educational system and provide equity to disadvantaged and high-need students. To address the barriers in the educational system, the ESSA (2015) provided states and districts with a more flexible approach to evaluate the performance of schools. The ESSA (2015) stressed the importance of meeting the expected standards; however, it gave autonomy to each state to develop the best methods to evaluate their schools and support students and teachers (U.S. Department of Education, 2015, 2017). Additionally, the ESSA described the need for teachers to integrate technology effectively in their classrooms and introduced blended learning as an environment that would help students succeed. According to the ESSA (2015), blended learning is defined as "a formal education program that leverages both technology-based and face-to-face instructional approaches," where the elements of online learning are combined with guided instruction, student-centered activities, and autonomy to create an "integrated learning experience" (Every Student Succeed Act 2015, p. 1).

The definitions of blended learning in the literature are context-dependent and often vague (Arnesen et al., 2019; Hrastinski, 2019; Zhang & Zhu, 2017). Because the term has been vaguely defined, it has provided room for creating definitions that will help with the guidance and implementation of blended learning initiatives in PK-12 settings (Arnesen et al., 2019; Yang et al., 2021). One of the most concrete definitions of blended learning was proposed by Graham et al. (2019b), who defined it as "the strategic combination of online and in-person learning. A common K-12 definition adds that the blend needs to provide students with some control over time, place, path, and/or pace" (p. 12). Each environment has unique characteristics requiring a "broader set of skills that you would need for a typical classroom" (Graham et al., 2019b, p. 12).

The Blended Learning Universe proposed seven models of blended learning that can be used in K-12 settings and the design of learning environments: Station Rotation, Lab Rotation, Individual Rotation, Flipped Classroom, Flex, A la Carte, and Enriched Virtual (Clayton Christensen Institute, 2021). The Station Rotation model describes students completing various learning activities in different stations in a fixed schedule, and at least one of the stations consists of an online learning activity. The Lab Rotation model is when students complete learning activities on a rotation; however, the online learning station takes place in a computer lab, allowing schools to use the learning environments they already have. The Individual Rotation model has students rotate to assigned computer stations and complete the learning activities they are assigned, meaning they might not complete the same stations as their peers. The Flipped Classroom model requires students to complete their instruction asynchronously (i.e., video, lectures) at home, and during class time, students engage in projects and guided instruction facilitated by the teacher. In the Flex model, students complete learning activities online based on their needs, while teachers support students as they need help, giving students a lot of control of their learning. The A La Carte model allows students to complete online courses and face-to-face courses simultaneously, providing schools with opportunities to support the diverse needs of the student body when the school does not have all the resources. Finally, the Enriched Virtual model allows students to complete their education online with some required face-to-face meetings with the teachers at school.

Many blended learning initiatives have been implemented without the support of peer review empirical research; therefore, more studies are needed to explore the affordances, limitations, and barriers that teachers and students are experiencing (Graham et al., 2019a; Graham et al., 2019b). More empirical research is necessary to develop additional frameworks that define, identify, and measure the competencies that teachers need to be successful in blended teaching (e.g., personalized learning) (Arnesen et al., 2019; Graham et al., 2019a; Graham et al., 2019b). While the ESSA (2015) introduced blending learning as the pathway for effective technology integration, teachers must know how to use effective blended teaching methods to successfully support diverse groups of students in dynamic contexts (Arnesen et al., 2019; Graham et al., 2019a). Graham et al. (2019b) explained the importance of blended teaching knowledge: "What teachers do in those environments has a much more direct impact on student learning" (p. 12). Because teachers must combine online and in-classroom activities effectively to support students' learning, preservice teachers must be prepared to integrate technologies in different learning environments (e.g., traditional, blended, online).

Preparing Preservice Teachers to Integrate Technology

According to Darling-Hammond (2006), effective teacher preparation programs provide student teachers with knowledge of curriculum, assessments, standards, and teaching strategies to impact diverse learners and create learning experiences to support their students' learning. For Darling-Hammond (2006), the goal was to put teacher preparation programs and teacher quality at the forefront of the discussion. Instead of focusing on teacher quality and providing funding to prepare quality teachers, government policies lowered the teaching standards and requirements. Darling-Hammond (2017) explained:

> Because of federal and state policies stimulated by these Administrations, there have often been greater subsidies for candidates entering teaching through alternative routes without prior training than there are for candidates who choose to enter pre-service programmes that would prepare them before they enter. These pathways into teaching that avoid the 'barriers' of preparation have supported the lowering of standards for teachers entering communities that offer fewer incentives to teach. (p. 293)

Darling-Hammond (2006, 2017) stated that this route is problematic because it results in teachers' attrition due to inadequate preparation and a lack of a teaching repertoire to deal with the diversity of student learning and classroom dynamics.

Teacher preparation programs require students to develop an understanding of technology integration in educational contexts (CAEP, 2018). For preservice teachers to be successful in their profession, the ability to integrate technology into their lessons is essential. The most common way of teaching students how to learn to teach with technology is through a single or standalone technology course (Bakir, 2016; Gronseth et al., 2010); however, some scholars have suggested that the standalone course might not be the best approach to teach the 21st century skills that preservice teachers need to integrate technology into their future classrooms (Bakir 2015; Kay, 2006; Wetzel et al., 2009). For instance, Tondeur et al. (2017) conducted a study with six inservice teachers to look at their experiences integrating technology and how it related to their teacher preparation programs. The authors suggested that, depending on the program, one course might not be sufficient to build student teachers' confidence and growth. Likewise, Ottenbreit-Leftwich et al. (2018) indicated that the four teachers in their longitudinal study reported "strong technology integration knowledge and self-efficacy as a result of the teacher education program" (p. 298). The school environment (external barrier) was a factor for the teachers not using technology in the way they expected, and the Ottenbreit-Leftwich et al. (2018) recommended working with K-12 programs to promote opportunities to ease external barriers. To find connections between the value and pedagogical reasoning for using technology, Hughes et al. (2020) examined the decision-making process of preservice and inservice teachers. The findings revealed that preservice teachers' technology activities were mostly teacher-centered (e.g., presentation of materials, engaging students watching a video), while inservice teachers developed student-centered activities to support learning. These findings support Kopcha et al.'s (2020) key idea that teachers make decisions about using technologies that are value driven. That is, "Teachers are more likely to use technology if and when it helps them to what they value–to efficiently and effectively manage their professional responsibilities" (p. 734).

Despite these findings, the debate around the most effective ways to teach preservice teachers how to integrate technology is ongoing. Currently, there is not enough empirical evidence that demonstrates standalone courses work or that other methods (e.g., integration of technologies in all courses) provide better results (Betrus, 2012; Kay 2006). Ottenbreit-Leftwich et al.'s (2010) meta-analysis of more than 100 teacher preparation programs suggested several strategies that could help preservice teachers learn how to integrate technology, including "hands-on technology skill building activities, practice with technology integration in the field, technology integration observation or modeling sessions, authentic technology integration experiences, and technology integration reflections" (p. 10). According to Tondeur et al. (2017), teacher preparation programs that provide preservice teachers with multiple ways of integrating technology yield teachers who integrate and use technology effectively in their classrooms.

Another way to improve preservice teachers' growth is by providing authentic learning experiences, such as field placements in technology-rich schools (Alexander & Kjellström, 2014; Nelson & Hawk, 2020). Nelson and Hawk's (2020) regression-based analysis of 146 preservice teachers found that field experiences could improve preservice teachers' pedagogical beliefs (including self-efficacy) and value beliefs; the authors concluded that teacher education programs "should emphasize technology rich experiences in the field for their preservice teachers" (p. 11). However, not all teacher preparation programs provide preservice teachers with technology-rich experiences (Nelson & Hawk, 2020; Ottenbreit-Leftwich et al., 2012). Many teacher preparation programs have difficulties in finding school placements and mentor teachers who are experts in technology integration (Alexander & Kjellström, 2014; Nelson & Hawk, 2020).

Preservice teachers' technology integration has been researched in terms of technology usage in different domains, technology knowledge (TPACK), attitudes, beliefs, self-efficacy, and confidence to use technology (Hughes, 2013; Liu, 2013; Tondeur et al., 2017). These studies concluded that preservice teachers' technology knowledge is limited, and student-centered technology uses are not common. Most of the studies relied on self-reported measures about students' perceptions of using technology in their future classrooms.

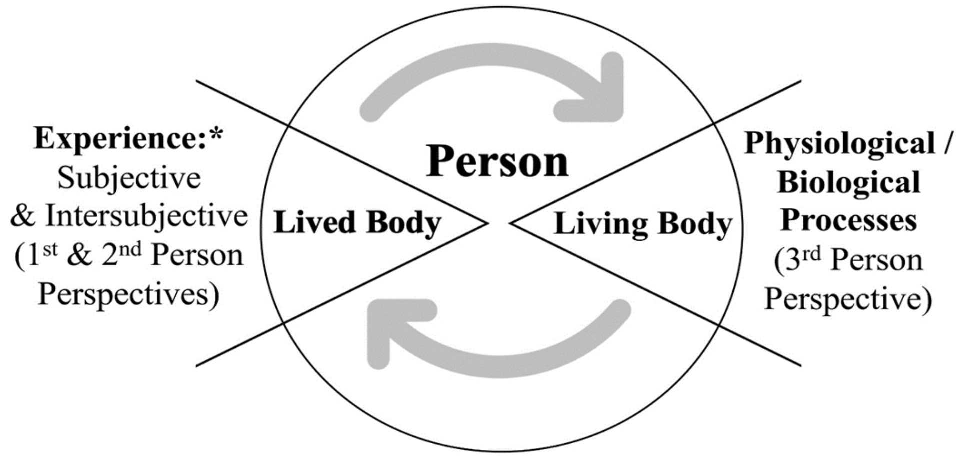
Theoretical Framework

Enactivism, or enactivist theory, is the theoretical framework that guides this dissertation. The enactivist theory is a theory of cognition based on phenomenology, the cognitive sciences, and living systems (Begg, 2013; Stillwell & Harman, 2021). The enactivist approach views the person as a dynamic system embodied in their everyday experience (Stilwell & Harman, 2021). Enactivist theory can be defined as "a way of understanding how all organisms including human beings organized themselves, and interact with their environment" (Begg, 2013, p. 81). The theory has been applied in mathematics education (e.g., Drodge & Reid, 2000), the medical sciences (e.g., de Haan, 20202a), and placebo effects (e.g., Ongaro & Ward, 2017), among others. Enactivist theory defines learning as “a complex matter, enmeshed in a convoluted web of biological and social agents, the incarnation of varied perceptions, of applying, of abstracting and of acting that involves both conscious and unconscious understanding and abilities” (Li et al., 2010, p. 406). In other words, there is a co-emergence between the person and the environment in which the system and the context are bounded, and cognition is part of the meaning-making process (Li et al., 2010; Stilwell & Harman, 2021).

Enactivist theory (see Figure 1) portrays the lived-body as the subjective experiences of a person bounded to the living body experience that cannot be reduced. The living-body is seen from a third-person perspective while the lived body is subjective, only accounted for, by a first- or second-person experience. However, both the lived-body and living-body interact together to make sense of the complexities of the system or environment in which they are bounded (circular process). The arrows in Figure 1 indicate the influence of the system or environment in the body-person-body relationship (Stillwell & Harman, 2021). The body-person-body relationship suggests that living organisms are situated in a dynamic environment in which the person must go through an adaptive process and make sense of the changes (Sandberg & Tsoukas, 2020). In the enactivist theory, embodied cognition is viewed as a process that occurs when a living organism interacts with the environment (Goodchild, 2014; Sriraman & Wu, 2014). Drodge and Reid (2000) explained that those interactions represent the embodiment of the mind – that is, the thinking process of the individual.

Figure 1

Enactivist Theory



Note. From "Phenomenological research needs to be renewed: Time to integrate enactivism as a flexible resource," by P. Stilwell and K. Harman, 2021, *International Journal of Qualitative Methods, 20*, p. 3 (http://www.doi.org/10.11776094066921995299). CC BY 4.0

In this dissertation, the enactivist theory provides a lens for understanding how preservice teachers' technology integration repertoires and decision-making processes are affected by their actions or interactions with the educational technology course. The enactivist process is activated by the interaction between the preservice teacher and the environment. A preservice teacher enrolled in the educational technology class is considered an individual unit within the environment of the course that is composed of students, the instructor, and resources. When a change in the class environment occurs, an activation process is generated in the mind of the preservice teacher, creating the need to adapt to the environment (Begg, 2013; Li et al., 2010; Sriraman & Wu, 2014). The adaptation of the preservice teacher depends on various factors, such as prior experiences, knowledge, and beliefs (Kopcha et al., 2020; Stilwell & Harman, 2021). In other words, the educational technology classroom, as a dynamic environment, triggers the change that preservice teachers must make sense of to evaluate the possible technology use for a variety of situations (Sandberg & Tsoukas, 2020). Their lesson plans and reflections are enacted understandings of teaching with technology. Thus, using the enactivist theory will provide insight into preservice teachers' thinking process as they make decisions about what technology to enact in their lesson plans and how their interactions in the educational technology course play a role in shaping their repertoire.

Conceptual Framework

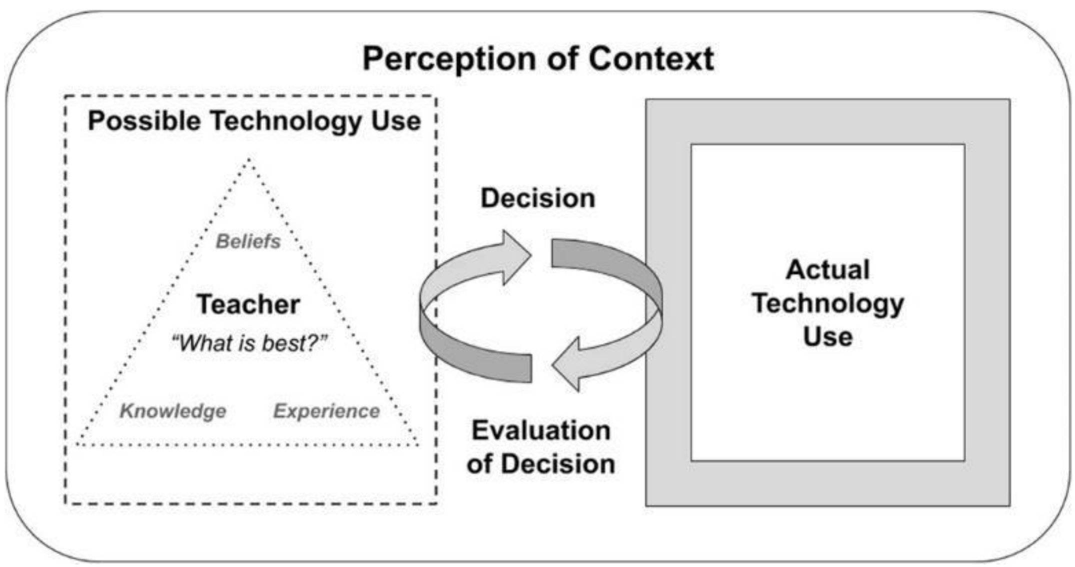
While the enactivist theory provides an overarching theoretical frame, the conceptual framework for this dissertation is developed around Kopcha et al.'s (2020) TRM and Mishra and Koehler's (2006) TPACK.

Teacher Response Model

Kopcha et al. (2020) defined technology integration as "1) value-driven, 2) embedded in a dynamic system, and 3) product of a teachers' perception of what is possible" (p. 731). The authors noted that many studies looked at teachers' technology use as a static concept in which only student-centered activities that promote learning are viewed as a high-level (or high-quality) use of technology. They went on to argue against "positioning any single category of use as being better than others" and promoted the notion of teachers using technology from a variety of levels "in a balanced way" (p. 743). By viewing technology use in this way, they highlighted the alignment between a teacher's decision to use technology and their definition of technology integration. Teachers use technologies that seem beneficial in different situations by considering the continual changes in their classroom, school, and school district. While teachers' beliefs are part of the decision-making process, they are not the only thing teachers draw on when they decide to integrate technology. The TRM looks at a teacher's beliefs alongside knowledge, experience, and the perception of context to portray an all-inclusive perspective where all these factors play a part in a teacher's decision-making process (see Figure 2).

Figure 2

Teacher Response Model (TRM)



Note. From "Process over product: the next evolution of our quest for technology integration" by T. J. Kopcha, K. L. Neumann, A. Ottenbreit-Leftwich, and E. Pittman, 2020, *Educational Technology Research and Development, 68*(20), p. 736 (https://doi.org/10.1007/s11423-020-09735-y). Copyright 2020 by Springer Nature.

In the model, the dotted rectangle represents the possible uses of technology. Inside the dotted rectangle, the dotted triangle represents the teacher. The dotted lines in both figures represent how teachers use a variety of factors (i.e., beliefs, knowledge, experience) to answer, "*What is best?*" for the given context and what technologies will support the teacher’s goals. Once the teacher answers the question, "*What is best for me and my students, and how can technology help?*" in the center of the dotted triangle, the arrows represent the internal negotiation and evaluation of the decision to meet their goal (p. 733). The teacher might go back and explore more options during the process. Finally, the Actual Technology Use rectangle represents the final decision and how the teacher enacts technology. The results of implementing technology in the classroom could affect future technology use depending on the outcome of the actual use (positive or negative), the effects of the environment, and the complexity of the classroom dynamics. While the TRM does not describe "how the technology integration repertoire develops" (Kopcha et al., 2020, p. 743), it has implications for studying the instructional technology strategies and tools that teachers draw on when they answer the "*What is best?*" question.

Repertoire

Most of the studies about technology integration in the classroom focus on the attitudes, self-efficacy, and barriers teachers (preservice and inservice) experienced (e.g., Ertmer, 1991; Hughes, 2013; Liu, 2013, Tondeur et al., 2017). While addressing those factors is essential in understanding why teachers are/are not using technologies in the classroom, it tells us very little about their teacher growth and how the technology integration repertoire changes at the different stages of their careers, including their preparation. Kopcha et al. (2020) described the importance of understanding how a technology integration repertoire develops in any context by understanding the internal and external decision process that a teacher undergoes when selecting the strategies. Additionally, they presented a thorough description of what constitutes a technology teaching repertoire, stating:

> A teacher's repertoire is more than attaining a certain level of technology integration or adopting a pedagogical orientation. It is about supporting teachers in developing a robust perspective on what is possible with technology while improving their ability to anticipate results and successfully meet their future goals. (p. 743)

In the same line, Garret (2007) defined a teaching repertoire as "organizing instructional strategies in some meaningful way" (p. 7). The author explained that teaching strategies are different from techniques (i.e., think-pair-share). The teaching strategies in a teacher’s repertoire must be aligned with the standards, learning objectives, assessments, and support a diverse group of students (Darling-Hammond, 2008; Garret, 2007).

In the book *Powerful Teacher Education*, Darling-Hammond (2006) provided insight into teacher quality and the importance of formal teaching education. The author described personal examples of her life as a teacher. She started as a substitute teacher and decided to get an emergency certification. While teaching, she found limited support from other teachers and the schools. As Darling Hammond (2006) expressed, "I was teaching by the seat of my pants with the limited repertoire of teaching strategies" (p. x). As a result, the author decided to understand what knowledge teachers need to increase their teaching repertoire. Research on policy, standards, and evaluation of teacher education confirms that teacher education programs provide the knowledge students need to develop their teaching repertoire (Darling-Hammond, 2006, 2008). According to Darling-Hammond (2006), most teacher education programs focus on providing "deep and flexible knowledge of subject and adaptability" (p. 20). The programs designed cumulative experiences to increase the knowledge, skills, and disposition to become effective teachers in the classroom.

Wilson et al. (2020) conducted a meta-analysis and found that educational technology courses increase knowledge growth in preservice teachers; however, what constitutes that knowledge is not reflected in the literature. Knowledge, as described in TPACK, is a difficult component to measure (Hughes et al., 2020). Student-teachers need to be skilled in pedagogical, content, and technological knowledge to successfully integrate technology in their future classrooms. The teacher education literature provides empirical research about best practices to design technology courses to increase the knowledge of preservice teachers (Bakir, 2016; Betrus, 2012; Kay, 2006) as well as strategies and activities that closes the gap between the internal and external barriers (Ertmer 1999, 2005; Ertmer et al., 2010; Ertmer et al., 2012) and descriptions of how well-prepared they are after completing their technology course (Ottenbreit-Leftwich et al. 2018); however, descriptions of the state of preservice teachers' technology integration repertoire before they transition into their inservice positions is not accounted for in the literature.

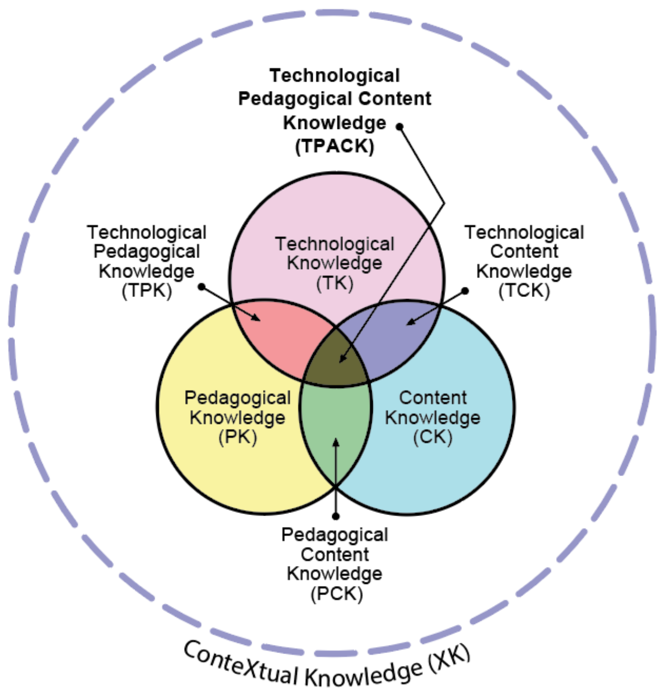
Kopcha et al.'s (2020) illustrative vignette explained that developing a "robust teaching repertoire" will help teachers apply the strategies needed to adapt in any given context. To understand the development of a technology integration repertoire, the authors suggested using the 4E framework. The 4E framework is an extension of Kolb's (2017) Triple E Framework (engage, enhance, extend) that adds efficiency as the last factor to understand the how and why teachers select instructional technologies to implement in their classrooms. The 4E framework “provides a mechanism for studying the development of a teacher's repertoire” and understanding "what a teacher views as possible without undue emphasis on any specific pedagogical orientations" (Kopcha et al., 2020, p. 743).

TPACK

The technological pedagogical content knowledge (TPACK) framework provides a broad perspective of what teachers need to know to purposefully integrate technology (Mishra & Koehler, 2006). The TPACK framework can be implemented in different disciplines, different educational settings, and by using different theories. Therefore, it is not bound to any philosophical orientation (Angeli et al., 2016; Mishra & Koehler, 2006; Mishra, 2019; Voogt et al., 2016). TPACK contains three broad components: technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). Figure 3 depicts how these three components intersect to create four additional components: technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPACK). All seven of the TPACK components are encompassed by contextual knowledge (XK), and the intersectionality of the three main components (TK, PK, and CK) is where technological pedagogical content knowledge occurs (TPACK). In other words, teachers must draw upon technological, pedagogical, and content knowledge in a given context to integrate technology effectively.

Figure 3

Technological Pedagogical Content Knowledge Model (TPACK)



Note. Revised version of the TPACK image. © Punya Mishra, 2018. Reproduced with permission.

The integrative paradigm positions the TPACK components as intersections in which the teachers make decisions about technology integration depending on the classroom dynamics (Angeli et al., 2016; Mishra & Koehler, 2006). Angeli et al. (2016) explained, "According to the integrative view, these subcomponents are integrated 'on the spot' during teaching, allowing teachers to make decisions about the educational uses of technology in their respective classroom" (p. 21). TPACK looks at the relationship among the knowledge components as one that "causes the representation of new concepts and requires developing a sensitivity to the dynamic, transactional relationship between all three components" (Koehler & Mishra, 2005, p. 134).

TPACK was developed to understand what teachers needed to know to effectively integrate technology in their classroom; however, several studies suggest that the complexity of TPACK might not accurately describe effective technology integration in real settings (Angeli & Valanides, 2009; Bentley-Dias & Ertmer, 2013). To address the complexities of TPACK, Harris et al. (2010) developed the Technology Integration Assessment Rubric (TIAR) to unpack the TPACK components and provide an additional way to evaluate teaching artifacts and triangulate the findings of the TPACK survey (Schmidt et al., 2009; Kopcha et al., 2014). Despite some critics, TPACK provides a framework to discuss technology use to support teaching and learning and analyze preservice teachers' decision-making process (Abbitt, 2011; Graham et al., 2012).

Summary

Chapter 2 summarizes the relevant studies in the field of educational technology and teacher education, such as the history of the field, definitions, and seminal studies. It also includes studies about teachers' beliefs and barriers to integrate technology (inservice and preservice), effective technology integration, professional development, and blended learning. Additionally, it situates the current study by presenting the theoretical and conceptual framework, describing the Enactivist theory, the TPACK framework, and the Teacher Response Model (TRM). Finally, it provides a synopsis of the areas of study where more research is needed and presents how the findings of the studies support the existing literature by contributing to the overall landscape.

CHAPTER III

METHODOLOGY

This convergent mixed methods dissertation study aimed to explore preservice teachers' technology integration repertoire. As such, I collected data from preservice teachers to develop an in-depth understanding of their progress. Using a collective case study design, this dissertation investigated how an undergraduate educational technology course impacts preservice teachers' knowledge about teaching with technology and how it affects the development of their technology integration repertoire. The following research questions guided this study:

1. To what extent do preservice teachers' TPACK self-perceptions and application change over the course of a semester-long educational technology course? (quantitative)

2. How does preservice teachers' technology integration repertoire change over the course of the semester? (qualitative).

3. How does the convergence of TPACK self-perceptions, TPACK application, and reflections illustrate preservice teachers' technology integration repertoire? (mixed methods)

Rationale

As has been previously discussed, technology teaching skills are essential for teachers. With the arrival of different media, from audiovisual materials to computers and mobile technologies, researchers and educators have embarked on the journey of finding the most effective ways to integrate technology into teacher education (Bakir, 2016; Ertmer, 1999; Kay, 2006; Ottenbreit-Leftwich et al., 2010). This journey has been impacted by the constant change of technology tools. Mishra and Koehler (2006) explained teachers (preservice and inservice) must have "the ability to learn and adapt to new technologies (irrespective of what the specific technologies are)" (p. 1028).

A recent study conducted by Ottenbreit-Leftwich et al. (2018) revealed that teacher preparation programs are helping students develop their technology integration pedagogies and increasing their self-efficacy and beliefs; however, little has been discovered about how well-prepared teachers are to teach with technology when they leave their teacher preparation programs (Lawless & Pellegrino, 2007). Findings in the literature about preservice teachers' and educational technologies (Hughes et al., 2020; Ottenbreit-Leftwich et al., 2018), enactivism (Begg, 2013), the TPACK framework (Mishra & Koehler, 2006), and the Teacher Response Model (Kopcha et al., 2020), respectively, provided a foundation for the proposed study.

Research Design

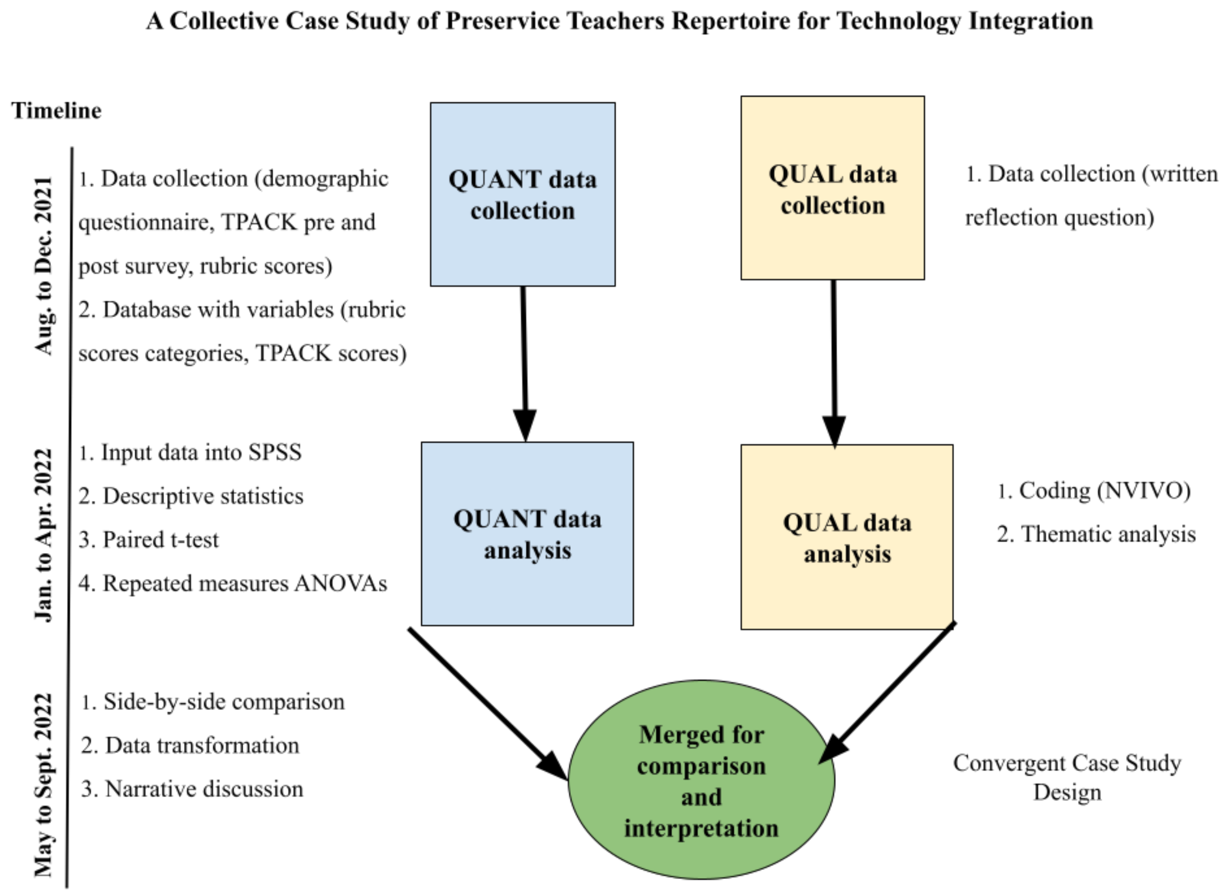
This study used a convergent mixed methods approach and a collective case study design to investigate changes in preservice teachers' technology integration repertoire. Figure 4 depicts the research design for this study. Mixed methods research consists of integrating qualitative and quantitative data to find answers to questions that cannot be interpreted with only one set of data (Creswell & Creswell, 2018; Creswell & Plano-Clark, 2018). For the purpose of this study, mixed methods is defined as:

> The type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration. (Johnson et al., 2007, p. 123)

A mixed methods approach was the most appropriate methodology to answer the proposed research questions in this study because it permitted the merging of both qualitative and quantitative methods to explain the state of preservice teachers' technology integration repertoire. Additionally, it presented a complete and holistic picture of the problem that could not be addressed by implementing only one methodological approach (Creswell & Plano-Clark, 2018; Tashakkori & Teddlie, 1998).

Figure 4

Mixed Method Case Study Diagram



Note. This figure depicts the convergent mixed methods collective case design and timeline that will be used for this study.

Case studies are widely used in different fields from business to education (Creswell & Plano-Clark, 2018). A case study design can be used in qualitative, quantitative, or mixed methods research because the design itself is not bound to any philosophical orientations (Creswell & Plano-Clark, 2018; Patton, 2015). For the purpose of this study, a case study was defined as "a detailed, intensive study of a particular contextual, and bounded, phenomena that is undertaken in real life situations" (Luck et al., 2006, p. 104). Case studies provide the opportunity to study current, complex real-life situations that are difficult to observe using other methodologies (Creswell & Creswell, 2018, Luck et al., 2006; Patton, 2015). The case itself is the unit of study. Because case study designs are variable, the selection of methods is based on "what works" to answer the research questions and create a complete understanding of the case(s) (Creswell & Plano-Clark, 2018; Patton, 2015). Furthermore, case studies provide the opportunity to study current, complex real-life situations that are difficult to observe using other methodologies (Creswell & Creswell, 2018, Luck et al., 2006; Patton, 2015).

In this research, the unit of study was preservice teachers' technology integration repertoire throughout a semester-long educational technology course; however, because I intended to explore changes in preservice teachers' technology integration repertoire, a collective case study design was the best fit. A collective case study applies a common set of research questions supporting the basis for studying each case (Stake, 1995, 2000). This study was considered collective because each preservice teacher participating in the study was considered an individual case to have a deeper understanding of their technology integration repertoire changes during the semester.

I applied Stake's (1995) flexibility design approach. According to Stake (1995), a flexibility design approach consists of going back-and-forth between the conceptual framework, data sources, and data analysis. The flexibility design is not a random process; it involves the awareness of the researcher with new issues and letting the quantitative results interact with the qualitative results and conceptual ideas in the merging of both strands (QUAN +QUAL) (Creswell & Plano-Clark; Stake, 1995). This approach was compatible with a convergent mixed methods approach and collective case study design because it allowed the opportunity to gather different types of data (QUAN +QUAL) simultaneously (Creswell & Plano-Clark, 2018; Luck et al., 2006; Stake, 1995). Finally, I based the selection of methods on "what works" to answer the research questions and create a complete understanding of the collective cases (Creswell & Plano-Clark, 2018; Patton, 2015), which is consistent with a pragmatic philosophical stance (Morgan, 2007; Tashakkori & Teddlie, 1998).

Research Site

The research site for this study was the College of Education at a Research 1 university in the South-Central region of the United States. Students were enrolled in a face-to-face section of an educational technology course in Fall 2021. The course modeled blended teaching and learning and used a variety of blended models, including station rotation, lab rotation, and flipped classroom (Clayton Christensen Institute, 2021).

Participants

Fourteen participants were recruited for this study. Participants were preservice teachers enrolled in a face-to-face section of an educational technology course. Thirteen participants identified as female and one as male. This is consistent with the sample population of the teacher preparation program at the university where the majority of students are women. Three sections of the class (two face-to-face; one online) were offered during the Fall 2021 semester with a maximum of 20 students enrolled in each section. Both convenience and purposeful sampling strategies were used in this study (Patton, 2015). Patton (2015) defined convenience sampling as "a sample in which participants are selected based on their ease and availability" (p. 309). The sample can be considered one of convenience because the researcher has easy access to this pool of participants since she teaches two sections of the course. According to Creswell and Creswell (2018), a convenience sample is the "least desirable of all sampling techniques because not all participants in the population have an equal chance of being selected" (p. 150). The researcher acknowledges the problems with convenience sampling; however, the pool of participants enrolled in the course provided "crucial information about critical cases" (Patton, 2015, p. 309) and helped collect the data needed to answer the research questions.

To achieve a representative sample, the homogeneity sampling technique was used to recruit participants (Patton, 2015). The homogeneity sampling technique focuses on selecting participants that are similar or share some characteristics (Patton, 2015). This study was considered homogeneous in that participants were upper-level preservice teachers (i.e., sophomores, juniors, and seniors). Some students at this level have completed upper-level education courses and participated in observations and/or tutoring. This sampling technique helped reduce variation and assisted with the selection of cases (Creswell & Creswell, 2018; Patton, 2015). This technique helped the researcher identify and select participants who provided "information-rich" data to study the phenomenon (Patton, 2015; Stake, 1995). The idea was to find a diverse pool of preservice teachers.

Recruitment: Sona Research Participation System

The Sona Research Participation System is widely used in more than 900 universities as a management tool to recruit participants for their studies. It follows the ethical standards for research with human subjects and is in compliance with the University's International Review Board. Instructors, graduate students, and researchers in the College of Education have access to this management tool. The researcher used this system to post the study and recruit participants. Students were informed of the opportunity of earning extra credit by the instructors and in the course syllabus. Students interested in participating accessed all the information about the study through the Sona Research Participation System. The materials included a document explaining what the study was about, how their data would be protected, and the consent form. Upon consenting, students were prompted to complete the demographic questionnaire and a baseline (Lesson Plan 1) activity (see Data Collection, below). Instructors had access through the Sona system to credit the points. Participants in the study earned one Sona credit, and the activity took them approximately one hour to complete. The researcher had access to all the materials completed by all participating students. The recruitment occurred at the beginning of the semester, ending around the fourth week in the semester for students to obtain extra credit points.

Data Collection

Both quantitative and qualitative data were collected; the data sources are described below.

Quantitative Data

For this study, quantitative data were collected from three sources: a demographic questionnaire (Appendix A), Schmidt et al.'s (2009) Survey of Preservice Teachers' Knowledge of Teaching and Technology (see Appendix B) to measure TPACK self-perceptions, and Harris et al.'s (2010) Technology Integration Assessment Rubric (TIAR) (see Appendix C) to measure TPACK application. Students who chose to participate in the research completed a nine-item demographic questionnaire. The demographic questionnaire asked about students' gender, age, major, year in college, pre-clinical experiences, previous/current coursework, and participation in OSU's Excellence in Collaborative Experiential Learning (ExCEL) program.

Schmidt et al.'s (2009) Survey of Preservice Teachers' Knowledge of Teaching and Technology (TPACK survey) consists of 46 items and uses a five-level Likert scale (e.g., 1-strongly disagree; 5-strongly disagree). The questions in the survey are aligned with the seven TPACK components (i.e., TK, PK, CK, TPK, TCK, PCK, TPACK). Examples of the survey items include, "I can learn technology easily" (TK) and "I can adapt the use of the technologies that I am learning about to different teaching activities" (TPK) (Schmidt et al., 2009). The validity and reliability of the instrument were established using an exploratory factorial analysis with 165 elementary preservice teachers reporting an internal consistency (Cronbach's alpha) ranging from .78 to .93 (Schmidt et al., 2009).

All students enrolled in the educational technology course completed this survey twice as part of their normal coursework: during the first week of class and during the last week of class. The researcher collected the responses of the students who consented to participate in the study via Qualtrics. All results were kept in a password-protected spreadsheet.

In addition to the questionnaire and survey responses, the researcher collected three lesson plans. One lesson plan was a baseline (Lesson Plan 1) activity (see Appendix D) that students completed upon consenting to participate in the study. Students completed the baseline Lesson Plan 1 activity through Qualtrics survey software, which was exported to a spreadsheet and protected with a password. The other two lesson plans were completed by students as a normal part of their coursework: The Maximizing Technology Lesson Plan (see Appendix E) and the Lesson Makeover (see Appendix F). Each lesson plan was analyzed using the Technology Integration Assessment Rubric (TIAR, see Appendix C) to generate rubric scores. The TIAR consists of four criteria with scores ranging from one (lowest) to four (highest). The four criteria items include Curriculum Goals and Technologies, Instructional Strategies and Technologies, Technology Selections, and Fit. The rubric was designed to evaluate TPACK by looking at preservice teachers' lesson plans or other teaching artifacts that include technologies. Each rubric criterion aligns with a TPACK component. Curriculum Goals and Technologies aligns with TCK. Instructional Strategies and Standards aligns with TPK. Both Technology Selections and Fit align with TPACK. The validity and reliability of the rubric were evaluated by 15 expert evaluators in two separate trials. The TIAR validation reported an internal consistency (Cronbach's alpha) of .91 (Harris et al., 2010).

Qualitative Data

Qualitative data consisted of reflections students completed when submitting each of the lesson plans: Lesson Plan Activity and Reflection (see Appendix D), Maximizing Technology Lesson Plan Reflection (see Appendix E), and Lesson Makeover Reflection (see Appendix F). Upon consenting to the study, participants permitted the researcher to collect the specific works completed in the class in addition to the baseline Lesson Plan 1 activity and reflection questions (see Appendix D). The Sona Research Participation System allowed the researcher to identify the students that agreed to participate and collect the data. The researcher created folders for each participant and housed them on a password-protected computer and database. The Maximizing Technology Lesson Plan and Lesson Makeover project reflections were collected when the lesson plans were collected (described above).

Data Analysis

The data analysis is presented by research question. Additionally, Table 1 presents the data collection and data analysis by research question.

RQ1: To what extent do preservice teachers' TPACK and TIAR scores change over the course of a semester-long educational technology course?

To examine research question one, the researcher used IBM SPSS Statistics v28 software to run descriptive statistics (mean, standard deviation, and frequency distribution) on both the TPACK survey and TIAR scores. For the TPACK survey, the researcher calculated mean scores for all participants in each of the seven TPACK components to create a component score. Additionally, paired t-tests were conducted on each of the seven components.

After evaluating each lesson plan with the TIAR, the researcher conducted separate repeated measures ANOVAs on overall rubric scores and the scores for each criterion (Curriculum Goals and Technologies, Instructional Strategies and Technologies, Technology Selections, and Fit) to examine differences in scores at three points in time: baseline Lesson Plan 1 Activity, Maximizing Technology Lesson Plan, and Lesson Makeover (Field, 2018). If the differences in scores for the three lesson plans were statistically significant, a Bonferroni correction was used to control for Type I error, and pairwise comparisons were conducted to determine the nature of the differences (Field, 2018). The TIAR was not used during the course to grade preservice teachers' lesson plans; students were graded using separated rubrics created by the instructor (Neumann et al., 2021). The TIAR was used to measure the TPACK application in the participants' lesson plans after the final grades were posted. (Hall, 2018; Harris et al., 2010; Kopcha et al., 2014).

Table 1

Data Collection and Analysis by Research Question

Research Question	**Data Collection**	**Data Analysis**
R1: To what extent do preservice teachers' TPACK and TIAR scores change over the course of a semester-long educational technology course? (***quantitative***)	Demographic Questionnaire	Descriptive statistics
	Survey of Preservice Teachers' Knowledge of Teaching and Technology (pre/post)	Descriptive statistics and paired t-tests on the seven component scores
	TIAR performance assessment scores on lesson plans (three lesson plans per student)	Descriptive statistics; Repeated Measures ANOVA on the overall rubric scores; Repeated Measures ANOVA on each criterion score
R2: How do preservice teachers' technology integration repertoire change over the course of the semester? (***qualitative)***	Lesson Activity Reflections	Thematic analysis
	Maximizing Technology Lesson Plan Reflections	Thematic analysis
	Lesson Makeover Reflections	Thematic Analysis
R3: How does the convergence of TPACK self-perceptions, TPACK application, and reflections illustrate preservice teachers' technology integration repertoire? (***mixed methods***)	Quantitative data ● TPACK Survey (post) ● TIAR performance assessment rubric (lesson plans)	Narrative Discussion
	Qualitative data ● Reflections	

RQ2: How do preservice teachers' technology integration repertoire change over the course of the semester?

To examine research question two, the researcher used Braun and Clarke's (2006) process for thematic analysis on the lesson plan reflection questions. Braun and Clarke's (2006) thematic analysis process consists of six steps: 1) familiarizing with the data, 2) initial coding, 3) generating themes, 4) validity and reliability of the themes, 5) defining and naming themes, and 6) interpretation and recording. Step 1 entailed reading all the data to get an overall picture and taking notes. Step 2 consisted of starting the coding process. In Step 3, the researcher examined the data and looked for patterns. Step 4 consisted of establishing the relationships with the patterns, codes, and categories that emerged from the data. In Step 5, the researcher began refining and naming the themes. Finally, in Step 6, the researcher connected the themes with examples from the data and interpreted the findings. This thematic analysis process was not bound to any theoretical framework; the idea was to understand the data without the influence of other theories or frameworks. The researcher conducted three separate thematic analyses – one for the reflection questions associated with each lesson plan assignment. The researcher kept written memos of the process and the actual numbers of initial codes, categories, code groups, and themes (Patton, 2015). To analyze the qualitative data, the researcher used NVIVO, a qualitative data analysis software, to organize and code the reflection questions

RQ3: How does the convergence of TPACK self-perceptions, TPACK application, and reflections illustrate preservice teachers' technology integration repertoire?

To examine research question three, the researcher merged the quantitative and qualitative data together creating a side-by-side comparison. When using a mixed methods case study design, Creswell and Plano-Clark (2018) recommended documenting the case or cases and merging the data using a side-by-side comparison and a narrative discussion of the findings.

Validity and Reliability

In this study, the researcher used two instruments: the TPACK survey and the TIAR performance assessment rubric. To assess the TPACK survey data (pre/post), the assumption of normality was checked by applying a bootstrap confidence interval for paired–samples t-test and skewness and kurtosis (Field, 2018).

Additionally, effect sizes were computed and reported to determine the difference in scores within the same participants (Field, 2018). To assess the quality of the TIAR scores, sphericity was assessed using Mauchly's test. In the case sphericity was violated, Type 1 error was controlled with a Bonferroni correction (Field, 2018), and the Greenhouse-Geisser was reported.

In qualitative research, reliability and validity are replaced by trustworthiness (Creswell & Creswell, 2018; Patton, 2015). For this study, trustworthiness was defined as a detailed evaluation of the quality of the researcher's methods to collect the data and the confirmation from the readers that the findings are grounded in the data (Creswell & Creswell, 2018; Patton, 2015). Using Lincoln and Guba's (1986) criteria for assessing the trustworthiness of qualitative data, the researcher addressed credibility, reflexivity, and transferability. Credibility was addressed by triangulating the qualitative data (Creswell

& Creswell, 2018; Lincoln & Guba, 1986). Triangulation of the qualitative data included checking findings and interpretations of all data collection methods (e.g., surveys, assessments, reflections) addressing the consistency of the findings through an extended engagement in the data analysis process (Lincoln & Guba,1998; Patton, 2015). Reflexivity was addressed by recording the researcher's observations and thoughts in a field notebook throughout the study. Recording the observations and thoughts helped address bias and how the researcher's views and beliefs influenced the data analysis (Glesne, 2016). Transferability was achieved by providing thick descriptions of the findings and allowing others to judge if the findings can be transferred to their own site (Lincoln & Guba, 1998).

Finally, the most common threats to validity in a convergent mixed-methods collective case study design include unequal sample sizes in the quantitative and qualitative sample sizes, not merging the results, and not making cross-case comparisons. To minimize those threats, the researcher used the same sample size for both strands, created a database, merged the quantitative and qualitative data using a theme-by-statistic joint display, and engaged in cross-case analysis (Creswell & Plano-Clark, 2018).

Researcher Subjectivities

For the last three years, the researcher has been teaching the educational technology course to preservice teachers. During this time, the researcher's interest in understanding what the students know about teaching and learning with technology became a passion. Because of the researcher's close relationship with the course and the context, the researcher acknowledged that their views and beliefs might influence the study (data collection, analysis, findings, and conclusions). Therefore, the researcher participated in a daily introspection of the research process, assessing thoughts and concerns with the verification processes through journaling, presenting an accurate representation of all the participants' accounts in the study. The researcher understood that being immersed in the project could limit the ability to discern and accepted the influence it might have on findings.

Ethical Considerations

The researcher complied with all the guidelines required for the research using human subjects. An application for conducting research was submitted to the Institutional Review (IRB), which included consent forms and research protocols, ensuring the protection of the information provided by the participants. The IRB approved (see Appendix I) all materials and procedures before data collection began. All students enrolled in all sections of the educational technology course were recruited face-to-face. Participants completed an electronic questionnaire that included demographic information (see Appendix A) and lesson plan activity (see Appendix D) that took at least one hour to complete. Before administering the demographic questionnaire, participants completed an electronic consent form (see Appendix G). The consent form indicated that the students could drop out voluntarily during the study without any penalty. Students obtained one credit unit for participating in the study through the Sona system. All the recruitment materials and the questionnaire were available through the Sona research participation system. All subject identifiers were removed from the data and replaced with codes to protect the privacy of participants. The results were used to fulfill the requirements for the Doctor of Philosophy and were by no means be traceable to individuals who participated in the study.

Summary

The purpose of Chapter 3 was to present the methodology selected to conduct the study. In this dissertation, the researcher used convergent mixed methods with a collective case study design. The sample and research site are described. Also, quantitative and qualitative data were collected using: a demographic questionnaire, a TPACK survey to measure self-perceptions, a TPACK-based TIAR to measure the application, and lastly, participants' written reflections coded using Braun & Clarke's (2009) six-phase thematic analysis process. In addition, data analysis included paired t-test and repeated measures ANOVA with explanations of the assumptions (i.e., normality and sphericity) and statistical procedures to control for Type 1 Error. Finally, validity reliability procedures, ethical considerations, and research subjectivities are discussed. Chapter 4 presents the analysis of the results using the data collection techniques and methods procedures described in Chapter 3.

CHAPTER IV

RESULTS

In this chapter, the results of the data analysis are presented in four sections: participant demographics, results of research questions one (quantitative), two (qualitative), and three (mixed methods). The first section describes the participants' demographics; the subsequent sections report the quantitative analyses, the thematic results using the six phases analysis process described in Chapter 3, and the convergence of the quantitative and qualitative results.

Participant Demographics

A total of 14 participants enrolled in the educational technology course participated in the study. The age range of participants was 18 to 23, with a mean (M) of 20.29 and a standard deviation (SD) of 1.38. Thirteen participants identified as female and one as male. Participants were at different points in their majors: five were classified as sophomores, six as juniors, and two as seniors. Their majors included early childhood, elementary, and secondary education (see Table 2).

Additionally, eight participants enrolled in the study had finished a part of their clinical experience. Six participants had completed or were enrolled in the field observations, while two participants were currently enrolled in their student teaching (see Table 2). Table 2 provides a complete frequency distribution of the majors and clinical experiences of the participants.

Table 2

Participant Demographics

Demographic	Frequency	Percentage
Age Group		
18-20	9	64%
21-23	5	36%
Gender		
Female	13	93%
Male	1	7%
Year in College		
Sophomore	5	36%
Junior	6	43%
Senior	2	14%
Other	1	7%
Major		
Early Childhood	6	43%
Elementary	4	29%
Secondary	4	29%
Clinical Experience		
Field Observation	6	43%
Currently Enrolled	3	21%
Completed	3	21%
Student Teaching	2	14%

Quantitative Results

Quantitative results were centered around the first research question, which asked, *to what extent (if any) do preservice teachers' TPACK self-perceptions and application change over the course of a semester-long educational technology course?*

Improvement of TPACK Self-Perceptions of Preservice Teachers

Paired t-tests were conducted in the seven components (i.e., TK, PK, CK, TPK, TCK, PCK, TPACK) to find significant differences. The researcher used Schmidt et al.'s (2009) Survey of Preservice Teachers' Knowledge of Teaching and Technology (see Appendix B) to measure TPACK self-perceptions. The TPACK survey consists of 46 items and uses a five-level Likert scale (e.g., 1-strongly disagree; 5 strongly agree). Examples of the survey items include "I can learn technology easily" (TK) and "I can adapt the use of the technologies that I am learning about to different teaching activities" (TPK) (Schmidt et al., 2009).

Six components of TPACK reported statistically significant increases, with medium to large effect sizes (d) ranging from 456 to .706. The content knowledge component (CK) reported only statistically significant increases in science and literacy.. However, although not statistically significant, preservice teachers reported mean increases in CK in social studies and math. For example, the content knowledge (math) of preservice teachers had a mean increase at the end of the course (M = 3.375, SD = 0.839) compared to the mean content knowledge of math at the beginning of the course (M = 3.357, SD = 1.201). Likewise, the content knowledge of social studies had a mean increase at the end of the course (M = 3.857, SD =.770) compared to the mean content knowledge of social studies at the beginning of the course (M = 3.690, SD =.756). Table

3 summarizes all TPACK components, including means, standard deviations, t-value, significance, and effect sizes for each component. Also, it reports the 95% confidence interval estimated using bootstrapping BCa to establish the actual mean differences among components.

Table 3

TPACK Self-Perceptions

TPACK component	Beginning of Course		End of Course		t(13)	p	BCa 95% for the difference		d
	M	SD	M	SD			LL	UL	
Technology Knowledge (TK) [a]	3.248	0.665	3.976	0.339	-4.042	.001	-1.088	-.430	.670
Content Knowledge (CK) [a]									
Social Studies [b]	3.690	.756	3.857	.770	-.940	.364	-.547	.095	.660
Science [a]	3.285	.866	3.690	.800	-3.319	.006	-.654	-.190	.456
Mathematics [b]	3.357	1.201	3.738	.839	-1.995	.067	-.761	-.047	.714
Literacy [a]	4.09	.590	4.452	.594	-.102	.010	-.571	-.142	.442
Pedagogy Knowledge (PK) [a]	3.52	.640	3.52	.506	-5.050	.001	-.761	-.331	.405
Pedagogical Content Knowledge (PCK) [a]	3.267	.576	3.968	.455	-6.287	.001	-.917	-.491	.417
Technological Content Knowledge (TCK) [a]	2.851	.798	3.82	.654	-4.559	.001	-1.453	.500	.796
Technological Pedagogical Knowledge (TPK) [a]	3.468	.587	4.329	.427	-.5.087	.001	-1.159	-.547	.633
Technological Pedagogical Content Knowledge (TPACK) [a]	3.017	.775	3.904	.661	-4.695	.001	-1.285	-.484	.706

[a] Statistically significant increase from the beginning of the course to the end of the course.
[b] Not statistically significant.

Improvement of TPACK Application of Preservice Teachers Lesson Designs

To measure the application of TPACK in lesson designs, Harris et al.'s (2010) Technology Integration Assessment Rubric (TIAR) was used (see Appendix C). The TIAR consists of four criteria with scores ranging from one (lowest) to four (highest). The four criteria include curriculum goals and technologies, instructional strategies and technologies, technology selections, and fit. The TIAR was not used to grade the lesson plans of the participants during the course.

Furthermore, repeated measures ANOVA revealed that the difference in the means of the TIAR scores in the three lesson plans was statistically significant, $F(2, 26) = 60.22$, $p = .001$. The follow-up pairwise comparisons were adjusted using a Bonferroni correction to control for the Type 1 error and revealed statistically significant increases from Lesson Plan 2 ($M = 11.93$) to Lesson Plan 3 ($M = 15.89$), $p = 0.01$, and from Lesson Plan 1 ($M = 7.64$) to Lesson Plan 3 (M=15.89), $p =.001$. The total TIAR score increased with each lesson plan (see Table 5).

Table 4

TIAR Scores for Each Lesson Plan by Criteria

TIAR Criterion	Lesson Plan 1	Lesson Plan 2	Lesson Plan 3
Curriculum Goals & Technologies [a]	2.21	3.36	3.93
Instructional Strategies & Technologies [a]	1.86	2.93	3.93
Technology Selections [a]	1.86	2.86	3.50
Fit [a]	1.71	2.96	3.96
Total [a]	7.64	11.93	15.89

[a] Statistically significant difference at all three points (lesson 1 to lesson 3, lesson 2 to lesson 3, lesson 1 to lesson 2), p < .05.

Individual repeated measures ANOVAs for each rubric criterion revealed statistically significant increases in all four criteria: Curriculum Goals & Technologies, $F(2,26) = 52.00$, $p = 001$; Instructional Strategies & Technologies, $F(2, 26) = 200.07$, $p = 001$; Technology Selections, $F(2, 26) = 200.07$, $p = 001$; and Fit, $F(1.06, 13.77) = 270.78$, $p = .001$. The Greenhouse-Geisser correction was used in the Fit criterion because sphericity was not met. The follow-up pairwise comparisons were adjusted using Bonferroni and revealed a statistically significant increase in the curriculum goals & technologies criteria from Lesson Plan 2 ($M = 3.36$ to Lesson Plan 3 ($M = 3.93$), $p =.001$, and Lesson Plan 1 ($M = .001$, and Lesson Plan 1 ($M = 2.21$) to Lesson Plan 3 (M = 3.93), $p = .001$; Instructional Strategies & Technologies from Lesson Plan 2 ($M = 2.93$) to Lesson Plan 3 ($M = .001$, and Lesson Plan 1 ($M = 1.86$) to Lesson Plan 3 ($M = 3.93$) $p =.001$, and Lesson Plan 1 ($M = .001$; Technology Selections from Lesson Plan 2 ($M = 2.86$) to Lesson Plan 3 ($M = 3.50$) $p =.001$, and Lesson Plan 1 ($M = 1.86$ to Lesson Plan 3 ($M = 3.50$), $p = .001$; and Fit from Lesson Plan 2 ($M = 2.96$ to Lesson Plan 3 ($M = 3.96$),

p =.001, to Lesson Plan 1 (M = 1.71) Finally, the scores for all rubric criteria also changed significantly from Lesson Plan 1 to Lesson Plan 2.

Qualitative Results

Qualitative results were related to the second research question: *How do preservice teachers' technology integration repertoire change over the course of the semester?* To explore the changes in the technology integration repertoire, the researcher used the six-phase thematic analysis process described in Chapter 3 to analyze the reflection questions completed by the participants in the three lesson plans. Three themes emerged during the analysis and are explained using illustrative quotations from the participants. In addition, this section explains how each theme describes the technology integration repertoire of the participants over the course of the semester. Pseudonyms are used when referring to participants. Table 5 provides a list of the pseudonyms used and demographic descriptors (year in college and major) for each participant.

Table 5

Participants' Pseudonyms and Demographic Descriptors

Pseudonym	Year in College	Major
Arden	Sophomore	Early Childhood
Bellamy	Junior	Elementary
Cameron	Junior	Elementary
Dakota	Junior	Early Childhood
Eli	Sophomore	Early Childhood
Finley	Senior	Secondary
Gavi	Junior	Elementary
Hunter	Sophomore	Early Childhood
Imani	I have already graduated, and I am back for another degree.	Secondary
Jesse	Junior	Secondary
Kendall	Senior	Elementary
Lee	Junior	Secondary
Maddox	Sophomore	Early Childhood
Neel	Sophomore	Early Childhood

Coding Process

In order to portray a clear picture of the technology integration repertoire of preservice teachers, the researcher analyzed 84 written reflection questions from the three lesson plans completed by the preservice teachers. First, the researcher read through all the reflection questions and wrote initial impressions and emerging patterns. Also, the researcher looked for outlier answers that did not fit any category. Categories and themes were continuously compared from each case, within and between each lesson plan to look for outliers and patterns. The researcher coded the themes and patterns using NVivo and kept memo notes of the coding process. The memo notes were kept aside to ensure trustworthiness and reflexivity.

Table 6 presents a summary of the coding process that led to the emergence of three themes.

Table 6

Refining Codes to Themes During Thematic Analysis of Qualitative Data

Qualitative Data		In Vivo Codes	Initial Codes	Merged Codes	Child Codes	Themes
Written Reflections	Baseline Lesson Plan 1 Activity	122	2	3	2	1
	Mid-Semester Lesson Plan 2	103	8	5	3	1
	End-Semester Lesson Plan 3	117	5	2	2	1
	All lesson plans combined	342	15	10	7	3

Reflection Questions

In the three lesson plans, participants answered two reflection questions:

1. For each use of technology in the lesson you planned, describe why you decided to use that technology. If you considered using any other tools than the ones that ended up in your plan, describe why you decided not to use them.
2. Describe how your new plan addresses one or more of the 4E's (Kolb's Triple E Framework plus Efficiency).

Thematic analyses of the written reflection questions mentioned above were performed on the responses submitted by the 14 participants (42 documents). After completing phase one of the coding process, the researcher coded 188 references with NVivo. A total of 342 NVivo codes were identified in the initial coding process. Examples of these codes include "critically think," "active social learners," "iPads," "digital books," and "engage learning," among others. After the initial coding, the researcher looked at the frequencies of the words (exact and variations) and started merging them into new initial nodes. A total of 15 initial codes were identified. For example, "engagement and motivation" became a unique parent code. This code included the following variations: engage, co-engagement, and motivation. The researcher continued merging the codes, narrowing them down to 10 combined codes. The 10 new merged codes were "engagement and motivation," "enhanced learning," "extended learning," "efficiency," "prior knowledge," "easy use," "familiarity," "active learning," "technology tools," and "collaboration." Each of the newly merged codes had child codes nested under the parent code. For example, the parent code "previous knowledge" had a child code nested in the hierarchy called “modeling instruction." Likewise, the parent code "meaningful learning" had a child code "real-life experience." Child nodes were merged into an existing parent code or kept as memo observation. Additionally, the researcher coded each lesson plan individually to organize the analysis in the context of the research question.

Next, the researcher combined all the lesson plans and merged the final codes into three overarching themes: 1) technology tools selected, 2) activities and strategies planned with the technologies, and 3) reason for using the technologies. To illustrate, the parent codes "collaboration," "easiness of use," and "familiarity" became part of the theme reasons for using technologies. In addition, two of the three main themes include two subthemes. For theme number two, the technologies used were broken down into two subthemes, teacher-centered and student-centered approaches to technology integration. Lastly, in the reasons for using the "technologies" theme, the subthemes included the 4E and the value of technology integration as reasons for choosing and integrating technologies by preservice teachers.

Overarching Themes

Technology Tools Selected. This theme highlights the technology tools that participants decided to use in their lesson plans. A total of 130 technology tools were used in all lesson plans.

Thirteen percent of participants chose a 1:1 technology classroom with laptops, followed by 9.23% of participants who selected educational apps using iPads. Only 3.85% of the preservice teachers chose a classroom cart with laptops. Only a few of the participants selected using a classroom cart with iPads, a computer lab, or a single-computer classroom (.77% each). These results were for all the written reflection questions combined from the three lesson plans. Table 7 displays the frequency distribution of the technology tools used in the lesson plans and mentioned by the preservice teachers in their reflection questions.

Table 7

Technology Tools Selected by Participants

	All Lesson Plans Combined Frequency	
	Preservice Teacher	
Technology Tools	n	%
1:1 Laptops	17	13.08
YouTube	15	11.54
Google Forms	12	9.23
Educational Apps (using iPads)	12	9.23
Google Slides	11	8.46
Smartboard	9	6.92
Google Docs	6	4.62
Google Drawing	5	3.85
Jamboard	5	3.85
Classroom Cart Laptops	5	3.85
Kahoot!	4	3.08
Internet	3	2.31
Story Board That!	2	1.54
Book Creator	2	1.54
Answer Garden	2	1.54
Epic (eBooks)	2	1.54
Penzu	2	1.54
Interactive Whiteboard	2	1.54
Genially!	1	0.77
ABC ya (Games)	1	0.77
Jeopardy Rocks	1	0.77
Flipgrid	1	0.77

Bubbl. Us	1	0.77
Padlet	1	0.77
Quizlet!	1	0.77
ABC Mouse (Videos)	1	0.77
iMovie	1	0.77
Digital Articles	1	0.77
Classroom Cart iPads	1	0.77
Computer Lab	1	0.77
Single Computer Classroom	1	0.77
Digital Projector	1	0.77
Total Frequency (mean)	130 (9.28)	100

Note. *n* represents the number of mentions of technology tools by a preservice teacher in the lesson plans; % represents the proportion of each mention.

In addition to the frequencies, Table 7 describes the types of technologies that the participants decided to use in their lesson plans. These technologies can be classified into three broad categories: 1) hardware (e.g., smartboard), 2) software (e.g., Google Slides), and 3) content tools (e.g., Internet). Most participants used software tools such as Google apps: YouTube (11.54%), Google Forms (9.23%), and Google Slides (8.46%).

To illustrate the rationale for selecting the tool, Lee reflected on their decision to have a 1:1 classroom with laptops, explaining, "I decided to use 1:1 laptops because that's what I used in the classroom as a student, so it often comes naturally." Finley made the choice “to use the YouTube video of an anti-war song to introduce the idea of the media’s bias against the Vietnam War,” and explained they “chose this because in one of my college classes the professor did this as an intro into every class." Similarly, Cameron made the choice "to use Jam Boards to share our thoughts and ideas" and explained that "when I had classes on Zoom, many of my professors had us use Jam Boards, so I knew that was the technology I wanted to use."

Activities and Strategies with Technologies. This theme showed how preservice teachers used the technology tools and what instructional strategies they implemented. In the baseline activity (Lesson Plan 1), participants were required to select one of six scenarios (see Table 8) and use the information provided to plan a lesson that effectively integrated technology. Participants did not have to use technology in all parts of the lesson, only in the areas they considered most effective and described their use (teacher or student-centered). Additionally, for Lesson Plan 1 participants did not need to develop the materials.

Most participants decided to use hardware tools (smartboard, iPads, laptops) and teacher-centric strategies (content presentation) as described in the written reflection questions. Table 8 presents an example of the six scenarios that participants chose for the design of Lesson Plan 1.

For example, Dakota selected the math scenario (see Table 8) and decided to use game apps (gamification) to teach math: "The game makes it challenging for them and doesn’t allow them to move on until they complete that level." Dakota went further and described the advantages of using educational apps for math versus having manipulatives: "With real life money it's kind of hard to get the same feature." Finally, Dakota described using the iPad as a teaching strategy: "iPad is great because the students are most likely already familiar with how to use one" and "they can aid learning in sometimes a more efficient way than other teaching method."

Likewise, Hunter selected the math scenario and decided to use a combination of the smartboard and iPads to design the lesson because "the smartboard would be easier to use for the purpose of manipulative" (drag and drop activities). The participant also explained the benefits of gaming app features: "iPads make sense for the digital counting games (gamification) they would be self-correcting."

Table 8

Sample of One Scenario Provided for the Design of Lesson Plan 1

Grade	Elementary- 1st grade
Content Area	Math
Oklahoma Academic Standards	**1.N.1.4** Count forward, with and without objects, from any given number up to 100 by 1s, 2s, 5s and 10s. **1.N.4.2** Write a number with the cent symbol to describe the value of a coin. **1.N.4.3** Determine the value of a collection of pennies, nickels, or dimes up to one dollar counting by ones, fives, or tens.

Subsequently, in the mid-semester lesson plan (Lesson Plan 2), participants were required to incorporate technology into all parts of the lesson (i.e., opening, mini-lesson, work period, and closer). The participants had to develop all the materials for each part of the lesson, such as presentations of content and activities with the technologies they decided to use.

However, in the end-semester lesson plan (Lesson Plan 3), preservice teachers were required to incorporate technologies only in parts of the lessons they thought would be most appropriate and develop the materials for the technologies they decided to use.

Table 9 summarizes the three themes, subthemes, and examples from the participants (all written reflections from the three lesson plans combined). In addition to the quote, inside the parentheses is the description of the category that depicts the type of tool (hardware, software, or content), the strategies (i.e., direct instruction, assessment), the 4Es plus efficiency, and the value of technology integration (i.e., active learning, motivation).

Table 9

Themes from Written Reflection Questions Data

	Theme	**Examples** (Categories)
Technology Tools Selected	The technology tools selected by the preservice teachers to support the learning goals in the three lesson plans completed in the course	• "I decided to create a storyboard along with a PowerPoint so the mini-lesson could be interactive." (**Software**) • "I decided to use YouTube videos to open the lesson because I knew that there would be engaging and visual videos for younger students" (**Software**) • "I decided to use Google Forms, because I wanted a way to evaluate the students' understanding of inferences." (**Software**) • "The smartboard would be easier to use for the purpose of manipulatives, as they can simply be moved rather than redrawn and won't get lost" (**Hardware**) • "The use of Epic also allows students to easily see the pictures and text of the book." (**Software** and **Content**) • "The students and I would take the photos and make an iMovie to show our knowledge of opposites" (software tool) • "I believe that by using a jamboard it allows for the assignment to feel less like work." (**Software**) • "I also feel like PowerPoint is a good skill for students to have and to use it properly to present information to a group setting." (**Software**)

Activities & Strategies with Technologies	Teacher-centered: Use of technologies in activities in which the teacher has most of the control	• "I utilized Genially to create a short interactive presentation that introduces the material we will cover and the project we will complete" (**Direct Instruction**) • "I chose google slides instead of power point because google slides is easier to share between computer" (**Direct Instruction**) • "I first decided to include a video in my lesson because I feel that videos provide the best way to open the classroom for discussion with students." (**Video**; activating knowledge (**cues, questions, prompts**) • "For the closer I used Google Forms because I felt like it was the most short and to the point exit ticket for students to get done." (**Formative Assessment**) • "I decided to use YouTube to play music at the beginning of class because I know many students relate music to their day-to-day lives." (**Music**) • "I decided to use google slides so students could see the notes they needed to take and photos from that time." (**Direct Instruction**) • "I decided to use Kahoot to help test the background knowledge of the students." (**Activating prior knowledge**)
	Student-centered: Use of technology in activities in which the student has most of the control.	• "I decided to use the Kahoot as the opener because it is a really fun way to start off class (I even put cute gifs in them)." (**Gamification**) • "The reason I chose the jeopardy game is because I know from student experience that it is fun to make it a game between classmates and even help the students study harder because they want to beat the other team and get the bonus points for the test." (**Gamification**) • "I chose Flipgrid because I know young kids love to film themselves and it would be a fun way for them to share their learning with their classmates." (**Student Led: Activating Prior Knowledge**) • "I chose Padlet and Bubble.us for the mini-lesson because I knew they would be a quick way to see my student's thinking as well as help them brainstorm." (**Collaboration**) • "I chose to use Google Docs because of its features and accessibility. Students will be able to share their narrative with their peers for revision and leave comments on their peers' paper". (**Collaboration, Practice, Feedback**)

Reasons for Using Technologies	**4'Es Framework:** Selection of technologies based on whether they engage, enhance, extend, or make learning more efficient.	• "The updated plan addresses the Engage portion of Kolb's Triple E Framework. It fits into this with the use of music and interesting photos from the time period. (**Engage**) • "It engages student in learning more effectively (children love screens, and the love games even mores, so combine them and it's like magic)." (**Engage**) • "By using technology in different stages of the lesson I believed it will keep everyone engaged. You're not staring at multiple different papers or lecturing". (**Engage**) • "The use of technology keeps students entertained while they work on their diagrams." (**Efficienc**y) • "This lesson uses technology to Enhance Learning. It helps students separate the different pieces of writing a narrative. It also makes the content more interesting by using visual aids and pictures." (**Enhance**) • "My lesson fits into the enhance part of the triple E framework. The technology added into the lesson makes the concept easier to learn and creates a way for the students to show their understanding." (**Enhance**) • "My lesson makeover meets the extended framework as it creates a bridge between everyday laws that control life and learning how those come to be." (**Extend**) • "My lesson plan addresses Extended learning as the standards they learned through this lesson are real life skills that they will use everyday." (**Extend**) • "Efficiency is also a big part in classrooms and lesson planning. In every part of my lesson, the teacher is involved which allows for efficiency and time management to keep students from being distracted and keeping them on task." (**Efficiency**) • "All the platforms that I used allow for students to utilize their peers and work on developing a deeper understanding of the material." (**Enhance**) • "My lesson showcases the Extended part of the framework by allowing students to continue to think about their writing topic outside of class." (**Extend**) • "This lesson allows students to draw conclusions from data, which is a skill that students can use in their everyday lives" (**Extend**)

Value of Technology Integration: Perception of what integrating technology in lesson plans could do to support learning.	• "I feel like I did a good job of using different technology avenues at each station to enhance technology use in the classroom and incorporating each student's different learning styles into the centers." (**Differentiation accommodating student needs**) • "The technology will motivate the students because they are getting to be creative and write a story outside of using the typical pencil and paper." (**Develops students' literacy**) • "They are getting to express their story in a more colorful way and present it to their class. They will also be co engaging since they have to share and present their story to their classmates." (**Multiple modes of presentation, supports collaboration**) • "This lesson helps to foster a culture where students take ownership of their learning goals and outcomes in group setting by having the students work collaboratively to gather their own data, display the data in a graph, and draw their own conclusions from the graph ." (**Supports student choice and agency)** • "A majority of students need the lesson presented to the m in a different format besides just being handed a worksheet." (**Multimodal representation**) • "I also feel that with the technology used they feel more motivated to get started with the lesson and will interact more with their activities and with others in class." (**Motivation**) • "By making it new I was able to incorporate a whole new style of technology which students can use interactively. I changed it from the old school textbook and worksheet model to a hands-on activity that consults media types" (**Multimodal representation**) • "The technology used with peer review helps students move from passive learning to active learning by engaging with their other classmates." (**Active learning**)

Subsequently, the theme of the activities and strategies was divided into two subthemes: teacher-centered approaches, with a mean frequency of 3.07%, and student-centered approaches, with a mean frequency of 2.57%, respectively. For example, Dakota decided to use a mostly teacher-centered strategy at the beginning of the lesson: "I wanted to start with a fun song/video about coins to grab their attention." Dakota decided to use a slide presentation immediately after the video because "after the video is when the teacher would present the slides while they are still engaged." Likewise, Gavi decided to use a video to provide a visual representation of the content: "I chose to use a youtube video in my opener because I felt that I would give the student a brief enough overview and then I could elaborate and build off of the video using my own example." Next, Gavi decided to lecture students using a presentation tool: "By doing a brief slideshow, I will be able to elaborate more in my own words and explain it to the students. The slides serve as talking points for me more than anything."

Additionally, preservice teachers focused on collaborative learning, formative assessments, and activating prior knowledge (cues, questions, prompts) strategies for student-centered activities (see Table 9). For example, Jesse used a combination of teacher- (presenting a video with instruction; an article for content) and student-centered (collaboration and peer-feedback) strategies to foster collaboration: "The technology I had in my lesson plans was YouTube video and an article about the different types of imagery you can use in poems." Then, Jesse explained the collaboration and peer-feedback component in the lesson when students are writing the poems: "Students are able to collaborate with their group members along with one other group about their poems and they are able to give constructive feedback to their peers."

Similarly, Maddox decided to use a combination of teacher- (direct instruction) "with an interactive dance and song, a teacher led lesson" and student-centered (student-led and collaborative) strategy with a "student-led paper, and class activity to close" to support a diverse group of students because the "variety in tasks makes this lesson more fun and accommodates different types of learners." Another example came from Imani, who decided to use a software tool to aid a group discussion: "I used Answer Garden, I like using it to ask class questions that way students can see everyone's responses and it is also easier for the teacher and see all responses as well." Imani then explained, "We have recently used Answer Garden in one of my classes so I was ready familiar with it."

Likewise, Arden decided to provide students with a selection of digital and non-digital tools by combining a digital presentation and a physical book in the lesson: "I decided to create a presentation of the students to engage and see the sentences themselves." Then Arden, based on their personal preference, decided to present a book: "I came up with the idea of showing the class a read-aloud book" because "I always like having physical homework on a piece of paper."

Reasons for Using Technologies. This theme encompasses the decision-making process of participants who integrated technologies into their lesson plans for this study. The theme is divided into two subthemes, the four E's and the perceived value of technology integration.

In the reflection question responses, the participants explained how their lesson plans addressed one or more of the four E's (i.e., engage, enhance, extend, and efficiency) and the purpose for which they decided to use technology tools.

4Es Framework. Most of the participants expressed using technologies to engage and motivate students to learn. Engagement in learning (22 instances in referencing the 4Es) was the most frequent of the 4Es described by preservice teachers as a reason to integrate technology into their lessons.

For example, Bellamy explained how their lesson plan meets the engagement part of the 4E framework using project-based, collaboration, and student choice strategies: "My plan addresses the Engage learning part of the Triple e *[sic]* framework. This activity allows for kids to collaborate and create their own poster how they want to design it, which will keep them involved."

Similarly, Arden described how their lesson plan blends group collaboration and videos (direct instruction) to be more engaging: "My new plan addresses engaging learning in the lesson. I created the lesson so the class could collaborate and work together at the beginning. I also included an engaging video that I thought the students would enjoy instead of getting lectured by using the dry erase board."

Furthermore, extended learning (15 instances referring to the 4Es) and enhanced learning (14 instances) came close to second and third, respectively. While Eli used a vocabulary lesson of "words they will use everyday" to extend students learning, Cameron used a cloud-based tool to "allow students to interact with each other digitally by posting comments and by collaborating online" to enhance students learning. To close, efficiency was described only in four instances. For example, preservice teacher Bellamy stated how the use of apps makes their lesson more efficient: "Finally, it is efficient because students can easily transition through the stages of their project by switching to the next app rather than waiting for the teacher to hand out papers, supplies, etc., and there is no clean-up, so there is more time for other learning in the day." Likewise, Hunter explained how their lesson plan is more efficient by incorporating automatic feedback and allowed teacher productivity: "Efficiency would be enhanced by the teacher not having to make individual corrections for every student, and students not having to wait and waste lesson time waiting on the teacher to check their work." On the other hand, Dakota thought about the age appropriateness of the students: "Since most kindergartners cannot read, I choose for the google forms assessments to be taken at the same time with the teacher reading of the questions. Efficiency comes into play."

Value of Technology Integration. Participants chose technologies to increase student motivation and ignite the learning process. This sub-theme was mentioned in 13 files. For example, Cameron described the importance of integrating technology into one of their lesson plans: "Now we have the resources and knowledge to understand that technology integration can boost student interest and motivation." Similarly, Jesse explained why using technologies would motivate students. "The technology used in it allows students to focus on the assignment task with less distraction, my lesson also motivates students to start the learning process."

Kendall and Cameron both reflected on selecting technologies based on their perception of what certain technologies could do. Kendall sought to create a dynamic learning environment by allowing “students to become active social learners” by having them work in teams to “co-use a document.” Cameron’s goal was to foster creativity, and they allowed “students to design their own topic and picture graphs” and have the “opportunity to communicate their knowledge and connections that they concluded from the graphs."

One example is from Kendall, who explained how using technologies in their lessons will create a dynamic learning environment: "The technology used also allows students to become active social learners, as they are working in pairs to co-use a document. This nurtures social learning and teamwork." Another example comes from Cameron, who stated how the technologies used in the lesson plan would foster creativity: "Moreover, this lesson models and nurtures creativity by allowing students to design their own topic and picture graphs. It also gives students the opportunity to communicate their knowledge and connections that they concluded from the graphs."

Mixed Methods

The mixed methods portion of the research focused on the third research question: *How does the convergence of TPACK self-perceptions, TPACK application, and reflections illustrate preservice teachers' technology integration repertoire?* Quantitative and qualitative data were merged in a narrative discussion for triangulation purposes (Creswell & Plano-Clark, 2018). During this process, confirmatory evidence was found in two technological components: TPK and TPACK. Additionally, atypical findings were found in two components of TPACK: TK and CK.

As reviewed in research question one, paired t-tests were conducted using the TPACK survey (Schmidt-Crawford et al., 2009) to measure participants' self-perceptions about technology integration. The results of the paired t-test were statistically significant in all components except content knowledge (CK), which was only statistically significant in two subjects (science and literacy).

Moreover, to measure the application of TPACK in lesson design, the researcher assesses participants' lesson plans with a TPACK-based TIAR (Harris et al., 2010; Appendix) and performed repeated measures ANOVAs in the three lesson plans. The results obtained revealed statistically significant gains in the three components of

TPACK, confirming the results obtained in the paired t-test on the technological components (TCK, TPK, and TPACK).

Quantitative results demonstrated improvements in all TPACKs except content knowledge (CK) in math and social studies. However, confirmatory findings of TPACK in the qualitative results were less evident, only confirming growth in TPK and slight growth of TPACK. Whereas reporting no evidence in TCK.

Technological Pedagogical Knowledge (TPK)

Technological pedagogical knowledge (TPK) was the most evident technological component in the reflections of the participants. TPK refers to the general knowledge of instructional strategies that can be used in all subjects (Graham et al., 2012; Mishra & Koehler, 2006). The TPK was evident in the three main themes of the thematic analysis: 1) technology tools uses; 2) activities and strategies with technologies; and 3) reasons for using technologies.

The participants selected technology tools and made decisions to use the technologies in their lesson plans for general reasons such as facilitating general pedagogies and supporting students. Most participants decided to use YouTube, Google Slides, and the Smartboard for presentation or displaying information (teacher-centered). For example, Imani used YouTube for displaying and presenting information: "I used the YouTube video because I felt it was a good preface for the writing process and beneficial to students before they begin to write." Imani explained another decision for using the video: "I also figured it was better than a teacher just standing up there and talking about it."

Likewise, Maddox decided to use YouTube for presenting information: "I chose to watch a reading of a book from YouTube." Like Imani, Maddox decided that presenting the information from a video was "a fun way for the children to see a book other than me sitting down and reading it to them."

Similarly, Eli decided to use a YouTube video for presentation and assessment of the material: "I used a YouTube video over the season in song form to help students go over what they were just quizzed."

In addition, TPK was evident in participants' decisions to use technologies to promote active learning, collaboration, assessment, practice/feedback, and teacher productivity (efficiency). Since participants were asked a specific question about the 4E framework (see Table 9), the written reflections provided richer descriptions to confirm gains in TPK.

For example, most participants decided that their technology-enriched lesson would engage or motivate students. Neel's decision for using the iPads and smartboard was to motivate students because "in my opinion, it motivates the students in the learning process whether the smartboard or ipads are being used to complete the phase of the lesson." Further, Neel explained how the smartboard and iPad help the teacher and the student: "It allows both the teacher and students to have ways to include technology into their part of the lesson as they can each be gauged on their own capabilities." This showcases the use of technologies to support learner motivation and teacher productivity.

Other examples showcasing TPK (see Table 9) include making the lesson more efficient, as Bellamy explained in the reflection, "because students can easily transition through the stages of their project rather than waiting for the teacher to hand out papers, supplies, etc. and there is not clean up, so there is more time for other learning in the day." Likewise, Dakota created a video to present/display information and to improve teacher productivity: "I did a good job with the video I created for the paper slide center it allows the students to have demonstration without the teacher being there. It saves time for the teacher while still allowing students to learn."

Moreover, participants' TPK is evident in their reasons for using technologies acknowledging the diversity of the students and prior knowledge. For example, Dakota decided to provide accommodations for all learners, while Eli desisted to use a technology tool because it might be too complex for the learners. To illustrate, Dakota decided to "construct stations that can accommodate many students' learning styles," then Dakota further explained that "one student may learn better by watching a video while the other is better at learning by playing a game." Eli decided to use Google slides: "I was also thinking about using Fakebook instead of Google slides to create a profile for each season," However, then Eli thought "it might be too complicated. They will be familiar with Google slides." Another example comes from Arden, who decided to create a presentation with visual representation: "As I am a visual learner myself, I decided to create a presentation for the students to engage and see the sentences themselves."

TPACK Descriptions

TPACK refers to the reasons or decisions for using technologies, such as transforming content representation, demonstrating knowledge in content-specific strategies, and understanding learners' content-specific knowledge (Graham et al., 2012;

Mishra & Koehler, 2006). Only two participants, Finley and Gavi, described in their written reflections instances of TPACK. For example, Finley (Lesson Plan 3) "changed it from the old school textbook and worksheet model to a hands-on activity that consults new media types." Finley went even further by explaining the content: "Laws control most every aspect of life, and many students are ignorant how they transform from an idea to an actual law."

While Gavi did not provide content-specific examples, they reflected on the importance of multimodal representation by "providing different resources for my students to gain better understanding of the material that is being presented in the lesson." Gavi explained that "it allows the students to complete the assignment in the Google Form and get it checked by a teacher to see if students need to rework any of the sentences." Also, Gavi is "providing a way to complete a formative assessment over the curriculum."

TK and CK Components Description

Technology knowledge (TK) refers to general technology knowledge that participants must have, such as learning how to use a tool (Mishra & Koehler, 2006; Mishra, 2019). The TK component was not included in the TIAR (application). It was only measured by the TPACK survey in which participants' growth and gains from the course were significant. Imani was the only participant who referred to TK in their lesson plan by teaching the students a presentation tool: "I also feel like PowerPoint is a good skill for students to have and to use it properly to present information to a group setting."

Lee described content knowledge (CK) to evaluate a lesson before considering implementing the technologies stating that the language used in the original lesson was not inclusive. "This lesson needs a makeover for many different reasons, some of the language they use is not inclusive and does not seem to take into account the feelings of other races during the lesson." Lee went even further to explain why the lesson was not inclusive: "Asking students if they'd choose to stay in the south since or move north, this is not inclusive at all since the majority of white students would choose to stay in the south since they wouldn't face what blacks were facing."

In general, the qualitative analysis confirmed the gains and growth in TPK in all participants. Only two participants described growth in TPACK, whereas two participants provided descriptions for TK and CK. TK and CK knowledge were only measured by one instrument (TPACK survey), which is based on participants' self-perceptions. Finally, the written reflection questions were based on the decisions for using technologies in the participants' lesson plan designs.

Summary

The purpose of Chapter 4 was to analyze the changes in TPACK in a semester educational technology course and to explore the development of the technology integration repertoire of participants. A convergent mixed methods approach with a collective case study design was used for data collection and analysis. A total of 14 preservice teachers enrolled in the educational technology course participated in the study.

To answer Research Question 1 and assess the TPACK changes, the researcher used two validated instruments: 1) Schmidt et al. (2009) TPACK self-perceptions survey and 2) Harris et al. (2010) TIAR performance assessment rubric.

The quantitative results of the paired t-tests showed that six components of TPACK reported statistically significant increases with medium to larger effect sizes (d) ranging from.456 to.706. However, in the content knowledge (CK) component, results reported statistically significant increases only in literacy and science. For repeated measures, the ANOVA results showed statistically significant gains in three technological components of TPACK (TPK, TCK, and TPACK).

Next, to answer Research Question 2, the researcher analyzed written reflection questions to explore the participants' reasonings for selecting the technologies. After the coding process using Braun & Clarke's (2009) six-phase approach, the results report three themes: 1) technology tools selected, 2) activities and strategies with technologies, and 3) reasons for using technologies.

To answer Research Question 3, the researcher merged the results into a narrative discussion. Qualitative results confirmed the results of paired t-tests and repeated measures ANOVA only in the TPK component, as illustrated with the examples. Furthermore, qualitative evidence also found descriptions of TPACK component in two participants. Additionally, in the TK and CK components, the qualitative results indicated that one participant described TK in their written reflection; while another participant described CK in their written reflection Finally, the discussion of results, limitations, implications, and considerations for future research are addressed in Chapter 5.

CHAPTER V

DISCUSSION

The purpose of this study was to explore TPACK changes and describe the technology integration repertoire of preservice teachers over the course of a semester-long course in educational technology. This chapter reviews the main findings presented in Chapter 4 and offers implications and recommendations for future research. The chapter includes the following sections: 1) summary of the findings by research questions, 2) limitations, 3) implications, 4) recommendations for future research, and 5) conclusions.

Summary of Findings

Quantitative and qualitative data were collected using a demographic survey TPACK self-perception survey (Schmidt et al., 2009), TIAR performance assessment rubric (Harris et al., 2010), and written reflection questions.

The three research questions listed below guide the discussion of this chapter.

1. To what extent (if any) do preservice teachers' TPACK self-perceptions and applications change over the course of a semester-long educational technology course? (*quantitative*)

2. How do preservice teachers' technology integration repertoire change over the course of the semester? (*qualitative*)

3. How does the convergence of TPACK self-perceptions, TPACK application, and reflections illustrate preservice teachers' technology integration repertoire? (*mixed methods*)

Research Question 1: TPACK-Self Perceptions and Application Changes.

The study findings demonstrate that participants' self-perceptions of their TPACK increased at the end of an educational technology course. The difference in the mean scores of the TPACK survey demonstrated growth in six components of the TPACK, and each component represents a large effect size. In the technological components of TPACK (TK, TCK, TPK, and TPACK), the gains represent an increased level of confidence in participants in teaching with technology, as reflected in the difference in scores from the beginning to the end of the course.

The content knowledge component was tested in science, literacy, mathematics, and social studies, but it only showed growth in literacy and science; it was not significant in mathematics and social studies. The increases in science and literacy are due to participants' exposure to several activities in the course such as makerspaces, literacy lesson plan examples, and enrollment in other courses.

The application of TPACK by the participants, from Lesson Plan 1 to Lesson Plan 2, to Lesson Plan 3, reveals growth in all three components: TCK (i.e., curriculum goals and technologies), TPK (i.e., instructional strategies and technologies), and TPACK (i.e., technology selections and fit). The results of TPACK self-perceptions and applications are confirmatory, suggesting that participants' self-perceptions and applications are positively related. All participants (14) in this study felt confident about using technology to support learning in their future classrooms, and their lesson plans reveal the same pattern. For example, in Lesson Plan 1 (baseline activity), all participants (14) had lower TIAR scores, with an average of 7.64. However, the average TIAR score of their lesson plans increased from 11.93 in Lesson Plan 2 to 15.89 in Lesson Plan 3. To illustrate, Jesse, in Lesson Plan 1, had a TIAR rubric score of 4; by Lesson Plan 3, Jesse's TIAR score increased to 16, demonstrating the TPACK application growth.

The results of participants' TPACK applications are consistent with their TPACK self-perceptions in the three technological components (TPK, TCK, and TPACK) and suggest the educational technology course (Neumann et al., 2021) promotes student growth in TPACK knowledge.

The quantitative results are comparable to numerous studies that have investigated teachers' knowledge using self-report surveys and their relationship to more objective outcomes such as lesson planning and quality of technology use in the classroom (Archambault, 2016; Chai et al., 2013; Chuang et al., 2015; Habib et al., 2020; Wang et al., 2018). Comparative studies also found positive associations between TPACK and performance assessments, suggesting the development of TPACK in preservice and inservice teachers through professional development training or as part of their teacher preparation programs.

Although TPACK growth cannot be correlated with actual use of technology in classrooms, several studies have suggested that higher confidence levels could be an indicator of the presence of technology-related self-efficacy and motivational beliefs (Backfisch et al., 2020; Tondeur et al., 2017; Valtonen et al., 2020). According to these studies, self-efficacy and motivation beliefs are strong predictors of teachers (preservice, inservice) integrating technology to support learning in classrooms.

Certain studies on TPACK development and performance-based assessments of preservice and inservice teachers (i.e., lesson plans) analyzed with TPACK-based rubrics rarely relate to self-reported levels of TPACK (Angeli & Valanides, 2005; Backfisch et al., 2020; Harris & Hofer, 2011; Kopcha et al., 2014; Neumann et al., 2021; Valtonen et al., 2020). These studies (Hall, 2018; Kopcha et al., 2014; Neumann et al., 2021; Valtonen et al., 2020) conducted paired t-tests or correlation tests using TPACK self-perception surveys and applications with TPACK-based rubrics at two points in time (beginning and end) and did not include a baseline lesson plan.

However, by measuring growth from Lesson Plan 1 to Lesson Plan 2 to Lesson Plan 3 in this current study, results indicate that participating preservice teachers' TPACK self-perceptions and application did change over the course of a semester-long educational technology course suggesting growth in TPACK development.

***Research Question 2: Technology Integration Repertoire Changes*.**

To gain insight into how preservice teachers' technology integration repertoire changes over the course of a semester, participants' written reflections for each lesson plan were analyzed individually and collectively. Three themes emerged from this analysis: 1) technology tools used, 2) activities and strategies integrating technologies, and 3) reasons for using technologies. The progression of the participants from Lesson Plan 1 to Lesson Plan 3 can be seen through these three themes.

To map the growth of their technology integration repertoire, the researcher focused on the rationales and the instructional decisions that participants provided in the written reflections. Harris and Hoffer (2011) suggested that technology integration growth can be seen in teachers' lesson plans (preservice, inservice) by looking at the way they organize their lessons. The organization of the lesson plan begins with the teachers focusing on the content, then moving toward designing activities to support student learning, and lastly, choosing the technologies to support the designed activities (Graham et al., 2012; Harris & Hoffer, 2011).

For the purpose of this discussion, growth is described as the progression of the participants' technology integration repertoire from technology tools toward learners first then technology (Kolb, 2017). The progression of the technology integration repertoire includes teacher and student-centered activities since both strategies are necessary when teaching a diverse student population in dynamic learning environments (Darling-Hammond, 2017; Hughes et al., 2020; Kopcha et al., 2020).

The participants' technology integration repertoire consists of teacher-centered strategies in which the participants selected a technology tool to present the content (Smartboard, Google Slides, YouTube!) or to complete an activity (Google Forms, Educational Apps). Student-centered strategies consist of activities such as gamification (Kahoot, Jeopardy, ABCya! Games) in which students participate in content created by the teacher or created by artificial intelligence and/or a collaboration/project-based or inquiry-based in which the students solve a problem, complete a project, and collaborate in groups giving learners more agency (Hughes et al., 2020).

Additionally, participants' answers to the 4Es demonstrate how teachers are decision-makers and designers, use tools based on their prior knowledge and beliefs, and design lessons with technologies that support student learning (Ertmer, 2005; Graham et al., 2012; Kolb, 2017; Kopcha et al., 2020; Hughes et al., 2020).

From Lesson Plan 1, it is evident that most participants have a limited technology integration repertoire; therefore, their rationale for answering "what is best" comes from their prior knowledge. For example, 7 out of 14 participants used the Smartboard to display information and provide direct instruction to students in Lesson Plan 1. Whereas 6 out of 14 participants decided to use iPads and laptops, and one participant decided to use Google Slides. For example, Finley decided to use the Smartboard "so that everyone can see and understand what was going on." Similarly, Kendall decided to use Google Slides "because it is a good way for students to separate information into smaller pieces."

The preservice teachers (PT) in this study thought about the tool and then tried to solve the problem of integrating technology into the lesson to support the standards and learning objectives. For example, Arden explains their rationale for using iPads: "I decided to use iPads as my technology of choice for this lesson as I thought it would be hands-on and some different than paper and pencil." Similarly, Neel describes why the smartboard was the best choice for their lesson: "The smartboard would be easier to use for the purpose of manipulatives, as they can simply be moved rather than redrawn and won't get lost."

Arden and Neel selected hardware such as iPads or Smartboards in these cases and did not list the activities they would use for the lesson. Often the technology tools are not the most suitable for the content or grade level. For example, Arden decided to use the iPad to complete a PK Math activity using Google Forms. The iPad is not the best tool to display Google Forms or for Pre-K students who are learning to read; therefore, the misalignment of the lesson was evident because the tools and strategies might not support the learning objectives and standards.

The description of the technology integration repertoire of the participants' Lesson Plan 1 focuses on teacher-centric pedagogies and technology selections that might not fit the content, standards, and learning objectives These findings are evident in their written reflections when all participants (14) selected hardware tools (i.e., smartboards, laptops, interactive whiteboards) and software tools (i.e., Google Slides, Videos). All participants focused on the affordances of the tools, such as: "be more engaging" or "better than paper and pencil," as described in their written reflection for Lesson Plan 1.

The Lesson Plan 2 assignment also asks the same reflection questions to evaluate the selection of technologies in their lesson plans with the 4E framework (engage, enhance, extend, and efficiency). The purpose of using the 4E framework is to measure authentic learning and make better decisions using technologies that add value to meet learning goals (Kolb, 2017; Kopcha et al., 2020). All participants (14) suggested that their lessons will be more engaging because students love technology. For example, Hunter explained their use of technology because "it engages students in learning more effectively (children love screens, and they love games even more, so combine them and it's like magic)."

Hunter's emphasis on the tool creates what Kolb (2017) calls "false engagement," as teachers put the tool first and the learners second, such as students browsing on the Internet or swapping in their iPad looking at memes distracting students from the task (Wartella, 2015).

On the other hand, the growth in their technology repertoire is evident in the written reflections of Lesson Plan 2 when the participants teach with technologies in all parts of the lesson. For example, Dakota decided to use technology to provide differentiation and accommodate all types of learners. To illustrate, Dakota decided to "construct stations that can accommodate many students' learning styles," then Dakota further explained that "one student may learn better by watching a video while the other is better at learning by playing a game."

To answer, "what is best," participants use a combination of teacher-centered and student-centered activities (Kopcha et al., 2020). Six participants use instructional strategies such as gamification (Kahoot, Jeopardy Rocks, ABCya!) and collaboration to engage and create an active classroom environment so that students will be more receptive to learning. For example, Jesse decided to use Jeopardy Rocks because "I know from student experience that it is fun to make it a game between classmates and even help the students study harder because they want to beat the other team and get the bonus points for the test." Similarly, Eli used Kahoot to create an active classroom environment, "Kahoot has always been something that I used in school, benefited my learning while creating a fun environment."

In Lesson Plan 2, participants still used teacher-centered activities, but their approach changed from tool-based to content-based, indicating growth. Although due to the nature of the assignment, the participants encountered an ill-defined problem (Jonassen, 2000), all participants found solutions to the problem by focusing on content, standards, and learning objectives and then looking at the technologies they want to use in each part of the lesson. For example, Cameron's written reflection shows evidence of the shift towards the content, explaining how they designed the activities first, then selected the technology, "I also designed authentic learning activities that aligned with the OAS standards and used digital tools, such as Jam Board, to maximize active learning."

Additionally, twelve participants used YouTube videos in Lesson Plan 2, primarily for deconstruction practices (Grossman et al., 2009; Korthagen et al., 2006). Kendal and Jesse used digital tools to promote class discussion (i.e., Jamboard, YouTube!). For example, Jesse decided to use a video to foster understanding of a complex story, "The YouTube videos help the students be able to break down the story and be able to follow along with the story." Also, Kendal used a digital tool to discuss the content and provide opportunities for all students to participate: "I decided to use a Jamboard because it allows every student to contribute to the class discussion."

In Lesson Plan 2, ten participants used a combination of teacher- and student-centered activities, while four participants only included teacher-centered activities. The student-centered activities included collaboration in projects (slide presentation, virtual storyboard, Google Doc, digital notebook) and feedback from peers and instructors to support students' learning. Examples of teacher-centered strategies include formative and summative assessments using Google Forms.

As evidenced in Lesson Plan 2, all participants designed a lesson plan using an effective technology integration strategy and reflected on their decisions to use the technologies; while in Lesson Plan 1, all participants selected a tool to promote engagement without considering other benefits.

The instances in which all participants described the 4E increased from the first lesson to the next, which would be a sign of growth because it reflects the evaluation process of the technologies of the participants to support learning in their lesson plan. *Engagement for Learning* is the one 4E that all participants used when evaluating the technologies in Lesson Plan 2 and was mentioned only by four participants in Lesson Plan 1. Additionally, *Enhanced Learning* (added value of the tool) and *Extended Learning* (real-life; authentic experience) were described by 12 participants' reflections. *Efficiency* (time management) was mentioned by four participants in Lesson Plan 2 reflection questions. Finally, only seven participants explained how their lesson meets all 4Es.

The complexity of developing their own materials for each part of the lesson influenced the participants' decisions to rely on content that was already developed to comply with the assignment instructions. This could be why YouTube was one of the most selected tools and may be, along with the fact that they are preservice teachers, the reason why the participants used mostly teacher-centered strategies in Lesson 1. (Graham et al., 2012; Hughes et al., 2020; Neumann et al., 2021). As Kopcha et al. (2020) describe regarding the Teacher Response Model, teachers will use "what they value" (p. 733) the most; therefore, it could be assumed that student-centered strategies modeled in the course within this study are not perceived as valuable. Hughes et al. (2020) also describe that preservice teachers are more inclined to select teacher-centered strategies because they lack opportunities to enact their lesson designs in practice. It could also be that they have rarely experienced student-centered pedagogies as learners and therefore do not consider it.

In Lesson Plan 3, participants were required to choose a lesson from a selection of lesson plans that included no technology integration and transform it into one that effectively integrates technology. The participants were not required to use technologies in all parts of the lesson and should only develop materials for the part of the lesson in which they believed technologies would enhance learning. Written reflections revealed that the participants' plans for using technology were primarily centered on the teacher (Hu & Yelland, 2017). Student-centered technology use was not evidenced as frequently as in Lesson Plan 2, only eight participants provided activities to support collaboration, practice, and feedback. Three participants used the very same strategies and tools they used in Lesson Plan 2, which would indicate no growth in TK; however, the alignment of their lesson plan improved significantly, which would indicate growth in TPK.

In summary, participants used mainly teacher-centered strategies in all lesson plans (Lesson Plan 1, Lesson Plan 2, Lesson Plan 3) this is consistent with certain studies that found that preservice teachers tend to use used more teacher-center strategies compared to inservice teachers (Graham et al., 2012; Hughes et al., 2020; Polly, 2014). Participants' reflections suggested that they are designing the lessons as an in-class assignment, not as an actual lesson plan they need to implement; therefore, the technology selected is focused on presenting/displaying information which is easier to develop (Polly, 2014).

Research Question 3: Convergence of TPACK Self-Perceptions, Applications, and Reflections.

Participants' TPACK growth was significant in their self-perceptions and applications in lesson designs. Participants demonstrated statistically significant gains in all technological components (TK, TCK, TPK, and TPACK). The quantitative finding suggests that the educational technology course prepared participants to effectively teach with technologies and develop their technology integration repertoire skills. However, the qualitative analysis of the written reflection question only finds gains in one TPACK component, TPK (general pedagogy knowledge). The findings are not surprising because the educational technology course is not content-specific; therefore, most of the strategies presented for the applications of technology could be used in any subject. Participants had been exposed for 16 weeks to multiple representations, tools, and activities modeling effective technology integration practices, and the findings are consistent with Hofer and Grandgenett's (2012) longitudinal study, which found growth in TPK after scaffolding the lesson plans.

As evidenced by their reflections, participants in this study integrated technology tools and strategies and made decisions based on prior knowledge, modeling strategies and tools used during the educational technology course, by other faculty in their teacher preparation programs, and by in-service teachers they have observed. The most common TPK strategies used by participants were the selection of hardware tools, software tools, and content tools to present/display information and provide visual representations of the content to students as revealed in their written reflections. The TPK is evident in several quotes from participants in this study (see Chapter 4, Table 8). For example, "The use of Epic also allows students to easily see the pictures and text of the book" (**Software** and **Content**) or "I chose Padlet and Bubble.us for the mini-lesson because I knew they would be a quick way to see my student's thinking as well as help them brainstorm" (**Collaboration**). The tools and strategies selected by the participants were not content-dependent, suggesting the development of TPK.

The participants' technology integration repertoire consisted of TPK strategies in which the technology used is teacher- and- student-centric. Participants used the same tools and strategies with individual variations; for example, five participants used Google Slides for direct instruction, and three used it as a collaboration tool for students to complete an activity. The growth of TPK strategies among participants implies that the advantages of technology tools might influence the way the participants interact with technologies, suggesting why participants use the same tool with different instructional strategies (Wallace, 2004).

Although collectively, all participants' written reflection questions confirmed the growth in TPK, four participants individually evidenced the following components: 1) TK (one participant), 2), TPACK (two participants), and 3) CK (one participant) components. There is not enough evidence to confirm gains in these components due to the complexity of defining each TPACK component and determining whether the quotes are giving rich descriptions to support gains or growth (Graham et al., 2012; Kimmons, 2015; Kimmons & Hall, 2016).

Overall, the participants in this study demonstrated improvements in TPACK after completing the course. TPACK growth was evident in participants' self-perceptions and applications after completing the educational technology course. The analysis of the written reflections evidenced participants' technology integration repertoire progression and confirms the development of TPK in their lesson plans.

Limitations

This study was carried out at the beginning of the COVID-19 pandemic, which affected participant recruitment. Instead of having at least five face-to-face sessions of the educational technology course, the researcher only had two classes for recruitment, possibly resulting in a smaller sample size than anticipated. Second, there is a gap between the time participants took the course and the time they will graduate from their teacher preparation program; therefore, relevant applications, intentions, and contextual factors for future practices cannot be considered in this study. Third, the educational technology course could not be isolated as a cause for all the statistical gains and large effect sizes in some components of the TPACK survey (PK and CK). The growth in these nontechnological components of the TPACK could be because preservice teachers were enrolled or have previously completed other education courses when they took the educational technology course (Hall, 2018; Mouza et al., 2014; Nelson & Hawk, 2020; Neuman et al., 2021). Additionally, they could have participated in a high school future teachers program, or they could have had greater exposure to the art and science of teaching prior to this course. Fourth, the two sections of the course were taught by the researcher; therefore, familiarity with the content and participants, and the lack of a second coder to assess the lesson plans in terms of TPACK, could have impacted the results even though the researcher followed all the procedures, decoded all the lesson plans before assessing them, and participated in reflexivity activities (memo notes and journaling) to reduce subjectivity and ensure trustworthiness (Creswell & Creswell, 2018; Patton, 2015).

Implications for Teaching

The findings of this study reinforce the importance of modeling effective teaching with technology. As suggested by the literature, modeling is one of the most important contributors to TPACK development (Graham et al., 2012; Wang et al., 2018). The more preservice teachers see faculty and P-12 teachers using technologies in their classroom with appropriate instructional strategies, the more likely students will implement and use technologies in their future classrooms (Hall, 2018; Hughes et al., 2013; Neuman et al., 2021; Tondeur et al., 2020; Wang et al., 2018). In addition, the course should provide opportunities for preservice teachers to understand their decision-making process through reflections and observations of TPACK content-specific lessons (Graham et al., 2012; Hughes et al., 2020).

Implications for Practice

The findings of this study suggest that exposing preservice teachers to a variety of tools and modeling effective technology integration in the design of lesson plans will significantly improve TPACK. To further develop preservice teachers' TPACK and expand their technology integration repertoire, teacher educators could provide a TPACK module with content-specific activities and tasks which could include approaches to evaluate technology tools, modeling of student-centered activities, and strategies to teach and design lesson plans with technologies.

This study also reveals that preservice teachers need more opportunities in the course to implement their lesson plans by shifting their mindset from functioning as students to seeing themselves as teachers. While participants did learn how to design and create meaningful learning activities with technology, they require more opportunities to reflect on their previous uses of technology, more opportunities to learn other frameworks for teaching with technology, and more opportunities to discuss approaches for teaching with technology in specific subject areas and cross-content lessons.

Having opportunities to teach their lessons in the class would help preservice teachers evaluate their lessons and reflect on what worked and what did not work and learn how to make new decisions during the process. Also, preservice teachers will benefit from having a lab component in the class to explore, play, and be creative with new emergent technology tools. The laboratory component will serve as a bridge between theory and application. Preservice teachers need multiple entry points to develop their technology integration repertoire, as growth takes more than knowledge; it also includes experiences and failures.

Implications for Service

The study's findings suggest that preservice, inservice, and teacher educators will benefit from participating in workshops that provide opportunities to explore technology tools and pedagogical strategies that support effective technology integration and develop TPACK. Additionally, preservice teachers enrolled in the educational technology course could participate in a voluntary mentoring partnership with inservice teachers who demonstrate exemplary TPACK in the classroom.

Implications for Research and Theory

The results of this study indicate that TPACK is a difficult construct to measure (Angeli & Valanides, 2005; Kopcha et al., 2014). Although the quantitative results were positive and demonstrated TPACK self-perceptions and application growth, the qualitative findings only showed growth in TPK (general pedagogical knowledge). One of the limitations of TPACK as a framework is that it only measures knowledge, not the quality of teaching or the quality of technology integration. Therefore, research should also focus on testing other technology integration models that capture the nonlinear process of teaching. For example, the teacher response model (TRM) (Kopcha et al. 2020), provides a shift toward looking at the decision-making process of teachers instead of what they need to know. The TRM takes into account teachers' perceptions of the context, the possible use of technologies, the evaluation of the decision, and the actual use.

Recommendations for Future Research

Conducting the study with a larger sample size could reveal interesting, and perhaps more representative, variations in the repertoire of technology integration of preservice teachers. Also, adding other sources of data collection, such as participants' videos of themselves teaching a lesson and stimulating video recall interviews, would provide richer descriptions of preservice teachers' technology integration repertoire and the decision-making process to select tools and strategies that could extend Kopcha et al.’s (2020) teacher response model. Finally, it would be beneficial to conduct a study following preservice students during their teaching practicum and as novice in-service teachers to explore existing mentoring models that support beginner teachers’ technology integration.

Conclusion

This convergent mixed method and a collective case study design explored how an undergraduate educational technology course impacts preservice teachers' TPACK knowledge about teaching with technology and how it affects the development of their technology integration repertoire. Quantitative findings indicate the growth of participants' TPACK knowledge (self-perceptions and application) over the course of the semester. The qualitative findings suggest that the preservice teachers' technology integration repertoire developed over the course of the semester from a tool-based approach to a learner-first and then tools approach. Furthermore, the merger of the data found confirmed the growth in the TPK component. The findings of this study provide a description of how preservice teachers develop their technology integration repertoire and TPACK during an educational technology course. This study is significant to teacher educators because it provides an overview of preservice teachers' TPACK growth during an educational technology course.

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APPENDICES

Appendix A: Demographic Questionnaire

1. Email address: ____

2. Gender o Male o Female o Non-binary/Fluid o Prefer not to answer o Other

3. What is your age?

Write your age number in the space provided.

o Prefer not to answer

4. Major

    - Early Childhood Education
    - Elementary Education
    - Secondary Education
    - Other, please specify:

5. Year in College

    - Freshman
    - Sophomore
    - Junior
    - Senior
    - Other, please specify

6. Are you currently enrolled or have completed your pre-clinical field experience in the PK-12 classroom?

    - Yes, I am currently enrolled
    - Yes, I have completed the pre-clinical field experience
    - No

7. Are you currently enrolled or have completed your student teaching or clinical practice field experience in the PK-12 classroom?

- Yes, I am currently enrolled
- Yes, I have completed the student teaching or clinical practice
- No

8. Are you currently part of the Excellence in Collaborative and Experiential Learning (ExCEL) Program?

- o Yes
- o No
- o I plan to apply in the future

9. Are you currently enrolled or have completed the following courses? Please select all that apply.

Course	Enrolled	Completed	Name of Instructor
Introduction to Teaching and Learning			
Middle Level Education			
Educating Exceptional Learners (SPED)			
Literacy Assessment and Instruction			
Role of the Teacher in American Schools			

Appendix B: Survey of Preservice Teachers' Knowledge of Teaching and Technology

Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies. That is, the digital tools we use such as computers, laptops, iPads, handhelds, interactive whiteboards, software programs, etc. Please answer all of the questions and if you are uncertain of or neutral about your response you may always select "Neither Agree or Disagree"

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
TK (Technology Knowledge)					
1. I know how to solve my own technical problems.					
2. I can learn technology easily.					
3. I keep up with important new technologies.					
4. I frequently play around the technology.					
5. I know about a lot of different technologies.					
6. I have the technical skills I need to use technology.					
CK (Content Knowledge)					
Mathematics					

7. I have sufficient knowledge about mathematics.					
8. I can use a mathematical way of thinking.					
9. I have various ways and strategies of developing my understanding of mathematics.					
Social Studies					
10. I have sufficient knowledge about social studies.					
11. I can use a historical way of thinking.					
12. I have various ways and strategies of developing my understanding of social studies.					
Science					
13. I have sufficient knowledge about science.					
14. I can use a scientific way of thinking.					
15. I have various ways and strategies of developing my understanding of science.					
Literacy					

16. I have sufficient knowledge about literacy.					
17. I can use a literary way of thinking.					
18. I have various ways and strategies of developing my understanding of literacy.					

PK (Pedagogical Knowledge)					
19. I know how to assess student performance in a classroom.					
20. I can adapt my teaching based-upon what students currently understand or do not understand.					
21. I can adapt my teaching style to different learners.					
22. I can assess student learning in multiple ways.					
23. I can use a wide range of teaching approaches in a classroom setting.					
24. I am familiar with common student understandings and misconceptions.					
25. I know how to organize and maintain classroom management.					

PCK (Pedagogical Content Knowledge)					
26. I can select effective teaching approaches to guide student thinking and learning in mathematics.					
27. I can select effective teaching approaches to guide student thinking and learning in literacy.					

28. I can select effective teaching approaches to guide student thinking and learning in science.					
29. I can select effective teaching approaches to guide student thinking and learning in social studies.					
TCK (Technological Content Knowledge)					
30. I know about technologies that I can use for understanding and doing mathematics.					
31. I know about technologies that I can use for understanding and doing literacy.					
32. I know about technologies that I can use for understanding and doing science.					
33. I know about technologies that I can use for understanding and doing social studies.					

TPK (Technological Pedagogical Knowledge)					
34. I can choose technologies that enhance the teaching approaches for a lesson.					
35. I can choose technologies that enhance students' learning for a lesson.					
36. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.					
37. I am thinking critically about how to use technology in my classroom.					
38. I can adapt the use of the technologies that I am learning about to different teaching activities.					
39. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.					
40. I can use strategies that combine content, technologies and teaching					

approaches that I learned about in my coursework in my classroom.					
41. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.					
42. I can choose technologies that enhance the content for a lesson.					

TPACK (Technology Pedagogy and Content Knowledge)					
43. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.					
44. I can teach lessons that appropriately combine literacy, technologies and teaching approaches.					
45. I can teach lessons that appropriately combine science, technologies and teaching approaches.					
46. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.					

Appendix C: Technology Integration Assessment Rubric (TIAR)

Criteria	4	3	2	1
Curriculum Goals & Technologies (Curriculum-based technology use)	Technologies selected for use in the instructional plan are strongly aligned with one or more curriculum goals	Technologies selected for use in the instructional plan are aligned with one or more curriculum goals.	Technologies selected for use in the instructional plan are partially aligned with one or more curriculum goals.	Technologies selected for use in the instructional plan are not aligned with any curriculum goals.
Instructional Strategies & Technologies (Using technology in teaching/learning)	Technology use optimally supports instructional strategies.	Technology use supports instructional strategies.	Technology use minimally supports instructional strategies.	Technology use does not support instructional strategies.
Technology Selection(s) (Compatibility with curriculum goals & instructional strategies	Technology selection(s) are exemplary, given curriculum goal(s) and instructional strategies.	Technology selection(s) are appropriate, but not exemplary, given curriculum goal(s) and instructional strategies.	Technology selection(s) are marginally appropriate, given curriculum goal(s) and instructional strategies.	Technology selection(s) are inappropriate, given curriculum goal(s) and instructional strategies.
"Fit" (Content, pedagogy and technology together)	Content, instructional strategies and technology fit together strongly with the instructional plan.	Content, instructional strategies and technology fit together within the instructional plan.	Content, instructional strategies and technology fit together somewhat within the instructional plan.	Content, instructional strategies, and technology do not fit together within the instructional plan.

Appendix D: Lesson Plan 1

Instructions:

1. Choose one of the scenarios below.
2. Use the provided information (grade, content area, and Oklahoma Academic Standards) for your scenario to plan a lesson that effectively integrates technology.
3. Plan your lesson by completing the template below the scenarios.
4. **You do not need to use technology in every part of the lesson;** use technology where it makes sense, make sure your use of it is effective, and indicate whether it is student-centered or teacher-centered use of technology.
5. After completing your plan, respond to the two reflection questions.

Grade	Elementary- 4th grade
Content Area	English Language Arts
Oklahoma Academic Standards	**4.7.R.1** Students will locate, organize, and analyze information from a variety of written, oral, visual, digital, non-verbal, and interactive texts to generate and answer literal and interpretive questions to create new understandings. **4.7.R.2** Students will compare and contrast how ideas and topics are depicted in a variety of media and formats. **4.7.W.1** Students will create multimodal content that effectively communicates an idea using technology or appropriate media. **4.7.W.2** Students will create presentations using videos, photos, and other multimedia elements to support communication and clarify ideas, thoughts, and feelings.

Grade	Elementary- 1st grade
Content Area	Math

Oklahoma Academic Standards	**1.N.1.4** Count forward, with and without objects, from any given number up to 100 by 1s, 2s, 5s and 10s. **1.N.4.2** Write a number with the cent symbol to describe the value of a coin. **1.N.4.3** Determine the value of a collection of pennies, nickels, or dimes up to one dollar counting by ones, fives, or tens.

Grade	Middle School- 7th grade
Content Area	English Language Arts
Oklahoma Academic Standards	7.3.W.1 NARRATIVE Students will write narratives incorporating characters, plot, setting, point of view, conflict, dialogue, and sensory details to convey experiences and events.

Grade	Middle School- 6th grade
Content Area	Social Studies
Oklahoma Academic Standards	**6.1.1** Apply geographic information to support analysis from primary and secondary sources located in a variety of texts. **6.1.2** Describe how various map projections distort the surface of the earth; apply the concepts of scale, distance, direction, relative location, absolute location, and latitude and longitude. **6.1.3** Integrate visual information, draw conclusions, and make predictions from geographic data and analyze spatial distribution and patterns by interpreting that data as displayed on geographic tools. **6.1.4** Integrate visual information and develop the skill of mental mapping of the political and physical features of Earth's surface in order to organize information about people, places, and environments.

Grade	High School- 11th grade
Content Area	English

Oklahoma Academic Standards	11.2.R.1 Students will summarize, paraphrase, and synthesize ideas, while maintaining meaning and a logical sequence of events, within and between texts 11.3.R.3 Students will analyze how authors use key literary elements to contribute to meaning and interpret how themes are connected across texts: ● theme ● archetypes

Grade	High School- 10th grade
Content Area	Social Studies
Oklahoma Academic Standards	**USH 7.1.C** Compare the viewpoints and the contributions of civil rights leaders and organizations linking them to events of the movement, including Dr. Martin Luther King, Jr. and his I Have a Dream speech, the leadership of Malcolm X, the role of organizations such as the Black Panthers; describe the tactics used at different times including civil disobedience, non-violent resistance, sit-ins, boycotts, marches, and voter registration drives

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Google Tech Tools (or ones intended for use with Google Tools)	
Docs (includes add-ons) Drawing Forms Sheets (includes add-ons) Slides Hangouts Sites Google Arts and Culture Google My Maps Google Earth Education Google Science Journal Be Internet Awesome (Interland)	Flippity Google Docs add-on store ● OrangeSlice (rubrics) ● Revision Assistant, too ● Parts of Speech Google Forms add-on store Google Sheets add-on store ● Autocrat Google Slides add-on store **Chrome extensions** Kaizena (feedback)

Toontastic Google Street View Made with Code YouTube Blogger Expeditions Tour Creator Tour Builder Fluency Tutor Scrible Talk and Comment SmartyPins Screencastify Geogebra AwesomeTable Stop Motion Animator CS First	Hypothes.is (annotation tool) Annotate (annotation tool) Verso RoboCompass (math) ChemReference (periodic table) Biodigital Human (3D human body) Astronomy Simulations & NASA Photo ThinkCERCA (personalized literacy) Gynzy ScienceBits Coggle (mind maps) InsertLearning (interactive webpages) Kami (annotation tool)

Category	**Non-Google Tech Tools**	**Category**	**Non-Google Tech Tools**
Interactive Presentations	Nearpod Genially Canva Sutori Pear Deck Thinglink	Curation & Brainstorming	Dotstorming Blendspace Popplet Bubbl.us Padlet AnswerGarden
Gaming	Symbaloo Connect Fours Pac-Man Flip Quiz Dust Bin Game Speed Match Jeopardy Rocks Gamestar Mechanic	Quizzing	Quizlet Quizziz Kahoot GoFormative Plickers Recap Socrative Triventy Quizalize GoSoapBox

Storytelling / Infographics	Book Creator Smore Snapsr Fakebook Flipgrid Twitter Generator Super Action Comic Maker Piktochart Powtoon iPhone IOS7 Generator SMS Generator Meme Generator Gif Maker Sway Read, Write Think Interactive Timeline Storyboard That TextingStory Chat Story Maker Sutori Chatterpix (iPad) Comic Book Maker (iPad) Draw and Tell (iPad) Mentimeter TimelineJS Make Belief Comix Kidblog	Video & animation	Loom Screencast-o-matic WeVideo Biteable ExplainEverything PlayPosit Powtoon EdPuzzle Adobe Spark Animoto Voki And Then I Was Like… Gif Maker Koma Koma (ipad) Educreations JellyCam Typito Nimbus Screenshot AnimakerClass My Simpleshow
Audio (music and podcasting)	Soundtrap Vocaroo Podomatic vozMe Anchor Synth	Other	SeeSaw Whiteboard.fi QR Codes Scratch Bulb Magnetic Alphabet (iPad) Aww TinyCards Tinkercad
Specific Content Areas	Newsela (English/Social Studies) Storybird (English) Fan Fiction (English) ListenWise (Literacy) Dremel Digilab (STEM)		

	Desmos (Math) CommonLit (ELA) Math, Physics, and Engineering Applets The Universe and More (Physics) SpongeLab Build a Body (Health / Biology) PhET (Science and some math) DocsTeach (Social Studies) TimeGraphics (Social Studies) TourBuilder (Social Studies)

Lesson Title	
Grade	
Content Area	
Technology Assumptions (What are you assuming about the technology access for the class you are designing this lesson for? Are they 1:1 Laptop/iPad? Laptop/iPad cart? Computer Lab? Something else?)	
Oklahoma Academic Standards	
Learning Objectives (Clearly articulate exactly what students will be able to do because of participating in this lesson.)	
Opener (Describe in great detail what the students and teachers will be doing in the lesson. A substitute teacher should have all the details they need to pick up this instructional plan and teach the lesson for you.)	**Technology used (if applicable):** **Student-Centered or Teacher-Centered Tech**

Mini-Lesson (Describe in great detail what the students and teachers will be doing in the lesson. A substitute teacher should have all the details they need to pick up this instructional plan and teach the lesson for you.)	**Technology used (if applicable):** **Student-Centered or Teacher-Centered Tech**
Work Period (Describe in great detail what the students and teachers will be doing in the lesson. A substitute teacher should have all the details they need to pick up this instructional plan and teach the lesson for you.)	**Technology used (if applicable):** **Student-Centered or Teacher-Centered Tech**
Closer (Describe in great detail what the students and teachers will be doing in the lesson. A substitute teacher should have all the details they need to pick up this instructional plan and teach the lesson for you.)	**Technology used (if applicable):** **Student-Centered or Teacher-Centered Tech**
Assessment(s) - Formative and/or Summative (List and explain the formative and/or summative assessments that will allow students to demonstrate mastery of the concepts/knowledge/skills learned during the lesson.)	
Additional Materials (List the additional resources needed to carry out the lesson.)	

Reflection Questions:

1. For each use of technology in the lesson you planned, describe why you decided to use that technology. If you considered using any other tools than the ones that ended up in your plan, describe why you decided not to use them.

2. Describe how your new plan addresses one or more of the 4E's (Kolb's Triple E Framework **plus Efficiency**).

Appendix E

Maximizing Technology Lesson Plan

Click here to review the instructions and example Maximizing Technology Lesson Plan. When you are ready, complete your submission below.

Lesson Plan:

Lesson Title	
Grade	
Content Area	
Technology Assumptions (Is your class 1:1 with laptops or iPads? Laptop or iPad cart? BYOD? Four desktop classroom? Something else?)	
OAS Standard(s)	
ISTE Standards for Students	
Learning Objectives	
Opener	**Technology used:** [replace this and hyperlink to materials here] **Student or Teacher Centered?**
Mini-Lesson	**Technology used:** [replace this and hyperlink to materials here] **Student or Teacher Centered?**
Work Period	**Technology used:** [replace this and hyperlink to materials here] **Student or Teacher Centered?**
Closer	**Technology used:** [replace this and hyperlink to materials here] **Student or Teacher Centered?**
Assessment(s) (Formative	

and/or Summative)	
Additional Materials Needed (besides the ones linked above)	

Reflection (respond underneath the line in 3-4 paragraphs):

1. For each use of technology in the lesson you planned, describe why you decided to use that technology. If you considered using or attempted to use any other tools than the ones that ended up in your plan, describe why you decided not to use them.
2. Describe how your new plan addresses one or more of the 4E's (Kolb's Triple E Framework **plus Efficiency).**

Appendix F

Lesson Makeover

Directions:

1. Select a lesson from the provided Teacher Edition Lesson Plans.
2. Transform your chosen lesson thoroughly into one that effectively integrates technology, engages students, and differentiates for all types of learners by completing the template below.
3. **You do not need to use technology in every part of the lesson**; use technology where it makes sense, make sure your use of it is effective, and indicate whether it is student-centered or teacher-centered use of technology.
4. Design the instructional materials you'd need to carry out your lesson with students and hyperlink them (even if you're planning to print them out for students). **Test the links!**
5. Complete the reflection questions below the lesson plan template.
6. Check the Lesson Makeover Rubric to make sure you've got everything covered.

Original Lesson (Hyperlinked)	
Lesson Title	
Grade	
Content Area	
Technology Assumptions (What are you assuming about the technology access for the class you are designing this lesson for? Are they 1:1? BYOT/BYOD? Laptop/iPad cart? Single computer classroom? Something else?)	
OAS Standard(s)	
ISTE Standards for Students	
Learning Objectives (Clearly articulate exactly what students will be able to do because of participating in	

this lesson.)	
Opener (Describe in great detail what the students and teachers will be doing in the lesson. A substitute teacher should have all the details they need to pick up this instructional plan and teach the lesson for you.)	**Technology used (if applicable):** **Student-Centered or Teacher-Centered Tech**
Mini-Lesson (Describe in great detail what the students and teachers will be doing in the lesson. A substitute teacher should have all the details they need to pick up this instructional plan and teach the lesson for you.)	**Technology used (if applicable):** **Student-Centered or Teacher-Centered Tech**
Work Period (Describe in great detail what the students and teachers will be doing in the lesson. A substitute teacher should have all the details they need to pick up this instructional plan and teach the lesson for you.)	**Technology used (if applicable):** **Student-Centered or Teacher-Centered Tech**
Closer (Describe in great detail what the students and teachers will be doing in the lesson. A substitute teacher should have all the details they need to pick up this instructional plan and teach the lesson for you.)	**Technology used (if applicable):** **Student-Centered or Teacher-Centered Tech**
Assessment(s) - Formative and/or Summative (List and explain the formative and/or summative assessments that will allow students to demonstrate mastery of the concepts/knowledge/skills	

learned during the lesson.)	
Differentiation/ Accommodations/ Modifications/Increases in Rigor (think UDL) (Identify and explain at least one Differentiated Instruction support that can be used for diverse student populations, such as ELL, gifted, IEP, hearing impaired.)	
Classroom Management of Technology (Identify the strategies used to help keep the students on task and actively engaged if/when they use technology.)	
Additional Materials (List the additional resources needed to carry out the lesson.)	

REFLECTION QUESTIONS

Your reflection must include a response to the following questions in paragraph format **BELOW** the next horizontal line:

1. Describe how your new plan addresses one or more of the 4E's (Kolb's Triple E Framework **plus Efficiency).**

2. For each use of technology in the lesson you planned, describe why you decided to use that technology. If you considered using or attempted to use any other tools than the ones that ended up in your plan, describe why you decided not to use them.

Appendix G: ADULT CONSENT FORM

OKLAHOMA STATE UNIVERSITY

PROJECT TITLE: Examining Preservice Teachers' Technology Integration Repertoire after an Undergraduate Educational Technology Course

INVESTIGATOR

Frances Alvarado-Albertorio, PhD Candidate, Oklahoma State University

DISSERTATION ADVISOR

Kalianne Neumann, Ph.D. Assistant Professor, Oklahoma State University

PURPOSE

The purpose of the study is to explore how an undergraduate Educational Technology course (EDTC) impacts preservice teachers' knowledge about teaching with technology and how it affects the development of their technology teaching repertoire.

PROCEDURES

Your participation will involve completing a demographic Questionnaire, lesson plan1 baseline activity, and allowing the researchers to include the information from four assignments you submitted for the course. Specifically, that work includes: 1) Technology and Technology Integration Pre- and Post-Surveys, Maximizing Technology Lesson Plan, Lesson Makeover Project, and the reflections associated with these lesson plan projects.

RISKS OF PARTICIPATION

There are no known risks associated with this project which are greater than those ordinarily encountered in daily life.

BENEFITS OF PARTICIPATION

There will be no direct benefit for your participation in this study. While there are no direct benefits for participating in this research, some individuals may feel a sense of satisfaction in knowing that they are contributing to an increased understanding of the learning gained by university students while completing an educational technology course.

CONFIDENTIALITY

Your identity and the records of your participation in this study will be kept private. Codes will be used on all research notes, and the key to the codes will be kept for up to two years; while we have the key to the codes, the data is considered identifiable. Any written results will discuss group findings and will not include information that will identify you.

Research records will be stored on a password-protected computer in a locked office and only researchers will have access to the records. We will keep data long enough to analyze the data and write up the results and revisit the data should we need to. All materials will be destroyed or deleted when no longer necessary for research.

COMPENSATION

Students participating in this study will earn 1 credit units through the Sona Research Participation System as this study will take approximately 45 minutes to complete.

CONTACTS

You may contact the researcher at the following address and phone number if you desire to discuss your participation in the study and/or request information about the results of the study:

Frances Alvarado-Albertorio, Graduate Student, 303 Willard Hall, School of Educational Foundations Leadership and Aviation, Stillwater, OK 74078, Phone: (412) 897-0623.

If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

PARTICIPANT RIGHTS

I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty. To withdraw my consent, I must make a written request to remove, return, or destroy the information.

Thank you for your consideration! Please keep a copy of this letter for your records.

Sincerely,

Frances Alvarado-Albertorio

PhD Candidate- Learning, Design, and Technology

Oklahoma State University

falvara@okstate.edu

412-897-0623

RESEARCH SUBJECT'S CONSENT TO PARTICIPATE IN RESEARCH

To voluntarily agree to take part in this study, you must click sign your name in the Qualtrics form. Signing your name indicates that you have read or had read to you this entire consent form and have had all of your questions answered. It affirms that you agreed to participate freely and voluntarily.

Appendix H: University Student Recruitment Script

My name is Frances Alvarado-Albertorio from the School of Educational Foundations, Health and Aviation at Oklahoma State University, falvara@okstate.edu

I invite you to participate in my doctoral dissertation study entitled: "Exploring Preservice Teachers' Technology Integration Repertoire: A Mixed-Methods Case Study" under the supervision of Dr. Kalianne Neumann. The purpose of the study is to explore how an undergraduate Educational Technology course (EDTC) impacts preservice teachers' knowledge about teaching with technology and how it affects the development of their technology teaching repertoire.

To participate in this study, you must be 1) 18 years of age or older and 2) enrolled in EDTC 3123: Applications of Educational Technology at Oklahoma State University.

Your participation will involve completing a Demographic Questionnaire, a Lesson Plan 1 Activity, and allowing the researchers to include the information from all assignments you submitted for the course. Specifically, that work includes: 1) Technology and Technology Integration Pre- and Post-Surveys, Maximizing Technology Lesson Plan, Digital Escape Room Project, Lesson Makeover Project, and Reflections. You completed all of this coursework as a regular part of normal instructional activities. The activity of completing this work would have occurred regardless of whether the research was being conducted. If you decide to participate your will earn 1-unit credit through the Sona Research Participation System as this study will take approximately 45 minutes to complete.

Your involvement in the research study, of using data for research purposes, is voluntary, and you do not have to participate. You may choose not to participate or to stop at any time without any penalty or loss of benefits to which you were otherwise entitled. If you agree to the use of your information/data for this research project, please select “Yes” in the Qualtrics form. Selecting the “Yes” button indicates that you have read or had read to you the entire consent form and have had all of your questions answered. If you don’t agree, none of your data will be included in the research and you can still participate in the Educational Technology course. If you decide to stop or you decide to withdraw from the study, the information that can be identified as yours will be kept as part of the study and may be analyzed, unless you make a written request to remove, return, or destroy the information.

Every effort will be made by the researcher to preserve your confidentiality including the following:

Codes will be assigned to participants and will replace identifying information. The key to the codes will be kept for up to two years; while we have the key to the codes, the data is considered identifiable. Consent forms, the key to the codes, and survey results will be kept in a locked cabinet and on a password-protected computer in the personal possession of the researcher.

The researchers will review the collected data. All materials will be kept for two years and destroyed when no longer are necessary for research. Information from this study will be used for the purpose of this study and any publications that might result from this study.

There will be no direct benefit for your participation in this study. While there are no direct benefits for participating in this research, some individuals may feel a sense of satisfaction in knowing that they are contributing to an increased understanding of the learning gained by university students while completing an educational technology course.

If you have any questions about this research project, please feel free to call me at (phone number) or send an email (email address). If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

Appendix I: IRB Approval

Oklahoma State University Institutional Review Board

Date:	07/12/2021
Application Number:	IRB-21-293
Proposal Title:	Examining Preservice Teachers' Technology Integration Repertoire after an Undergraduate Educational Technology Course
Principal Investigator:	Frances Alvarado Albertorio
Co-Investigator(s):	
Faculty Adviser:	Kalianne Neumann
Project Coordinator:	
Research Assistant(s):	
Processed as:	Exempt
Exempt Category:	

Status Recommended by Reviewer(s): Approved

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in 45CFR46.

This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.

The final versions of any recruitment, consent and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any unanticipated and/or adverse events to the IRB Office promptly.
4. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,

Oklahoma State University IRB

Appendix J: Copyright Permissions

This Agreement between Frances Alvarado-Albertorio ("You") and Springer Nature ("Springer Nature") consists of your license details and the terms and conditions provided by Springer Nature and Copyright Clearance Center.

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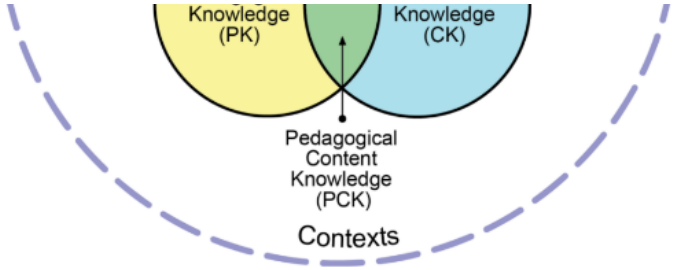

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Appendix K: Timeline of the Study

Month/Year	Procedures
May 2021	● Submit proposal for IRB approval
June - July 2021	● Add study to Sona ● Inform EDTC 3123 instructors of updates that need to be made to the syllabus, Maximizing Technology Lesson Plan submission document, and Lesson Makeover submission document ● Design alternative extra credit opportunity for students not wanting to participate in the research ● Inform EDTC 3123 instructors of alternate extra credit opportunity
August - September 2021	● Recruitment of participants starting the second week of class and ending at week fourth ● Questionnaire and Lesson Plan Activity (upon assenting to participate) ● Collect responses from the TPACK pre-survey ● Begin evaluating the lesson plan activity using the TIAR ● Begin analyzing quantitative data (demographic questionnaire, lesson plan activity, and TPACK pre-survey) ● Begin thematic analysis of qualitative data (lesson plan activity reflection questions) ● Keep a digital journal (reflexivity and trustworthiness) ● Create a database and folders for each participant to save the results and assignments completed ● Create a spreadsheet keeping track of the coding process
October - November 2021	● Begin collecting individual Maximizing Technology Lesson Plan and Lesson Makeover submission documents ● Begin evaluating the Maximizing Technology Lesson Plan and Lesson Makeover lesson plans using the TIAR ● Begin analyzing quantitative data from the TIAR ● Begin thematic analyses of qualitative data – reflection questions ● Update the database and folders ● Update the coding process spreadsheet
December 2021	● Collect responses from the TPACK post-survey ● Determine the final sample size ● Keep working on the thematic analyses

January - February 2022	● Complete the quantitative analysis of the TPACK surveys (pre/post) ● Finalize the statistical analyses of the questionnaire, TPACK surveys, and TIAR scores
March 2022	● Write Chapter 4 (results) ● Work on the thematic analyses
April 2022	● Write Chapter 5 (discussion)
May 2022	● Revise manuscript ● Sent manuscript to advisor
June - October 2022	● Revise dissertation based on advisor's feedback ● Submit final version to committee ● Set dissertation defense
November 2022	● Dissertation defense
December 2022	• Graduation

VITA

Frances Alvarado-Albertorio

Candidate for the Degree of

Doctor of Philosophy

Thesis: EXPLORING PRESERVICE TEACHERS' TECHNOLOGY INTEGRATION REPERTOIRE: A MIXED METHODS STUDY

Major Field: Education

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Learning, Design, and Technology at Oklahoma State University, Stillwater, Oklahoma in December, 2022.

Completed the requirements for the Master of Library and Information Science at University of Pittsburgh, Pittsburgh, Pennsylvania in 2004.

Completed the requirements for the Master of Science in Mass Communications at Florida International University, Miami, Florida in 2002.

Completed the requirements for the Bachelor of Business Administration at Pontificia Universidad Católica, Ponce, Puerto Rico in 1997.

Experience:

Graduate Teaching Associate, Oklahoma State University
Stillwater, Oklahoma, 2017-2022

Professional Memberships:

Member: AECT, AERA, ALA