ABSTRACT

IGUNZA, NIXON ODARI. Investigating Technology Use and Integration: Experiences Among Community College Transfer Students in a Mathematics Education Teacher Preparation Program (Under the direction of Dr. Robin Anderson).

This study explored the technology use and integration experiences among community college transfer students in a mathematics education teacher preparation program. The study aims to investigate how these students perceive their self-efficacy in using technology to teach mathematics and how their past experiences have shaped their readiness to use technology. It was conducted in a large research institution in the Southern United States in the 2024/2025 academic year. Two theoretical frameworks were used: the Technological Pedagogical and Content Knowledge (TPACK) framework, which assessed participants' knowledge of integrating technology, and the Technology Acceptance Model (TAM), which examined participants' acceptance of and motivation to use technology.

The study employed a narrative case study inquiry to explore the lived experiences of individual students in the teacher preparation program. Data was collected via the TPACK-M USA survey, semi-structured interviews and artifacts. Data analysis involved descriptive statistics in the quantitative phase and coding techniques, as well as thematic analysis in the qualitative phase, to identify and report the emerging themes in the lived experiences of technology use and integration.

Findings revealed that while senior CCTS students demonstrate greater confidence and preparedness in technology use than junior CCTS students. These comparison shows that students start the program with limited technology skills and low confidence in technology use, but improve after taking mathematics content and methods courses. Using technology in classrooms during student teaching provided opportunities to practice, thereby increasing their self-efficacy in technology integration. An analysis of a sample of lesson plans of senior CCTSs affirmed that these students integrated technology in their placement classrooms. In conclusion, the CCTSs' experiences revealed growth in both technology use skills and self-efficacy. However, these students faced various transition challenges, suggesting the need for enhanced support.

Investigating Technology Use and Integration: Experiences Among Community College Transfer Students in a Mathematics Education Teacher Preparation Program.

by
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DEDICATION

To my family: my wife Agnes Vutsigwa; my Daughters Natasha Furaha and Joy Alicia; my son Liam Baraka; my siblings, and my parents, Francis Igunza and Florence Amagove. Let this work inspire my children to dream and pursue big endeavors in the future.

BIOGRAPHY

Nixon Odari Igunza was born in western Kenya. He obtained an associate degree in Mathematics and Biology from Kagumo College in Kenya and subsequently pursued a Bachelor of Science degree in Education with a focus on Mathematics and Computer Studies at Kabarak University in Kenya. Nixon has taught at three different high schools in Vihiga County, western Kenya. He later earned a master's degree in mathematics education from Rutgers University in New Jersey. Subsequently, he enrolled at North Carolina State University to pursue a PhD in Teaching and Learning in STEM, with a focus on Mathematics and Statistics Education.

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I thank God for allowing me to pursue this dream, for He says in Jeremiah 29:11, "For I know the plans I have for you, declares the Lord, plans to prosper you and not to harm you, plans to give you hope and a future." As his son, I look forward to using this knowledge to touch the lives of others.

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AUTHORSHIP STATEMENT

This dissertation, by Nixon Odari Igunza, was completed in partial fulfillment of the requirements for the Doctor of Philosophy degree. It presents original research conducted by the author under the guidance of the dissertation committee.

Chapter one was conceptualized and written by the author. Members of the dissertation committee provided feedback on the framing of the research problem and the organization during proposal development meetings.

In chapter two, the author conducted the literature search, synthesis, and writing. Committee members provided guidance on relevant theoretical frameworks and suggested additional literature for inclusion. The author made all interpretations and syntheses.

In chapter three, the author developed and implemented the research design, data collection instruments, and analytical procedures. The dissertation committee provided methodological guidance, feedback on instrument design, and recommendations for qualitative and quantitative analysis strategies.

In chapter four, the author conducted data analysis and interpretation. Committee members reviewed the findings and provided feedback to enhance clarity and alignment with the research questions. The author made the final analytic decisions and interpretations.

The author presented the discussion, conclusions, and implications for research, policy, and practice in Chapter 5. Dissertation committee members provided feedback on the interpretation of findings and the implications for mathematics teacher education programs and community colleges.

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AI tools were used in a limited and responsible manner during the dissertation process, in accordance with Section 3.6.E of the Graduate School Handbook. AI tools were used to support editing for clarity, organization, and grammar, to assist with rephrasing text for readability. AI tools were not used to generate original research ideas, to design the study, to analyze data, to interpret findings, or to draw conclusions. All intellectual contributions, analyses, interpretations, and final written content are the sole work of the author.

Sole Authorship Statement:

Except for advisory feedback, editorial suggestions, and acknowledged contributions, the author is the sole author of this dissertation. The author conducted all research activities, analyses, and interpretations, and the writing.

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CHAPTER 1: INTRODUCTION

Background of the Study/Problem Statement

Technology plays a pivotal role in shaping teaching and learning practices in today's rapidly evolving educational landscape (Voogt et al., 2018; Zaman & Ch, 2024). This role is especially true in mathematics, where digital tools enhance instruction and student engagement (Ní Shé et al., 2023). The integration of technology into mathematics education has garnered significant attention, not only for its potential to improve student learning but also for the growing demand for proficient educators to use these tools effectively (Epper & Baker, 2009; Nelson et al., 2019).

In this study, technology refers to digital tools and resources used by educators and learners to engage with mathematics, thereby enhancing conceptual understanding (AMTE, 2022). The digital resources and tools include, but are not limited to, computers, calculators, virtual manipulatives, programming platforms, interactive applets, block-based coding, virtual collaborative tools, learning management systems, and statistical and mathematical inquiry software (Dick & Hollebrands, K, 2011; Kumi-Yeboah et al., 2020; M. O. J. Thomas, 2001). According to Dick and Hollebrands (2011), digital tools and resources in mathematics teaching can be classified into conveyance and math action technologies. Conveyance technologies refer to digital tools that transmit or receive information (Dick & Hollebrands, 2011). In the mathematics classroom, these technologies enable teachers and students to create presentations and communicate with one another. Examples are PowerPoint, document cameras, the Internet, projectors, and Google Drive resources (Dick & Hollebrands, 2011; Kumi-Yeboah, 2020). Math action technologies, on the other hand, are math-specific digital tools and resources. Thus, they perform mathematical tasks and respond to a user's actions in math (Dick & Hollebrands, 2011).

Examples include computational tools such as spreadsheets, graphing calculators, and computer algebra systems; Dynamic geometry environments such as Cabri, Geometer's Sketchpad, Desmos, and GeoGebra; and computer simulations.

This study is informed by the Association of Mathematics Teacher Educators (AMTE, 2022) statement on Technology Integration for Equity and Learning in Mathematics Teacher Education and K-12 Settings. According to AMTE (2022), to enhance instruction and to help students develop a stronger conceptual grasp of mathematics, critical evaluation of digital tools and resources is essential. AMTE (2022) recommends five interrelated strategies to help Mathematics Teacher Educators (MTEs) successfully integrate technology into their teaching. These strategies include using technology to advance equity and equitable teaching practices; supporting teachers in using technology to develop their mathematical content knowledge; supporting teachers in using technology to help their students learn mathematics; supporting teachers in online, hybrid, and distance education; and evaluating technology-supported teaching and learning.

These strategies focus on helping teachers advance their understanding of mathematical material, encouraging fairness in classroom practices through technology, and using the right technological tools to improve students' mathematical literacy. Additionally, the statement emphasizes how important it is to provide educators working online, hybrid, and distance learning environments with ongoing support (AMTE, 2022). This need was made even more evident during the COVID pandemic, as educational institutions remained closed to in-person engagement. Therefore, students felt they would graduate on time, despite being constrained by school closures due to the prohibition on physical interactions to prevent the spread of COVID-19 (R. Huang et al., 2019). Consequently, adopting online instruction helped students maintain grade-level requirements (Mailizar et al., 2020). AMTE encourages MTEs to study and self-evaluate to ensure that technology integration aligns with educational goals and is pedagogically sound.

Meanwhile, the U.S. education system faces a significant teacher shortage, a challenge that has persisted for decades but has become more acute in recent years (Sutcher et al., 2019; Wiggan et al., 2021). As of the 2017-18 school year, estimates suggested an annual shortage of approximately 112,000 teachers, a figure supported by data indicating that around 109,000 individuals were working without certification in teaching roles across the United States (Sutcher et al., 2019). Although the figures have decreased in 2023, the teacher shortage remains at 55,000 teachers in kindergarten through high school (Devlin Peck, 2025). This shortage is particularly severe in subjects such as mathematics, science, special education, and English as a Second Language (ESL). Butcher et al. (2019) further note that the teacher shortage crisis disproportionately affects low-income urban and rural districts, where it manifests more severely. This growing demand is compounded by high teacher attrition rates, as many teachers leave the profession due to dissatisfaction with working conditions, low compensation, and a lack of administrative support (Ingersoll & May, 2012). According to Devlin Peck (2024), in the 2023 academic year, 5095 classrooms in North Carolina had teacher vacancies. Furthermore, mid-year teacher turnover increased from under 4% to over 6% between the 20/21 and 21/22 academic years.

Teacher attrition significantly contributes to the shortage, with approximately 200,000 teachers leaving each year (Sutcher et al., 2019). Factors such as poor compensation, high demand for highly qualified subject specialists, and a negative perception of the teaching profession further exacerbate this issue (Ingersoll & May, 2012). The teacher shortage can be addressed by improving teacher retention through better working conditions, mentorship programs, and professional development opportunities (Sutcher et al., 2019). Additionally, the multiple teacher preparation pathways can be leveraged to increase the number of students enrolled in these programs. It is essential to develop alternative pathways to bridge the gap between the number of teachers graduating from educational institutions and the shortfall in schools, as most education systems currently rely on traditional pathways to teaching. This strategy is supported by Darling-Hammond and Sykes (2013), who proposed that alternative pathways to teaching, such as community college transfer programs, can help address this shortage.

Community colleges play a crucial role in mitigating this teacher shortage by serving as an accessible and affordable gateway for many students pursuing education, particularly in mathematics and science (Bailey et al., 2015). With approximately 50% of all U.S. college students enrolled in community colleges, these institutions are integral to the country's education system (Mellow & Hellan, 2008). Community colleges offer an accessible and affordable pathway to teacher preparation, allowing transfer students to complete developmental education, professional development, and transferable coursework toward a four-year degree in education (Coleman, 2015). These transfer pathways are significant in addressing teacher shortages by broadening the pool of future educators, particularly in underserved communities. As part of the solutions to the teacher shortage, community colleges serve as an important pathway into higher education for non-traditional and underrepresented students by providing access to quality education and adopting technological innovations that support learning in mathematics (Mejia et al., 2021).

Despite the significant role community colleges play as a pathway to teaching, Community College Transfer Students (CCTSs) often face unique challenges as they transition to university settings. A key difference between community colleges and universities is access to technology and educational resources (Ali et al., 2023). These disparities can affect their self-efficacy and confidence in using educational technology, a major component of modern teaching. Teacher educators are responsible for equipping future teachers with the technological skills necessary for effective practical instruction and instill in them the mindset and willingness to utilize technology to enhance student learning (Riera et al., 2023; Thomas et al., 2017). This teacher's role is important for community college transfer students, whose varied experiences with technology may shape their beliefs, practices, and overall preparedness (Jaggars et al., 2015). To ensure that these students are prepared to meet the demands of modern, technology-enhanced classrooms, it is important to understand how they transition from community college to university settings and how their technology-integration skills evolve.

Previous research on preservice teacher technology integration has focused on candidates enrolling in four-year teacher education programs or on experienced teachers, leaving out CCTSs. There is little empirical work exploring how CCTSs experience and perceive the shift from a resource-constrained community college with limited technology integration to the rich digital university environments.

Lastly, a few studies trace how self-efficacy and knowledge for technology integration develop as CCTSs progress in their teacher preparation program. By exploring the technology use and integration experiences of CCTSs through a narrative case study (Sonday et al., 2020), this study provides insights into how these students navigate the complexities of technology use and integration. The study integrates TPACK (Mishra & Kohler, 2006) and TAM (Davis, 1989) to examine the knowledge and motivation of technology integration. This study, therefore, fills a gap between digital-divide and teacher education research, highlighting the challenges and growth of the CCTS population in four-year educational institutions.

The study took place in a Mathematics Education Teacher Preparation Program (METPP), which is ranked as the best in her state. The students in the METPP are exposed to math content, teaching methods, and general education courses. Technology is a key component that is deeply covered in teaching methods courses to prepare teachers who are ready for modern teaching that incorporates technology. The MTEPP consists of courses in education, computer science, core math content courses, statistics, professional, and General Education Program (GEP) courses, constituting a total of 120 hours in the program (see Appendix A).

In the METPP, all the instruction is delivered via technology, and some courses are technology specific. Among the METPP courses, Math & Science Education (EMS) 490 School Mathematics, from an advanced perspective, covers some technological use in specific high school mathematics topics, while EMS 480 Teaching Mathematics with Technology focuses primarily on using and teaching mathematics with technology. All participants in this study have taken at least one methods course in which they used both conveyance and math-action technologies.

Purpose of the Study

The available literature dwelt on the success of CCTSs in Science, Technology, Engineering, and Mathematics (STEM) majors, attrition rates, and the use of technology in developmental mathematics. However, there is a lack of literature on the experiences of CCTSs with technology use and integration. This lack of studies on technology use and experience necessitates this research to bridge the existing gap in the technology use and integration experiences of CCTSs.

The aim of this study is to explore and understand community college transfer students' technology use and integration experiences in a mathematics education teacher preparation program. The study examined how transfer students perceive their self-efficacy in using technology for teaching, their acceptance of educational technology, and how their prior experiences at community colleges shaped their preparedness to integrate technology into their teaching. The study, therefore, investigated how students' confidence in using technology (self-efficacy) develops during their teacher preparation program. The study also identified and compared the differences in technology use between community college and university settings from the perspective of transfer students. The study seeks to establish how factors, such as institutional support and mentorship, influenced transfer students' ability to integrate technology in their mathematics instruction effectively. Finally, the study explored insights into the challenges and opportunities that CCTSs encounter when using technology during their field placements.

The decisions of the researcher were guided by two theoretical frameworks: the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006) and the Technology Acceptance Model (TAM) (Davis et al., 1989). In this study, TPACK was chosen because it provides a framework for understanding the knowledge required for teachers to use and integrate technology effectively. TAM, on the other hand, helps to assess and understand teachers' perception and intention to use technology in their future classrooms (Davis et al., 1989; Holden & Rada, 2011; Joo et al., 2024) and how the level of technology user acceptance impacts their progress. Four research questions guided the study.

Research Questions

1. How prepared do CCTSs feel to use educational technology in their current mathematics education program?
2. How does the use of technology in mathematics differ between community colleges and the University, as experienced by CCTSs?
3. How does self-efficacy for teaching with technology change for CCTSs in their teacher preparation in the program?
4. How do CCTSs use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?

In the next section, I review the available literature on the use and integration of technology in teacher preparation programs. The literature includes challenges and barriers to technology integration in math education, educational technology use in university teacher preparation programs, community college as a pathway to teaching, self-efficacy in teaching with technology, and technology integration frameworks.

CHAPTER 2: LITERATURE REVIEW

Introduction

Although there have been tremendous improvements in educational technology access, the digital divide remains a major barrier to equitable classroom technology integration (Gonzales et al., 2020). Students from low-income backgrounds, especially those in rural or underserved urban areas, often lack access to technology at home, limiting their ability to engage in classroom learning fully (Banerjee, 2020; Jaggars, 2011). Similarly, Hew and Brush (2007) emphasize that these students may also lack digital literacy skills, putting them at a disadvantage compared to peers with greater exposure to technology outside of school.

In this section, I reviewed the available literature and connected the literature to the theoretical underpinnings of the study. The literature includes challenges and barriers to technology integration in math education, educational technology use in university teacher preparation programs, community college as a pathway to teaching, self-efficacy in teaching with technology, and technology integration frameworks.

Challenges and barriers to technology integration in math education

Technology has revolutionized how processes and services are executed in every facet of life. In mathematics education, technology has been found to transform how students study and individualize math instruction (Hamidi et al., 2011). Tailoring instruction to individual needs aligns with the call to transform education to equip learners with 21st-century skills like critical thinking and problem-solving (Díaz et al., 2022). Integrating technology into mathematics classrooms is complex and often encounters several difficulties. According to Schoepp (2005), these difficulties are referred to as barriers because they prevent the flawless implementation of technology in the classroom. These barriers are multifaceted and comprise access to technology, teacher preparedness, classroom management, and institutional support (Pine-Thomas, 2017).

Researchers and educators have used varying categories to classify barriers to technology integration into the classroom. Some studies have divided the barriers into intrinsic and extrinsic, with differing definitions. For instance, Ertmer (1999) defined extrinsic barriers as first-order citing access, time, support, resources, and training as examples, and intrinsic barriers as second-order citing attitudes, beliefs, practices, and resistance. In contrast, Hendren (2000) viewed intrinsic barriers as relating to administrators, teachers, and individuals, whereas extrinsic barriers were seen as relating to organizations rather than individuals.

Cuban (1985) also examined barriers from an organizational change lens, classifying them as first- or second-order change. This definition was later adopted for technology integration barriers. Brickner (1995), drawing on Cuban organizational change theories, viewed first- and second-order barriers relating to change in teacher training regarding the use of computers as instructional tools. On the other hand, Ertmer (1999) explored barriers to integration of technology and classified them as first- and second-order barriers in relation to pre-service and in-service teachers.

Brickner (1995) described first-order as extrinsic factors encompassing access to computers, software availability, technical support, and preparation time, and anything that requires a technological fix to resolve. This perspective aligns with Ertmer's (1999), who described first-order barriers as external obstacles, including inaccessibility to computers and software, insufficient instruction planning time, and inadequate technical and administrative support. On the other hand, second-order barriers are internal obstacles intrinsic to teachers and rooted in teachers' pedagogical beliefs and established classroom practices (Brickner, 1995;

Castro, 2016; Ertmer, 1999; Pape & Prosser, 2018).

Another study by Bingimlas (2009) classified barriers as teacher-level and school-level barriers. He differentiated the barriers based on the individual (teacher-level barriers), such as lack of confidence and time, and resistance to change, or the institution (school-level barriers), such as lack of technical training and access to resources. Similarly, in a study examining the challenges K-12 schools face in integrating technology into their teaching practices, Hew and Brush (2007) identified six primary barriers: resources, institutional policies, culture of the subject, attitudes and beliefs, knowledge and skills, and assessment practices. In this case, resources and institutional policies can be categorized as first-order barriers. In contrast, culture of the subject, attitudes and beliefs, knowledge and skills, and assessment practices can be categorized as second-order barriers. This classification is consistent with Ertmer (1999) and Brickner (1995), who also categorized barriers into first and second order.

In a study conducted by Izmirli and Kirmaci (2017) on "new barriers to technology integration," the researchers identified a lack of design-thinking skills among teachers in adapting technology for various contexts, groups, and instructional needs as a third-order barrier to technology integration. Izmirli and Kirmaci (2017) noted that first-order barriers to technology integration have significantly reduced in recent years, while second-order barriers persist, hindering the widespread adoption of technology in mathematics classrooms.

Brickner (1995) suggested that overcoming first-order barriers involves incremental changes, allowing teachers to gradually incorporate technology into their teaching practices. On the other hand, to address second-order barriers requires a more profound reflection on educational methods and a reassessment that confronts fundamental beliefs surrounding teachers' current practices (Ertmer, 1999, 2005; Hew & Brush, 2007). Therefore, in this study, barriers are categorized as either first-order or second-order barriers. These barriers include teacher-related challenges, institutional and structural barriers, and classroom and student-related barriers.

Teacher-related challenges

Teachers play a crucial role in the implementation of technology (Fitria & Suminah, 2020). However, the challenges they face are significant barriers to integrating technology into mathematics education. Despite the considerable increase in access to and use of technology, teachers still encounter various obstacles that hinder this integration (Francom, 2020; Lowther et al., 2008). Some teacher-related challenges include a lack of technological skills and training, and resistance to change and teacher beliefs.

Lack of Technological Skills and Training

Teachers often struggle with inadequate training to integrate technology into their instructional practices. Past studies indicate that teachers feel underprepared to use technology effectively, especially for higher-level mathematics instruction. Pine-Thomas (2017) noted that even when educational tools are available, the lack of continuous professional development (PD) contributes to teachers' failure to incorporate technology into their pedagogical practices. Furthermore, even when teachers have participated in PDs to improve their technological skills, such training might fall short of addressing the foundational beliefs that shape the teachers' perceptions of effective teaching methods (Kim et al., 2013). Furthermore, novice teachers may be less confident in using technology effectively in their lessons, particularly in mathematics (Stein et al., 2020; Thurm & Barzel, 2020).

As previously noted, providing students with technology does not imply practical use; thus, teachers play a crucial role in implementing technology in the mathematics classroom

(Lavicza, 2010; McCulloch, 2018). A study by Wilson et al. (2020) found that teacher knowledge is the main focus in teacher preparation programs. Thus, when Teacher Knowledge is underdeveloped, it becomes a barrier to technology integration in the classroom (Durf & Carter, 2019; Kirmaci, 2017). A study by McCulloch et al. (2018) on factors influencing secondary mathematics teachers' integration of technology in mathematics lessons found that teacher knowledge is crucial to technology integration in the classroom. McCulloch et al.(2018) noted that Technological Knowledge helps to determine when, how, and why to use technology so that teachers do not merely use it as an add-on. Harrison and Lee (2018) further support the importance of teacher knowledge, emphasizing that teachers must have appropriate skills to select suitable applications or quality activities that meet the threshold for strong learning objectives in a mathematics classroom.

Preservice math teachers (PSMTs) often struggle to integrate technology into their lesson plans effectively, instead relying on traditional methods to enhance mathematical understanding (Bowers & Stephens, 2011). This phenomenon may indicate the teacher's limited knowledge of the technology or its use. Many teachers do not receive adequate professional development (PD) to effectively integrate technology into their mathematics instruction, resulting in underutilization or ineffective use of the available tools (Bray & Tangney, 2017; Jesso & Kondratieva, 2016). For example, in the study by Buteau and Muller (2006), the faculty had to undergo training before adjusting their role in the classroom to facilitate student creativity and intellectual independence. This finding confirms the importance of ongoing PD to enable teachers to adapt to the changes that come with technology integration.

Resistance to Change and Teacher Beliefs.

Teacher beliefs about the role of technology in education can also act as barriers to integration. Stein et al. (2020) found that while novice teachers acknowledged the potential of technology to enhance learning, many struggled to integrate it due to deeply ingrained beliefs about traditional teaching methods. Similarly, Pape and Prosser (2018) noted that community college mathematics faculty often resist integrating technology, citing concerns about its alignment with established pedagogical practices. Schoepp (2005) also found that although teachers felt there was sufficient technology available, they believed they were not sufficiently supported, guided, or rewarded for integrating technology into their teaching. However, resistance to change does not seem to be a barrier but an indicator of an underlying problem (Bingimlas, 2009), implying that there must be reasons why teachers resist change.

Hew and Brush (2007) noted that teachers' beliefs are often more influential than their knowledge in predicting their behavior toward technology use in the classroom. This trend suggests that beliefs can act as a barrier even when teachers possess technical skills since their educational beliefs shape how they view the relevance and applicability of technology (Hew and Brush, 2007). These findings align with the study conducted by Kim et al. (2013), which posits that, even after addressing first-order barriers, teachers' enduring beliefs play a crucial role in shaping their teaching practices and, subsequently, their use of technology in the classroom. Therefore, a more comprehensive approach to training is necessary_ one that extends beyond merely technical skills to explore teachers' beliefs regarding pedagogical knowledge. This suggests that these foundational beliefs significantly influence how technology is integrated into their teaching methods.

Institutional and structural barriers

In addition to teacher-related challenges, institutional and structural barriers significantly influence technology integration in mathematics education. These challenges include inadequate access to technology, insufficient support from school leadership, and constraints imposed by curriculum demands.

Limited Access to Resources.

Many schools, particularly those in low-income or rural areas, face significant difficulties in providing the necessary technological infrastructure to support integration (Bingimlas,2009). Hew & Brush (2007) emphasize that the lack of access to up-to-date devices and inadequate funding are among the most frequently cited barriers to technology integration in K-12 schools. The disparity in resource allocation also leaves many teachers without the necessary tools to integrate technology effectively, where specialized tools such as graphing calculators, dynamic software, and interactive platforms are essential for enhancing instruction (Enaz, 2023; Trouche & Monaghan, 2016; Xu, 2025).

External barriers, comprising insufficient funding and inadequate access to reliable internet, create challenges for students and teachers (Dinc, 2017), further contributing to the digital divide in many educational settings (Hew & Brush, 2007). According to Brown (2021), the digital divide refers to inequalities in access to computers and the internet between different cultural or social groups. The digital divide includes both access to computers and internet and their usage (Brown, 2021; Djik, 2012, 2017). For instance, schools in rural and underserved urban areas often lack the resources to provide each student with access to technology, leaving many teachers to rely on outdated or inefficient tools (Medina Herrera et al., 2024). To that end, Castro (2016) argues for the importance of institutional investment in technology and professional development to enable meaningful classroom use.

Moreover, Ertmer and Ottenbreit-Leftwich (2010) highlight that first-order barriers, like limited hardware access and insufficient technical support, can severely limit a teacher's ability to incorporate technology into their pedagogical practices. A study by Pape and Presser (2018) on community college mathematics established that instructors' largest hindrances to technology uptake in the classroom were unreliable technology and a lack of resources. Addressing these barriers requires schools and districts to prioritize technological infrastructure, ensuring teachers and students can access the tools they need for a technology-rich educational experience.

Time and Curriculum Constraints.

Teachers face substantial time constraints and academic workload that often inhibit their ability to incorporate technology into their lessons (Francom, 2020). The need to cover mathematical concepts within a limited timeframe often discourages implementation and experimentation with new technological tools. Hew and Brush (2007) observed that teachers have limited time to plan and execute technology-incorporated lessons, often forcing them to resort to traditional methods, especially in subjects with heavy content requirements like mathematics.

Additionally, Cullen et al. (2020) found that the pressure to adhere to a strict curriculum leaves little flexibility for teachers to incorporate technology into their instructional practices innovatively. The high-stakes nature of standardized testing compounds this issue, as teachers may prioritize test preparation over exploring new technologies (Au, 2011). This practice is more profound in community colleges, where mathematics instructors face the challenge of aligning technology use with curriculum goals while preparing students for standardized exams (Pape &

Prosser, 2018).

The rigid structure of the curriculum in many mathematics courses presents a significant barrier to the use of technology (Pape & Prosser, 2018). Interestingly, Reich (2020) established that teachers may be reluctant to experiment with new tools or platforms if they perceive that doing so would distract them from covering the required content. This results in a scenario where technology is underutilized, and its potential to enhance student learning through interactive, student-centered activities remains untapped.

Classroom and Student-Related Barriers

Beyond institutional and structural barriers, technology integration is also hindered by classroom dynamics and student-related factors. Teachers must navigate the complexities of managing diverse student needs, addressing varying levels of digital literacy, and mitigating the risks associated with technology-related distractions.

Managing Diverse Student Needs.

Teachers often struggle to manage students' diverse learning needs in technology-enhanced classrooms. Stein et al. (2019) found that while novice teachers became more comfortable using technology over time, managing student diversity, particularly in terms of engagement and interaction with technology, remained a persistent challenge. The need for prolonged time for technology familiarity is more pronounced in mathematics education, where students' familiarity with technological tools can vary greatly, leading to uneven participation and comprehension. Daher and Lazarevic (2014) emphasize that in classrooms with a wide range of student abilities, technology may inadvertently widen the gap between high- and low-achieving students. Some students may benefit significantly from interactive tools, while others may struggle with the same technology, increasing achievement disparities. For teachers, tailoring technology use to meet the diverse needs of their students requires careful planning and differentiated instruction (Goyibova et al., 2025).

Digital Divide

A review of the literature indicates that the digital divide is a multifaceted problem concerning unequal access to information and communication technologies (ICT) (Soomro et al., 2020). This divide affects people's ability to participate effectively in society (Soomro et al., 2020) and is not just a technical issue but also a reflection of broader social problems (Tarman, 2003). According to Gorski (2005), several key factors, including access to technology, socioeconomic disparities, global inequalities, and issues of equity and social justice, contribute to shaping the digital divide.

The digital divide is not only about access but also about systemic barriers that reinforce existing social inequalities. Gorski (2005) further classifies these factors into -isms: racism, sexism, classism, Linguisticism, and ableism.

Racism – The racial digital divide is a symptom of systemic racism.

Sexism – Gender inequities in technology access and participation reflect broader societal inequalities. These include disparities in online participation, cyber-harassment, and access to digital tools.

Classism – Socioeconomic disparities in access to technology reinforce class-based privileges.

Linguisticism – Limited availability of first-language web content and culturally relevant digital resources further excludes marginalized groups.

Ableism – The digital divide disproportionately affects individuals with disabilities, creating barriers to access and engagement.

Gorski’s classification reframes the digital divide not just as a technical problem but also as a broader reflection of systemic oppression. He argues that race, socioeconomic status, gender, language and disability divisions cannot be eradicated through providing hardware and software computer resources. Thus, recognizing the "-isms" in education implies that equity efforts by teacher education programs must address systemic biases. This approach will ensure that marginalized students are supported beyond the software and hardware access.

Levels of the Digital Divide

Different scholars have also characterized the digital divide at different levels. For instance, Gomez (2018) divided it into three levels: the first, second, and third.

First-Level Digital Divide

In the 1990s digital divide focused on the access gap to the Internet and digital resources (Gómez, 2018). The gap involved describing the varying degrees of Internet availability between developed and developing countries, highlighting the imbalances among regions, social groups, and collectives in developed countries. The main concern was promoting Internet access among vulnerable groups who lacked the economic resources to afford devices and Internet connections (Gómez, 2018). However, this approach was criticized for reducing the access gap to a technological and economic problem based on a binary model of "haves and have-nots." Recent studies have explored the link between conditions of access and digital inequalities, considering factors such as the economic impact of maintaining technology and the consequences of using different devices, like smartphones versus computers (Helsper, 2021).

Second-Level Digital Divide

This level involves the use of digital technologies by different users and thus is referred to as the Usage Gap. As Internet access became more common, studies shifted their focus from how people access the Internet to how they use digital technologies, considering their social, cultural, and economic backgrounds, motivations, interests, and digital skills (Gómez, 2018).

This shift questioned the idea of youth as a homogenous group of Internet users, suggesting the existence of multiple digital generations. This perspective has contributed to a better understanding of digital inequality, highlighting gaps like the 'skills gap' related to the competencies needed to utilize digital technologies effectively. The "motivation gap" explores how attitudes and interests influence technology adoption. The 'emotional gap' refers to the emotions associated with using digital technologies, where negative emotions can hinder digital domestication. However, this perspective has been criticized for lacking theoretical depth and for failing to connect digital inequalities with broader sociological theories.

Third-Level Digital Divide

This level, also referred to as the utility gap, concerns the offline outcomes and benefits people gain from using digital technologies. It connects digital inequalities to social activities and life trajectories, showing how they reinforce existing social stratification. This perspective considers how social inequalities are the root of digital inequalities, and digital inequalities, in turn, increase and reinforce existing social inequalities.

On the other hand, Soomro et al. (2020) identified four levels of the digital divide: motivational, physical, skills and usage access. Each level influences an individual's ability to engage with technology effectively. Motivational access involves the willingness to adopt and use ICT; physical access, the availability of hardware and connectivity infrastructure; Skills access, the ability to utilize digital technologies, classified into operational, informational, and strategic skills; and usage assesses how individuals engage with digital tools and services (Soomro et al., 2020).

These differences notwithstanding, this study focuses on the available literature. Over time, the first-level gap has been eliminated by availing digital resources to learning institutions. Thus, I focus on the second level onwards, which currently still hampers the effective use and integration of technology in education.

The Digital Divide in Education

The relationship between technology accessibility and academic achievement is complex and influenced by multiple factors (J. Huang & Russell, 2006). In this digital era, learning outcomes are heavily impacted by access to technology. According to Higgins et al. (2019), technology motivates learners and improves student engagement in mathematics, thus affecting outcomes.

Bridging the digital divide is necessary to achieve digital equity. Bridging the divide will ensure that all students, regardless of background, have meaningful opportunities to engage with technology in education (Barlow, 2021). Examining how students use technology in learning environments is key to this effort (Barlow, 2021). Teachers play a vital role in mitigating the digital divide. Therefore, they need adequate access to computers, training, and support to integrate technology effectively into classroom instruction (Brickner, 1995).

Digital Distraction in the Classroom

The availability of digital devices, such as smartphones, tablets, and laptops, has altered the educational landscape, transforming the classroom ecology (Goundar, 2014; Pérez-Juárez et al., 2023). According to Gounder (2014), research has raised concerns regarding student distraction. This concern suggests that uncontrolled use of digital devices negatively impacts student concentration, learning, and academic performance.

Digital distraction, the use of technology for non-educational purposes during class, is another critical issue. A study by Flanigan and Babchuk (2022) found that 70-90% of students text during class, while 40-60% use laptops for off-task activities. Daher and Lazarevic (2014) argue that while technology has the potential to engage students, ineffective classroom management can lead to misuse. Additionally, technology maintenance contributes to digital distraction. Gonzalez et al. (2018) found that students' reliance on technology for academic tasks, coupled with maintenance issues, negatively impacted their GPA.

Technology-based distractions involve using devices for activities that are not directly related to achieving the intended learning outcomes. This off-task behavior, if unchecked, becomes a habit, consuming a significant portion of instructional time. According to Goundar (2014), digital devices are highly pervasive and require constant, cognitively demanding attention as shown in a multiphase study tracking student behavior by Perez-Juarez et al. (2023) found that an average respondent used a digital device for non-class purposes 11.43% of the time daily in 2015, consuming 20.9% of students' class time. This frequency slightly decreased to 9.06 times daily in 2019, with the distraction duration remaining high at 19.4%. The most common non-class activities reported by college students are texting, emailing, and social networking (Kay et al., 2017). Similarly, secondary school students frequently engage in emailing, web surfing, and social media (Kay et al., 2017). Distractions can also be caused by visual and audio activities (Kay et al., 2017). These activities include making calls, receiving notifications, and typing on keyboards. When students use digital devices for non-class activities, it leads them to lose focus, causing them to miss important instructions. According to McCoy (2019), experimental research has confirmed that distracted students performed poorer on memory measures and tasks involving divided attention, which reduces long-term retention and impairs subsequent test performance.

Mitigating digital distractions requires a holistic approach that encompasses engaging pedagogy, enhanced teacher training, robust policy, and targeted student self-regulation strategies (Pérez-Juárez et al., 2023). Effective pedagogy must ensure that students are focused on learning with technology, rather than the technology itself (Mistreta, 2014), since boredom is a critical cause of distraction (McCoy, 2019). Instructors should implement strategies that increase student engagement. Lastly, for sustainable use of technology, students must develop self-internal controls and critical awareness (Pérez-Juárez et al., 2023).

Strategies for Effective Technology Integration

Effective technology strategies should support both traditional and technology-mediated modes of instruction. Merely treating technology as an “add-on” to unchanged pedagogical practices is not effective, thus resulting in minimal learning gains (Epper & Baker, 2009). Teachers should implement active learning strategies that promote meaningful interaction with technology to address digital distractions and improve engagement. Pape et al. (2018) suggest using tools that provide real-time feedback, such as student response systems or interactive whiteboards, to keep students focused. Using real-time feedback tools will ensure that technology is used purposefully to foster student participation, thus reducing distractions and enhancing learning outcomes.

Effective strategies utilize technology to provide individualized learning, foster design competency, and integrate real-time feedback. PSMT must be trained not just in using technology, but in designing instruction with technology actively to enhance competence and self-efficacy (Angeli, 2005; Williams, 2015). To provide this kind of training, PSMTs should be provided with opportunities to design technology-integrated lessons. The ability for PSMTs to design technology-integrated lessons will be a key predictor of their technology self-efficacy. Angeli (2005) adds that instructors should be guided to design lessons based on constructivist theories, in which the learner is viewed as an active constructor of their own knowledge.

Furthermore, Tondeur (2012) proposed that teacher educators should create a collaborative learning environment in which PSMTs can work with peers, thereby reducing anxiety. Additionally, collaboration skills can also be enhanced by designing PD sessions that require active engagement during collaboration among PSMTs (Mistretta, 2015).

To cultivate teacher self-efficacy in technology integration, Williams et al. (2023) claim that MTPP should expose PSMTs to experiences that align technology with their pedagogical and content knowledge. Williams and colleagues add that these experiences can be provided by designing technology-integrated lessons and building competence through assessments like e-portfolios. Instructional transformation can be achieved through rigorous PDs to help familiarize PSMTs with new technologies (Dillon et al., 2019). For effectiveness, the PDs should focus on specific technology needs as opposed to mandating specific competencies through situated PD and coaching.

Effective integration of technology in MTPP encompasses tools that play different roles. Technology should also be utilized for immediate feedback, continuous assessment, and efficient data management. According to Pape and Prosser (2018), institutions should leverage technology to collect and use real-time data for instructional use. Therefore, training should leverage technology to collect and use real-time data for instructional purposes. Therefore, training should demonstrate how technology can be used to analyze student performance data (Ertmer et al., 2012). The success of integrating technology depends greatly on the teacher's ability to select appropriate software and websites (Mistretta, 2015). This selection ensures that the chosen technology is well-suited to the task at hand. Consequently, teachers must be able to evaluate instructional technology based on its connection to math standards or its specific instructional use (Mistretta, 2015).

According to Tondeur et al. (2012), preparing teachers is a systematic change. They therefore propose that technology should be infused into the entire teacher preparation program to ensure that skills and knowledge are not isolated or unused. Additionally, institutional leadership at the highest level should also develop a shared vision for technology integration, guided by technology planning and leadership (Tondeur et al., 2012). In so doing, administrators will be able to address institutional barriers to the integration of technology (Pape & Prosser, 2018). This effort will help provide sufficient technical support, reliable technology, and enough resources.

Institutional and Structural Barriers to Technology Integration

Beyond classroom-level challenges, institutional and structural barriers also hinder the successful integration of technology in mathematics education. Overcoming these barriers requires increased investment in technological resources to ensure equitable access for all students, flexibility in curriculum design to allow for technology-enhanced learning experiences, and professional development to equip teachers with the necessary skills to integrate technology effectively. By addressing both external and internal barriers, teacher preparation programs can better equip pre-service teachers with the skills and knowledge needed to navigate the demands of a technology-driven educational environment.

Educational Technology Use in University Math Teacher Preparation Programs

Technology is used in the university math classes in two ways. First, technology is used in math classes to help students understand concepts more effectively. Lastly, to prepare students in teaching with technology, MTPP teaches PSMTs how to integrate technology into their pedagogical practices.

Technology Usage in Mathematics and Mathematics Education Courses

In university mathematics teacher preparation programs, technology is a critical component in mathematics and mathematics education courses. Several studies support the notion that technology can enhance students' interest and confidence in mathematics, motivating teachers to integrate technology. Lee and Hollebrands (2008) propose that technology can be utilized as an amplifier (conveyance) or a reorganizer (math-action). Thus, in this study, technology tools are categorized into two: conveyance tools, which transmit or receive information, such as PowerPoint, Google Docs, and document cameras, and mathematics action tools, which can be used to perform mathematics tasks (Dick & Hollebrands, 2011). Technology provides a means to visualize complex mathematical concepts, encourage exploration, and enable a more interactive learning environment (Ben-Jacob, 2016). Math action tools offer PSMTs opportunities to experiment with mathematical representations and analyze the relationships between equations and their graphs. Hew & Brush (2007) highlight the importance of these tools in making abstract mathematical concepts more tangible for learners.

Technology in mathematics can potentially transform teaching and learning in mathematics classrooms (Baldwin & Squires, 2019). Hoyles (2018) noted that technology enables students to explain the mathematical relations that inform their explorations using a specific technological tool. According to Bowers and Stephens (2011), technology enables students to develop fluent representational knowledge. Students must develop a conceptual understanding of mathematical concepts and apply them in different contexts (Buteau & Muller, 2006). The findings in a study by Gningue et al. (2014) suggested that the engaging nature of technology and the immediate feedback it provides can boost student motivation. This aspect of technology can encourage teachers to create student-centered lessons using technology.

Research on mobile devices reveals the same pattern. A review on iPad use in mathematics by Livy (2024) found that although the studies reported mixed effects on learning outcomes, mobile technology could motivate the learning and dispositions of students. Furthermore, Hollebrands (2017) extended the traditional didactic triangle (teachers, Students, and mathematics) by adding technology. She acknowledged that factors like beliefs, norms, culture, and attitudes influence how technology is enacted. She further observed that to use technology, teachers must consider the fidelity and the role it will serve. These considerations imply that teachers' motivations to use technology are intertwined with their mathematics views and pedagogical values. Representational fluency allows students to learn from evidence by making connections between different representations.

Dynamic software, such as GeoGebra, widely used in mathematics education, offers powerful features for exploration and interactive learning (Drijvers et al., 2011). Dynamic software allows students to manipulate objects and make connections between concepts. Moreover, incorporating technology into mathematics education courses is crucial for preparing future teachers to integrate these tools into their classrooms. Lei's (2009) study on "digital natives as preservice teachers to examine their beliefs, attitudes, technology experiences, and expertise" found that teacher candidates who regularly used technological tools in their university courses were more likely to incorporate them into their future classrooms. These tools enhance the learning process and give pre-service teachers a foundation for developing their pedagogical content knowledge (TPACK), which is essential for the effective use of technology in the classroom (Niess, 2005).

Technology tools also foster a collaborative learning environment, as Hew and Brush (2007) advanced, where students and pre-service teachers can work together to solve problems, explore mathematical concepts, and share strategies for using technology to enhance instruction. Ertmer and Otteinbreit-Leftwich (2010) advocate for partnerships between universities and local K-12 schools to integrate technology in teacher preparation programs. Through these partnerships, preservice teachers were observed and had the opportunity to practice technology integration in natural classroom settings.

Best Practices for Preparing Pre-Service Teachers for Technology Integration

The best practices for preparing pre-service teachers to integrate technology into their teaching begin with providing them with hands-on experience with relevant educational technologies. Ertmer and Ottenbreit-Leftwich (2010) argue that merely exposing pre-service teachers to technology is insufficient; they need structured, guided practice in using it for teaching and learning purposes. Teacher preparation programs must move beyond teaching technical skills to focus on using technology to enhance student learning.

Studies have shown that when pre-service teachers feel confident using technology, they are more likely to implement it. This notion is reiterated by Yeung et al. (2012), who suggest that developing confidence requires programs to offer both instructional technology courses and field-based experiences, where pre-service teachers can observe how technology is applied in real classroom settings. Additionally, teacher educators need to model the use of technology in their teaching to influence pre-service teachers' beliefs about the relevance of technology integration (Kent & Giles, 2017).

Finally, providing continuous professional development to ensure that pre-service teachers are exposed to the pedagogical aspects of technology use is key in fostering long-term, effective integration. Voogt et al. (2013) suggest that teacher education programs should encourage collaboration among pre-service teachers and provide opportunities for them to discuss the role of technology in their teaching.

Field Placements and Technology Use

Field placements are critical to teacher preparation, providing PSMTs practical opportunities to apply their knowledge in real-world settings (Belland, 2009). They serve as essential extensions of Technological Pedagogical Content Knowledge (TPACK) development since pre-service teachers can translate theoretical knowledge into practical applications in the classroom. A survey on technology use in lower secondary mathematics by Drijvers et al (2016) noted that insights into learning with technology can "provide motivation for teachers to consider new approaches for teaching mathematics with technology". However, effective technology integration remains inconsistent during these placements (Dean & Sykes, 2021), with PSMTs frequently encountering challenges and needing structured support to integrate technology meaningfully.

Technology integration in teaching mathematics is increasingly emphasized in teacher education programs (Delice et al., 2015), aiming to equip pre-service teachers with skills to enhance student learning. Developing TPACK, a framework that combines content, pedagogy, and technology, is foundational for PSMTs, as it enables them to effectively navigate the complexities of integrating digital tools into mathematics teaching (Yigit, 2014). In teacher preparation programs, TPACK is developed through structured, technology-enhanced lessons, helping PSMTs understand the pedagogical implications of technology use (Angeli & Valanides, 2015).

Despite these preparatory efforts, Stein et al. (2019) found that novice teachers, even when exposed to technology during their university coursework, often struggle to integrate it into their lessons during field placements due to classroom management challenges and varying levels of student engagement with technology. Thus, incorporating technology into field placements remains complex, requiring the involvement of mentor teachers and university faculty to provide ongoing support and constructive feedback on technology use (Tondeur et al., 2017).

The role of mentor teachers is pivotal in shaping PSMTs' experiences and attitudes toward technology (Giles et al., 2020). Effective modeling by experienced teachers can reinforce positive attitudes and practices in technology integration. Ertmer et al. (2012) argue that for technology to be effectively integrated, mentor teachers must actively model its use and guide pre-service teachers in incorporating digital tools into their instruction. Meagher et al. (2011) found that PSMTs who observed their mentors' effective use of advanced digital tools, such as dynamic geometry software, were more inclined to incorporate similar technologies into their teaching. Such exposure enhances practical skills and positively influences PSMTs' beliefs about the benefits of technology for inquiry-based learning.

However, the inconsistency in mentor modeling presents a significant challenge. Some mentor teachers may lack familiarity with advanced digital tools, resulting in minimal technology use during classroom activities (Dockendorff & Zaccarelli, 2024). This inconsistency in technology practices can result in limited exposure for PSMTs, thus reducing their likelihood of adopting these tools in their future teaching (Semenikhina et al., 2020). Therefore, there is a need for more standardized training and resources to support mentor teachers in consistently modeling effective technology practices across placements (Bullock, 2004; Ertmer et al., 2006).

Pre-service teachers often encounter significant technological barriers during field placements, including limited access to resources, inadequate mentorship, and resistance from mentor teachers who may not prioritize the use of technology. Bozkurt (2016) found that logistical challenges, such as time constraints and inconsistent use of technology in the curriculum, create a challenging environment for PSMTs, limiting opportunities for meaningful technology practice.

Variations in technology availability across school settings further compound these challenges. Hennessy et al. (2022) observed that PSMTs might encounter restricted access to devices in low-resource schools, creating inequitable experiences that hinder the development of practical technology skills. Furthermore, institutional constraints or mentor teachers' perceptions of technology as supplementary rather than integral can discourage PSMTs from incorporating digital tools in their lessons (Pape & Prosser, 2018).

When available, technological tools like interactive whiteboards and student response systems (SRS) offer valuable support for PSMTs, particularly in formative assessment practices. Pape and Prosser (2018) highlighted how these tools enable pre-service teachers to actively engage students and gather real-time data on student understanding, refining their instructional strategies and improving student outcomes. However, lack of access to such tools during field placements remains a significant barrier in many learning institutions, limiting the potential for PSMTs to realize technology's pedagogical benefits fully.

Despite these barriers, PSMTs often benefit from informal support, including peer networks and online resources. Caniglia and Meadows (2018) noted that PSMTs frequently rely on online platforms to access lesson plans, instructional videos, and technology integration techniques, especially in settings lacking structured support. Peer support during field placements fosters collaborative learning and innovation, enabling PSMTs to navigate integration challenges more effectively. According to Hennessy et al. (2022), the interpersonal dimension of peer learning is crucial, as it allows PSMTs to reflect on their experiences and refine their technology practices.

Teacher preparation programs must address the limitations of current field placements for PSMTs to overcome barriers and integrate technology effectively. Programs should adopt best practices such as the TPACK framework, provide continuous professional development, and ensure that field placements offer access to technological resources (Dockendorff & Zaccarelli, 2024). By enhancing support for mentor teachers and promoting the pedagogical benefits of enables the rapid collection of integrating technology offering crucial technology, teacher education programs can better equip PSMTs to meet the demands of modern classrooms.

PSMTs' experiences with technology during field placements are shaped by formal TPACK development, mentor support, access to technology, and peer networks (Martin et al., 2021). While field placements offer valuable hands-on learning, inconsistencies in resources and support limit the efficacy of technology integration. Effective mentor modeling and access to peer support networks are essential for reinforcing positive technology practices and addressing the barriers PSMTs face in enhancing mathematics instruction with technology (Dockendorff & Zaccarelli, 2024).

Nevertheless, the students enrolled in teacher training programs have multiple entries into teacher training programs. One of these pathways is the community college pathway, which can be for students who attend a two-year traditional community college before transferring to the university, or for high school students who enroll in college-level courses before graduating from high school (dual enrollment students).

Community College as a Pathway to Teaching

Teacher shortages across the United States have led to the development of multiple pathways to teaching, with each tailored to accommodate diverse candidate needs and contexts (Sutcher et al., 2019). These pathways range from traditional university-based programs to alternative certification routes, community college pathways, and targeted career-technical programs.

The community college pathway is often supported by articulation agreements with four-year universities, which ensure that credits earned in associate degree programs transfer seamlessly to these institutions. For example, Bragg (2007) reports that community colleges have developed structured pathways, such as the 2+2+2 model, which involves two years of high school, two years at a community college, and two years at a four-year university. These partnerships offer a wide array of teacher education programs, allowing students to gain early exposure to the profession, engage in internships, and acquire credits that count toward high school graduation and college degrees.

Community College Transfer Experiences

Community colleges play a crucial role in the American higher education system, serving as entry points for students aspiring to complete a four-year degree. However, transfer students often face challenges impacting their academic success and social integration at their receiving institutions. Transitioning from a community college to a four-year institution presents significant student challenges. According to Jenkins and Fink (2014), although 80% of the community college students would like to transfer to a four-year educational institution, less than 35% of students make it in less than 6 years.

While these pathways expand access to teaching careers, they operate within distinct funding models. Both community colleges and universities depend on a mix of funding sources, the proportional contributions often differ. According to Tollefson (2009), although Community colleges historically relied more heavily on local funding, this has decreased over the last century, from 94% in 1918 to 8% in 2007. State funding has become a significant source of revenue for community colleges, now accounting for 45-47% of operating revenue. Tuition and fees contribute a substantial and growing portion to community college budgets, around 20-26%. Universities also receive state appropriations and tuition revenue but often have additional revenue streams such as federal research grants, endowments, and private donations, which are less prominent in community college funding models (Tollefson, 2009).

Public community colleges are funded by federal, state, and local governments, student tuition and fees, and auxiliary sources like sales, gifts, and investment income (Bellweather, 2024). According to Richmond and Hahnel (2024), a national breakdown of two-year public institutions (FY2022 data), average revenue shares were approximately 27% federal, 11% state, 31% local, 20% tuition, and 8% sales/services, with gifts and other sources making up 3%. The wide variation in funding levels for community colleges raises significant equity issues. A study by Cohn and Baum (2023) found that these funding levels differ substantially across states.

These funding disparities are more visible when considering tuition and fees. Community colleges and universities have seen significant increases in tuition and fees over the past few decades (Baum & Cohn, 2023; Tollefson, 2009). However, the total amounts vary greatly, with universities charging much higher tuition than community colleges (Tollefson, 2009). The rise in tuition at both types of institutions is often linked to decreasing proportional state support. Both community colleges and universities compete for state appropriations, sometimes directly with other public agencies (Wu et al., 2015). Sources indicate that community colleges have historically faced disadvantages in this competition. Many states use formula funding for both, often based on student enrollments measured as Full Time Equivalent (FTE) during the appropriations process(Weerts et al., 2012). However, the specific models and the importance placed on different factors can differ between the two sectors. The federal government offers financial aid directly to students through programs like Pell Grants, which are usable at both community colleges and universities. Universities, especially research universities, typically have a threefold mission of teaching, research, and public service, with research activities being a major cost and funding driver (Jongbloed, 2015). In contrast, community colleges mainly focus on instruction, workforce development, and transfer pathways, which influence their funding requirements and priorities.

Both community colleges and universities are vulnerable to state budget cuts, particularly during economic downturns. However, community colleges, with their greater reliance on state and local funding and often lacking substantial endowments, might experience these cuts more acutely (Tollefson, 2009). The trend of rising tuition and fees at both community colleges and public universities is a form of privatization, shifting the cost burden from the state to students.

The CCTSs difficulties in transferring are due to several factors. Gard et al. (2012) highlight that transfer students often face difficulties with credit transfer, financial aid, and social and academic integration. To start with, many community college students are accustomed to smaller class sizes and a more supportive academic environment, making the transition to larger, more impersonal university settings a daunting prospect.

Certainly, academic preparedness is a crucial factor affecting transfer success. Ishitani and McKitrick (2010) found that while community college students generally perform well in their new institutions, they may struggle initially with the increased academic rigor and expectations. This transition often leads to a phenomenon known as "transfer shock," where students experience a temporary dip in academic performance as they adjust to their new educational environment. These challenges highlight the importance of preparatory support from community colleges and receiving institutions to help ease students' academic transition.

Furthermore, community college transfer students' social and cultural adaptation is essential to their university experience. Castro and Cortez (2017) emphasize that minority transfer students, particularly Latinx and African American students, often encounter unique barriers due to the lack of a “transfer-receptive culture” in many universities. A transfer-receptive culture acknowledges the diverse backgrounds of transfer students and offers resources to support their unique needs. This cultural adjustment is particularly critical for underrepresented students who may not feel fully included within predominantly white institutions. Conversely, Lester et al. (2013) noted that a sense of belonging and connection with faculty and peers significantly influences transfer students' social integration and academic motivation. Walker and Okpala (2017), in a study on how the relationships between transfer students and faculty can impact students' engagement and success, argue that in cases where transfer students feel undervalued or receive inadequate support, their motivation and retention rates may decrease. Strong faculty support and inclusive programming can foster a more welcoming environment, encouraging transfer students to participate actively in campus life.

Institutional support is vital in enhancing the experiences of community college transfer students. Hyatt and Smith (2020) argue that one of the most effective ways to support these students is through articulation agreements and guided pathways that streamline the credit transfer process and ensure continuity in their academic journey. Articulation agreements between community colleges and four-year universities can mitigate transfer credit issues, reducing the likelihood that students will need to retake courses or extend the time to their academic programs.

Financial aid and academic advising are additional resources central to transfer student success. Gard et al. (2012) identified financial aid access as a significant factor in students' ability to persist post-transfer. Many transfer students face financial constraints, and complex financial aid processes can lead to delays or disruptions in their education (Huerta et al., 2022). Effective academic advising that includes transfer-specific resources and assistance with financial aid can thus make a big difference in student retention and completion rates (Gard et al., 2012).

Research has shown that active engagement within the campus community is a crucial factor in academic success for transfer students (Lester, 2005). In a study on community college transfer students at four-year institutions, Ellis (2013) found that successful transfer students tend to be highly motivated, persistent, and well-prepared by their community colleges for the academic challenges at the university level. Engagement in academic clubs, social events, and peer networks can help transfer students feel connected (S. L. Thomas, 2000), increasing their academic performance and overall satisfaction with their university experience.

However, according to Ishitani and McKitrick (2010), many transfer students struggle to find a sense of belonging and purpose at their new institutions. Consequently, Ishitani and McKitrick (2010) suggest that universities could address this gap by developing transfer-friendly orientation programs and peer mentorship initiatives to promote engagement and community integration.

Technology Use in Community College Math Classes

Mesa, Celis, and Lande (2014) observed that although community colleges educate nearly half of undergraduates and almost half of all mathematics students, little research exists on quality community college mathematics instruction.

Several studies have found that technology can enhance students' confidence and interest, motivating teachers to effectively integrate it into their teaching (Ertmer & Ottenbreit-Leftwich, 2010). In a study of community college students learning algebra and pre-algebra with virtual manipulatives, Gingue et al. (2014) found that all students were motivated to work with manipulatives online. However, in the absence of technology, the students struggled to understand the concepts. Drijvers et al. (2016) further noted that investigations into learning with technology can motivate teachers to consider new approaches in teaching mathematics with technology. The lessons derived from such explorations encourage teachers to use technology as a way of enriching mathematical experiences and fostering conceptual learning. Research on mobile devices reveals the same patterns. For instance, Livy (2024) found that iPads and mobile technology could motivate students' learning and dispositions, implying that teachers could adopt mobile technology use in the classroom to increase student engagement.

Vilardi (2013), in a comparison study of technology-assisted and traditional pre-calculus algebra courses, found that students in the traditional algebra group scored higher than those in the technology-mediated group, suggesting that the mere availability of technology does not guarantee better learning outcomes. These results point to the importance of student support and pedagogical quality in technology-mediated courses. Additionally, Vilardi (2013) noted that community college online courses often address academic integrity and proctoring issues rather than focusing on actual learning.

Advances in Foundational Mathematics.

Traditionally, developmental mathematics has been taught like high school math, mainly through lectures (Kosiewicz et al., 2016). However, students need more than just remedial content. Students need instructors to use a variety of teaching methods and to focus on student-centered learning, allowing learners to solve real-life challenges (Beamer, 2021). Besides the efforts of community colleges, the public criticizes them for low student success rates in developmental mathematics. Conversely, various reasons contribute to low success rates in developmental courses (Finder-Atkins & Stockdale, 2017). Several academics have addressed this gap, including Beamer (2021), who recommended collaborations among all stakeholders to modify policy, curriculum design, funding, and developmental mathematics instruction.

Additional investigations by Grubb and Gabriner (2013) found that students placed into a traditional developmental math sequence may face academic challenges because lecture-based teaching methods often focus on drills and sub-skills, lacking connections to other courses and real-world applications. Other challenges are associated with being placed in developmental math, which extends the time and money needed to complete a degree, potentially discouraging some students from enrolling in or persisting through college (Kosiewicz et al., 2016). This claim is also supported by Chen (2016)'s NCES report, where 82 percent of students entering public 2-year institutions desired to earn a bachelor's or graduate degree. However, Rosenbaum et al. (2009) reported that students' expectations may not accurately represent their plans because many do not understand that bachelor's or graduate degrees cannot be earned at 2-year institutions. These degrees may not be necessary to work in their intended occupation. According to Attewell et al. (2006), students assessed as requiring remediation are more likely to be members of underrepresented groups. This implies that community colleges should innovatively seek solutions that address the vulnerability of the underrepresented group of students.

Community colleges have adopted new strategies, including innovative approaches, developmental mathematics education models, technology solutions, and integrated academic support systems to boost completion rates (Ngo, 2020; Fong et al., 2016). As a result, various models have been implemented, including accelerated, co-requisite, modular, just-in-time, and emporium models. Additional approaches involve offering structured and rigorous support services, such as supplemental instruction programs and tutoring labs (Redl, 2020). An example mentioned by Redl (2020) is the Gator Success Center at Lamar State College-Orange, which helps foster positive outcomes. These advancements have bridged the gap between high school and college math expectations, providing students with foundational math skills for academic success (Kim, 2016; Ngo, 2020). Among the new approaches are the innovative redesigned programs that instructors must familiarize themselves with (Fong & Visher, 2013).

The redesigned programs focus on students and the curriculum and address instructor delivery skills as replicated in the acceleration programs at Broward College and Tarrant County College, which have successfully enhanced student success and retention rates. Drawing from cognitive and developmental psychology, education provided to developmental students should be based on a combination of theoretical approaches (Mireles, 2010). Instructors should learn about these theoretical approaches and practice combining and implementing them to provide effective developmental education. For example, the shift towards co-requisite models in developmental mathematics has shown positive outcomes in pre-service teacher training programs (Finder-Atkins & Stockdale, 2017). Implementing co-requisite labs and innovative activities while progressing through educational pathways improves students' math skills. Many States, including North Carolina, have redesigned their developmental math programs to address the emerging concerns among students and other stakeholders.

The North Carolina (NC) foundational math redesign involved significant structural, curricular, and pedagogical modifications to remedial math courses (Kalamkarian et al., 2015). The State of North Carolina introduced a contextual and conceptual approach to delivering the math curriculum. The structure begins with rich application opportunities and meaningful context before focusing on procedural skills for problem-solving (Kalamkarian et al., 2015). The math curriculum guide defines conceptual learning outcomes for each module and provides sample introductory application exercises and problems. The redesigned math courses in North Carolina emphasize a deep understanding of mathematical concepts alongside the ability to perform required skills (Kalamkarian et al., 2015).

In conclusion, effective technology integration strategies in community colleges must move beyond merely introducing technology tools to include changes in the curriculum, institutional support and changing faculty mindset (Epper & Baker, 2009). Therefore, these changes must involve a holistic and systemic approach targeting motivation, achievement and faculty competency (Rothwell, 2011).

Comparing technology usage in the Community College experience and the university experience

Community colleges serve as essential entry points for many students pursuing mathematics education, especially those from diverse and underrepresented backgrounds (Taylor & Jain, 2017). These institutions often focus on providing foundational technological skills through accessible digital tools to support students' basic competency. This focus, however, can be limited by budgetary constraints, which impact the availability of advanced technological resources and support for students (Cullen et al., 2020). As a result, students in community colleges may primarily engage with basic software for computational tasks and remedial mathematics (Serin, 2023), often not experiencing the more advanced educational technologies available at universities.

Despite these limitations, community colleges are crucial in establishing initial digital literacy and mathematical understanding. Ellis (2013) highlighted that community colleges prepare students for the university setting by developing essential mathematical skills and fostering positive attitudes toward technology use. However, the available tools may not fully prepare students for the more sophisticated technologies in a university environment. Moreover, Gard et al. (2012) emphasize the importance of comprehensive transfer advising and the need for preparatory technological training that aligns with the expectations of four-year institutions to ensure a smoother transition.

On the other hand, technology use in mathematics education at the university level is often more integrated and advanced, reflecting the standards set by educational organizations such as the National Council of Teachers of Mathematics (NCTM) (Cullen et al., 2020). Universities typically provide access to sophisticated mathematical action tools, such as dynamic geometry software, computer algebra systems, and interactive simulations, which facilitate an inquiry-based learning environment and enhance problem-solving skills (Bowers & Stephens, 2011). This contrast in technology accessibility and usage can be challenging for community college transfer students, who may initially struggle to adapt to these expectations.

Research by Dockendorff & Zaccarelli (2024) indicates that universities often expect transfer students to quickly acclimate to these advanced technological tools, as they are integral to university-level mathematics courses and pedagogy. To meet this challenge, university programs often incorporate frameworks like TPACK (Technological Pedagogical Content

Knowledge) to guide technology integration, aiming to help students connect mathematical concepts with pedagogical practices effectively (McCulloch et al., 2021). The advanced resources and structured technological training at universities underscore the disparities between institutions, highlighting the need for an aligned curriculum and technology access across both educational settings.

Self-efficacy in teaching with technology

As cited in Zeng (2022), by Bandura (1982), self-efficacy is described as an individual's ability to complete a certain task successfully. Although educational research has used Bandura's operationalized definition to characterize self-efficacy as having seven dimensions, this study was focused on two: teachers' decision-making and organizational abilities. Kent and Giles (2017) suggest that it is not easy to change an experienced teacher's self-efficacy; thus, it is easy to develop that of preservice teachers before they enter the mathematics education field. The PSMT's self-efficacy indicates how they use technology in their careers.

Transfer student's preparedness for using technology

Self-efficacy and Preparedness in Technology Use.

Although technological knowledge is necessary, teachers must also feel confident in using technology (Ertmer & Ottenbreit-Leftwich, 2010). This is supported by Taimalu and Luik (2019), who argue that what teachers believe can be achieved with technology and how they believe they can manage technology determines their self-esteem. For PSTs to increase their self-confidence, the teacher educators should be effective role models of integrating technology into their teaching. Additionally, Anderson et al. (2011), noted that teachers' value of technology beliefs have a great impact on how technology is used in the classroom. Teachers' self-efficacy is important in successfully integrating technology into classroom instruction (Kent & Giles, 2017).

Ertmer and Ottenbreit-Leftwich (2010) emphasized that self-efficacy directly influences how teachers approach technology in the classroom. Higher self-efficacy often leads to more innovative and effective integration strategies. Building this self-efficacy is essential for transferring students, who may have varied experiences with technology from their community colleges.

Xie et al. (2023) further posits that beliefs about the educational value of digital resources can shape teachers' willingness to adapt and incorporate technology, especially when they feel supported through training and resources. Cohen (2019) adds that students who enter universities with limited STEM and technology exposure often have lower self-efficacy, creating significant challenges in meeting the technological demands of their new academic environment.

Although technology available to teachers and students has increased tremendously, evidence indicates that it is not being fully integrated into classroom practices. Evidence has shown that teachers' beliefs about technology can predict their use of technology in the classroom (Bice & Tang, 2022). When teachers perceive technology to have value in the teaching and learning process, they are more likely to use it (Taimalu & Luik, 2019).

Prior Experience with Technology and Transfer Student Preparedness.

Community college transfer students often come with various technological competencies depending on the resources and training available at their previous institutions (D'Amico et al., 2014). A lack of consistent exposure to digital tools in community colleges can hinder students' perceived competence when transitioning to university programs that assume familiarity with advanced technology (Fernández-Batanero et al., 2021). Additionally, Gomez et al. (2021) highlight that transfer students with limited previous access to educational technology experience more difficulty adapting to technology-rich environments, impacting their confidence and readiness for classroom integration.

Structured professional development programs at the university level are crucial for bridging gaps in transfer students' technology preparedness. For instance, Thurm and Barzel (2020) found that professional development builds pre-service teachers' skills and positively influences their beliefs about the value of technology in mathematics education. Likewise, Bentley (2024) points out that community colleges that use corequisite models to integrate developmental skills with college-level content effectively build students' confidence in technology use, a model that universities can adopt to support transfer students.

Moreover, Cruz, Wilson, and Wang (2019) found that pre-service teachers with a solid mathematical background tend to feel more prepared to use technology to enhance learning outcomes. This finding highlights the importance of training in technology and reinforcing mathematics skills as part of the preparation for transfer students. Universities that offer targeted support, such as mentorship and access to digital tools, help transfer students strengthen both their technology and content knowledge (Edouard, 2023).

Transfer students face unique barriers in technology integration, including discrepancies in available resources and institutional expectations between community colleges and universities. Dinc (2019) argues that limited access to updated technology in community colleges can contribute to lower preparedness among transfer students as they transition to settings with more advanced technological demands. This discrepancy often creates additional challenges in adapting to classroom expectations, as students may feel inadequately prepared (Wu et al., 2015).

Xie et al. (2023) also note that insufficient training and professional support further widen the preparedness gap for transfer students, making institutional investments in support systems and resources essential for improving technology integration. Furthermore, An and Reigeluth (2011) found that programs that prioritize hands-on technology experiences and peer learning opportunities help alleviate these barriers by enabling students to practice and build self-efficacy in supportive environments.

Addressing these challenges requires a multi-faceted approach, including structured professional development and institutional support. Han et al. (2017) found that experiential learning during field placements and constructive feedback from mentors significantly enhance pre-service teachers' confidence and preparedness for technology integration. Additionally, Holden and Rada (2011) suggest that incorporating usability training into pre-service programs can foster positive attitudes and greater acceptance of technology use among transfer students.

Supportive university environments that offer resources, mentorship, and technology-focused workshops can greatly aid transfer students in building the necessary skills and confidence to integrate technology into their future classrooms. Bentley (2024) argues that such environments address the preparedness gap and encourage positive attitudes toward using technology as a teaching tool.

Technology integration frameworks

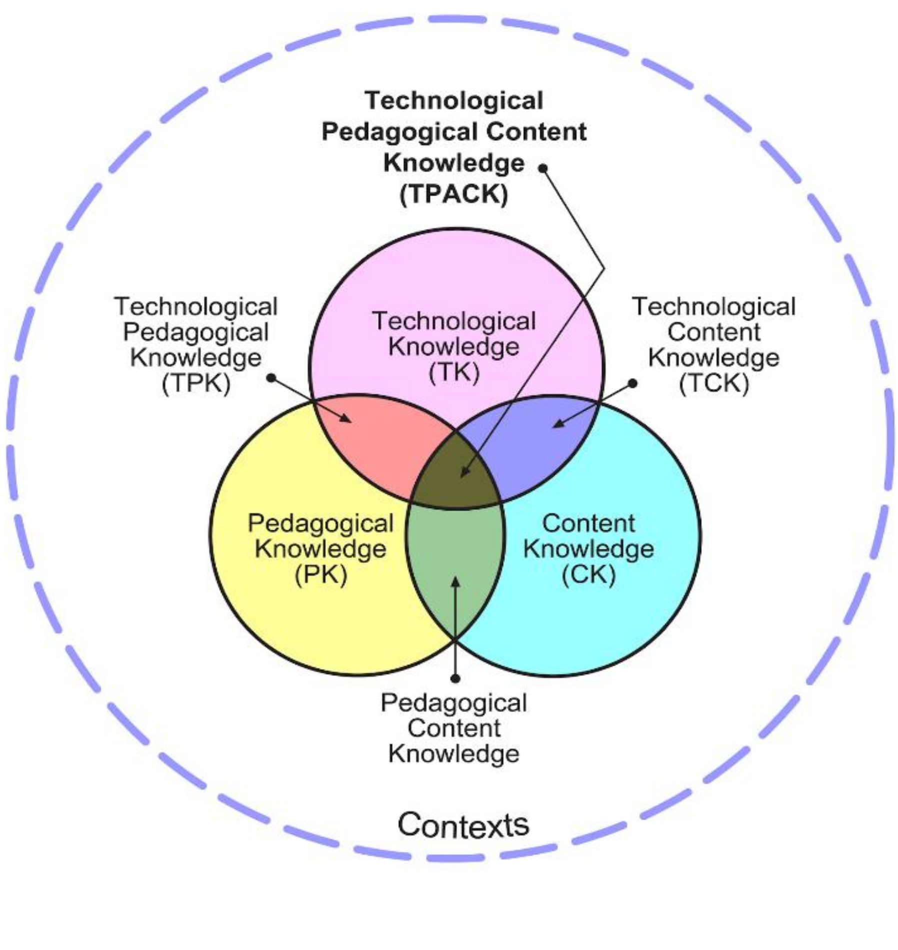
Two theoretical frameworks guided researchers' decisions and provided a lens through which the experiences of community college transfer students on technology use and integration in a math teacher preparation program were examined. The Technological Pedagogical Content Knowledge (TPACK) framework helps to understand the competencies pre-service mathematics teachers require. At the same time, the Technology Acceptance Model (TAM) is used to explore their motivation and acceptance of technology in the classroom. Together, these frameworks provide a lens for investigating the preparedness, experiences, and challenges that community college transfer students face, as well as the impact of user technology acceptance when integrating technology into mathematics education.

The TPACK Framework

The TPACK framework, developed by Mishra and Koehler (2006), expands upon Shulman's (1986) concept of Pedagogical Content Knowledge (PCK) by adding Technological Knowledge (TK) to emphasize the knowledge required to integrate technology into teaching. The three components: pedagogy, content, and technology knowledge in the framework, interact with each other to inform sound teaching and learning practices, as shown in Figure 1. Teachers must understand the relationships between technology, pedagogy, and mathematical content knowledge for effective integration (Bos & Lee, 2024).

Figure 2.1

Technological Pedagogical and Content Knowledge (TPACK) Framework



TPACK is essential for mathematics education, as it helps teachers make abstract concepts more accessible through visualization and interactive tools. Hill and Uribe-Florez (2019) point to the importance of TPACK in instruction, particularly for complex concepts where technology can significantly enhance student understanding and engagement.

Studies by Niess (2005) and Rakes et al. (2022) argue that TPACK is instrumental in helping teachers understand how to use technology to foster conceptual understanding over procedural learning. Niess et al. (2005) describe five developmental levels within TPACK—Recognizing, Accepting, Adapting, Exploring, and Advancing—illustrating a teacher's progression in integrating technology into instruction. Community college transfer students, who may come from backgrounds with limited access to technology, must progress through these levels as they transition into university-based programs with higher technological expectations. Bueno and Niess (2023) found that authentic teaching experiences within TPACK-focused courses improved pre-service teachers' confidence and ability to apply digital tools effectively in mathematics instruction. Their study emphasizes the importance of practical, technology-rich tasks in fostering TPACK, particularly for transfer students who may require additional structured experiences to reach higher TPACK levels.

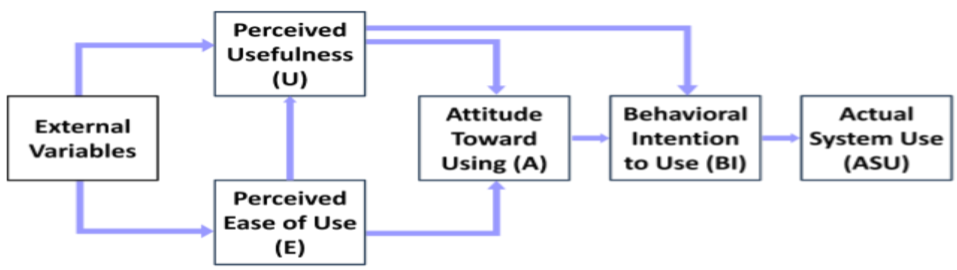
Consequently, Lee and Hollebrands (2008) found that instructional decisions of teachers are influenced by their beliefs and perceptions across technology, pedagogy and content. They propose that developing teachers' knowledge in all three TPACK domains while focusing on student teaching can help them make informed decisions about when and how to use technology. Such programs should build teachers' beliefs that motivate teachers to incorporate technology as part of meaningful math activity.

The Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), provides insight into the factors influencing whether individuals accept and use technology.

Figure 2.2

Technology Acceptance Model (TAM)



Note. Technology Acceptance Model (TAM) from Davis (Davis, 1989). In this diagram, “actual system use” is abbreviated as ASU.

In educational settings, TAM highlights perceived usefulness (the belief that technology will enhance teaching) and perceived ease of use (the belief that technology is straightforward) as critical determinants of technology adoption. Njiku et al. (2022) emphasize that the perceived ease of use and perceived usefulness are vital to transfer students transitioning from community colleges, as they may have limited exposure to advanced educational technology. For these students, perceived ease of use can significantly impact their self-efficacy, while perceived usefulness influences their motivation to integrate technology into their teaching practices (Holden & Rada, 2011). For instance, Corkin et al. (2016) found that pre-service teachers with positive initial experiences using technology were more inclined to continue using it, underscoring the importance of providing accessible tools that build confidence in the early stages.

Integrating TPACK and TAM provides a comprehensive framework to examine transfer students' preparedness and technology acceptance in mathematics education. According to Bakar et al. (2020), teacher preparation programs should design curricula that integrate TPACK-based training with TAM principles to address the knowledge and motivational aspects of technology adoption. This combined approach ensures that students recognize the instructional value of technology (aligned with TAM's perceived usefulness) while gaining the skills to apply these tools effectively within a mathematics context (aligned with TPACK).

For community college transfer students, hands-on experiences in technology integration can bridge gaps in TPACK and TAM dimensions. Bueno and Neiss. (2023) found that pre-service teachers' confidence and willingness to use technology increased significantly when tasks were content-specific, highlighting how perceived usefulness (TAM) and the pedagogical application of technology (TPACK) work together to build motivation and competence. Corkin et al. (2016) further found that insufficient exposure to practical technology applications during training could disconnect TPACK's technical requirements from real-world classroom demands. Support through mentorship, access to resources, and structured training sessions can help address these barriers, enabling transfer students to gradually build TPACK knowledge and positive attitudes toward technology integration.

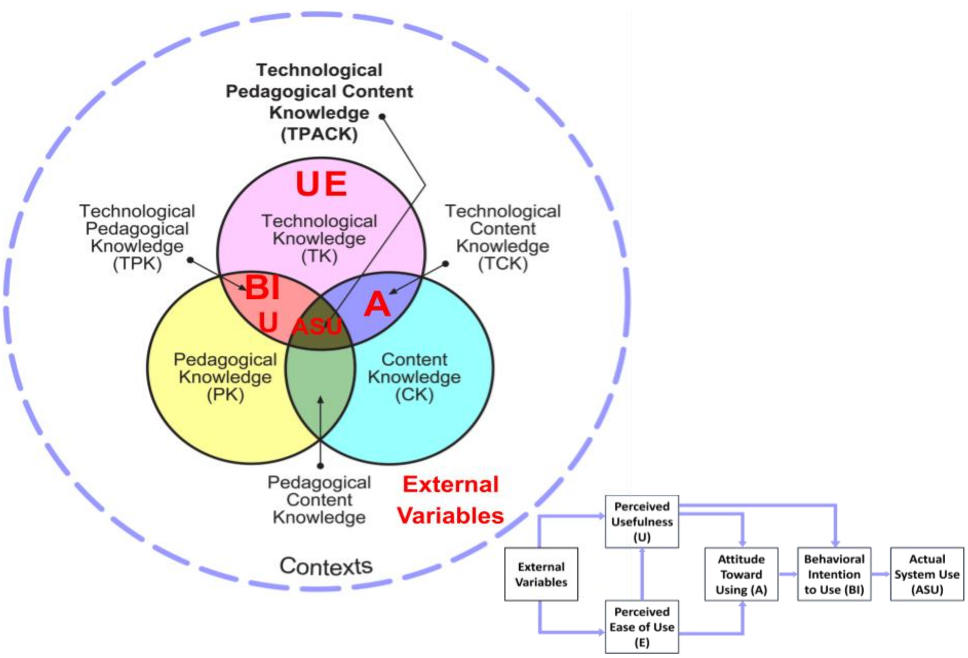
Math teacher preparation programs can leverage the integration of TPACK and TAM to create structured, supportive environments that address competence and motivation in technology use for transfer students. Özbek et al. (2024) propose incorporating content-specific tasks that reinforce TPACK competencies and foster positive attitudes toward technology use, ensuring that transfer students view technology as an essential part of teaching rather than a supplementary tool.

Combined Theoretical Frameworks

The TPACK framework (Mishra & Koehler, 2006) assessed how PSMTs integrate technology into their teaching by examining the interaction of technology, pedagogy, and content knowledge. On the other hand, the TAM (Davis, 1989) framework was employed to evaluate participants' ease of use and perceived usefulness of technology in their educational and teaching contexts. TAM was used to explore how these factors influence their acceptance and use of technology in the classroom. For this study, “actual system use” in the TAM model has been abbreviated as “ASU.” Integrating TPACK and TAM provides a comprehensive perspective on how user acceptance influences the integration of technology.

Figure 2.3

TPACK-TAM Framework



Note. TPACK-TAM Framework (modified). The diagram illustrates how the TAM model's constructs align within the TPACK framework, utilizing abbreviations. The abbreviations U, E, A, BI, and ASU represent perceived usefulness, perceived ease of use, attitude toward technology.

In this study, TPACK and TAM have been integrated to create the TPACK-TAM framework. Using the combined frameworks, the researcher examined the experiences of community college transfer students in using and integrating technology. The components of TAM fit in TPACK as follows.

Technological Knowledge (TK) ↔ E

TK refers to the teacher's understanding of technology and its applications, while perceived ease of use (E) measures the extent to which an individual believes technology can be used without much effort; thus, both relate to technology use. Teachers with strong TK are more likely to view technology as easy to use (Koh et al., 2013). Such teachers can navigate and troubleshoot technological tools with relative ease.

Content Knowledge (CK) and Technological Content Knowledge (TCK) ↔ BI

CK and TCK refer to the alignment of technology with content, while BI (behavioral intention to use) is the willingness to use technology in the future. Hence, they all focus on future desires for technology use. If a teacher understands the alignment between technology and content delivery, the intention to integrate it into the classroom increases (Koh et al., 2013).

Pedagogical Knowledge (PK) and Technological Pedagogical Knowledge (TPK) ↔ U

PK focuses on understanding teaching strategies, and TPK refers to the knowledge about how technology can enhance pedagogical practices. U (perceived usefulness), on the other hand, is the belief that using technology will improve performance. The components are connected as they are all concerned with how technology impacts the outcomes. When teachers effectively know how to integrate technology into their pedagogical strategies, they may view technology as capable of improving teaching and learning outcomes (Koh et al., 2013).

TPACK ↔ ASU

The two frameworks, TPACK and ASU, represent the actual use of technology, thereby bridging the gap between theory and practice in technology integration. Teachers with strong TPACK are more likely to incorporate technology productively in their teaching (Koh et al., 2013).

TAM external variables ↔ Context

External variables might influence an individual's beliefs toward the system (Das, 2021; Davis et al., 1989). These factors include user training system characteristics and user participation during system design. On the other hand, context refers to the environment within which technology is deployed, like institutional support, classroom size, and technology infrastructure (Rakes et al., 2022). Therefore, external variables in TAM can either hinder or promote the development of TPACK, thus impacting user acceptance.

In this study, the combined TPACK-TAM framework provides a lens to assess how the PSMTs develop their technology use and integration skills. TAM can be effectively used to determine an individual's acceptance and use of technology (Hsu & Lin, 2022). In contrast, TPACK provides a lens through which researchers can examine how PSMTs learn and develop their skills in using and integrating technology (Yigit, 2014). However, the presence of technology and knowledge of its use does not guarantee that PSMTs will incorporate it into their teaching practices (Sungur Gül & Ateş, 2023). New software and mathematics apps are regularly developed with the evolving technology landscape. Modern teachers, therefore, must develop skills that will allow them to be flexible when learning new technologies. Employing TAM allowed the researcher to explore the PSMT's willingness to accept and use new technologies in the field. Hence, combining these two frameworks provides a robust lens for examining PSMT's experiences in learning and implementing technology use.

In the next section, I examine the methodology employed in this study to investigate the use and integration of technology in teacher preparation programs.

CHAPTER 3: METHODOLOGY

Introduction

The purpose of this study was to investigate CCTSs' technology use and integration experiences in a mathematics education teacher preparation program using the TPACK-TAM framework. Available literature indicates that past studies have been undertaken on the success of CCTSs in STEM majors and their attrition rates; however, there is a lack of literature on their experiences with technology use and integration. This lack of studies on technology use and experiences of CCTSs necessitates this study to bridge the existing gap. A qualitative, narrative case study design (Sonday et al., 2020) was employed to extract and center participant stories, providing insights into the technology use and integration experiences of CCTSs. By focusing on the stories of transfer students, this method allowed for a rich and detailed exploration (Butina, 2015; Clandinin et al., 2016) of their technology use and integration, the opportunities and challenges they encountered, and how their experiences influenced their transition to a four-year institution.

This chapter outlines the research design for this study, including the researcher's role, instrumentation, and materials used, as well as procedures for recruitment and participation, methods for data collection and analysis, and ethical considerations.

Research Design and Rationale

This study employed a narrative case study (Monson et al., 2021; Sonday et al., 2020) to investigate the experiences among CCTSs in using and integrating technology during their training in the math teacher preparation program. Narrative inquiry is commonly utilized in Psychology, Sociology, Education, and health care (Clandinin, 2006; Wells, 2011). Thus, this method is suitable for exploring the experiences of CCTSs during their training journey.

Researchers collect and analyze personal stories and accounts, which can take various forms, including memoirs, diaries, interviews, artifacts, digital media, and observations (Clandinin, 2006). The choice of narrative methodology is inspired by Clandinin and Connolly's (2000) definition of narrative inquiry, which is viewed as,

> .. a way of understanding experience. It is a collaboration between the researcher and participants over time, in a place or series of places, and all social interaction with Milieus. An inquirer enters this matrix in the midst and progresses in the same spirit, concluding the inquiry still in the midst of living and telling, reliving and retelling, the stories of the experiences that made up people's lives, both individual and social (Clandinin & Connelly, 2000, p.20)

A narrative case study focuses on the voices of the participants (Clandinin, 2006), which is important for marginalized communities. The CCTS's group of students consists of a small student population that is often forgotten within the larger group of undergraduate mathematics education majors. This method explores the experiences of CCTSs through stories shared by individual participants. Creswell and Poth (2016) note that narrative inquiry is particularly suitable for an in-depth examination of individuals' experiences over time and within their specific contexts. In this study, the technology use and integration of CCTSs are explored, from community college admission into the math education program to teaching placement. Creswell and Poth (2016) further affirm that the goal is to understand how participants make meaning of their experiences through the stories they tell. This approach recognizes the centrality of relationships between participants and researchers, and the relationships of experiences studied over time. Thus, the researcher and participant co-construct a coherent narrative of the phenomenon under study.

In this study, the entire population of senior and four junior CCTSs mathematics education students at Wonderful University, a large research institution in the southern United States, was surveyed. The survey results were then used to understand the general abilities of these student groups. The community college transfer students' groups (seniors and non-seniors) were all interviewed to gain an in-depth understanding of their lived experiences. Additionally, the community college transfer senior students were interviewed a second time to gain insight into their field placement experiences to ascertain how they integrate technology into their classes. The community college transfer seniors also provided a sample of their lesson plans for document analysis for triangulation.

In this study, after analyzing individual participants' narratives for themes, a cross-case analysis was conducted to identify similarities and differences between the experiences of the two groups: seniors and non-seniors. Yin (2018) states that case study methodology best determines beliefs and perceptions. This aligns with this study, as it seeks to understand the participants' perception of technology use. The sample size is also small, so employing qualitative methods provides more in-depth information to cover the weaknesses that would arise from the small number of participants (Vasileiou et al., 2018).

Additionally, Creswell (2014) proposes a case study for investigating detailed and thorough data collection, whose sources may include interviews, documents, and information from transcribed materials. This selective case study focuses on a single issue and presents multiple case studies. The unit of analysis was a group: non-seniors and seniors. The data sources were interviews, survey instruments, and lesson plans. The cross-case analysis helps to compare groups to provide more insights based on identified similarities or differences. This investigation aims to determine "why" preservice teachers use technology and justify their decisions. The "how" and "why" questions work to explain an issue; hence, merging narrative inquiry and case study was the best approach for the investigation at hand. The research questions below were utilized.

Research questions that guided the study are;

RQ1. How prepared do CCTSs feel to use educational technology in their current mathematics education program?

RQ2. How does the use of technology in mathematics differ between community colleges and the University, as experienced by CCTSs?

RQ3. How does self-efficacy for teaching with technology change for CCTSs in their teacher preparation program?

RQ4. How do CCTSs use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?

Setting

The study was conducted in the 2024-2025 academic year in a math education teacher preparation program in a large research institution in the southern United States. The institution was chosen because it is ranked among the best teacher preparation institutions in the state. Additionally, the institution collaborates with neighboring community colleges through articulation agreements, enabling students to transfer after graduating with their associate's degrees or completing a specified number of credit hours. Lastly, the math education curriculum incorporates a technology component into all math education methods courses, in addition to a specific technology mathematics methods course taken by undergraduate students, making it a vital component of technology integration in teaching practices.

Participants

The participants were selected using purposive sampling, focusing on seniors enrolled in the math education teacher preparation program who can offer rich insights related to the research topic (Robinson, 2014). The survey participants comprised non-senior and senior students currently enrolled in a university's mathematics education teacher preparation program. This entire group comprises six traditionally enrolled and four Community college transfer students (*See table 3.1*).

Table 3.1

Summary of Survey participants' demographics

	Pseudonymn	**Attended CC**	**Years at CC**	**MTPP**
1	Angelina	Yes	2 years	Middle Grades Math Education
2	Priyanka	No	0	Middle Grades Math Education
3	Hanifa	No	0	Math/ Math Education
4	Venessa	Yes	2 years	Middle Grades Math Education
5	Lawrence	No	0	Middle School Math and Science Education
6	Kimberly	No	0	Secondary Mathematics Education
7	Jane	No	0	Secondary Mathematics Education - Stats Specialization
8	Grace	No	0	Secondary Mathematics Education
9	Kendall	Yes	4 years	Middle Grades Mathematics Education
10	Mathew	Yes	2 years	Middle Grades Math Education

A subset of 4 participants from the survey were selected for the interviews using purposive sampling. This group consisted of students who responded “Yes” to the prompt of “having enrolled in a community college before transitioning into the math Education program”. A purposive sampling strategy ensured that only junior and senior students enrolled in mathematics programs were recruited for the study. This decision is in line with Robinson (2014), who recommends that purposive sampling be used to ensure that certain categories of individuals who may have a unique or important perspective on the phenomenon of the study, and their presence in the sample is guaranteed.

This selection strategy targeted community college transfer students, who shared their experiences in accordance with the interview protocol. Although the protocol was developed earlier based on research questions, it was modified to incorporate themes arising from quantitative data analysis.

Data Collection and Analysis

This study collected data through surveys, semi-structured interviews, and artifact collection. The use of semi-structured interviews as the primary mode of data collection allowed for a flexible conversation through a predetermined interview protocol, while providing participants with an opportunity to share their experiences and perspectives (Maxwell, 2012) on technology use and integration. The qualitative data were analyzed using thematic analysis, and finally, the documents underwent document analysis.

Data Collection Methods

The study employed a survey to obtain foundational data on PSMT's background on technology use and integration. The CCTSs were then interviewed to obtain individual experiences data. Lastly, the senior CCTSs provided a sample of their lesson plans for analysis.

Instruments

Survey

This study employed the TPACK-M US survey instrument, which was constructed by Schmidt, Thompson, Mishra, Koehler, and Shin (2009) (see Appendix 1). This survey instrument was developed while "examining how preservice teachers develop and apply technological pedagogical content knowledge (TPACK) throughout their teacher preparation program and in

PK-6 classrooms during practicum and student teaching experiences”. They constructed the Survey of Preservice Teachers' Knowledge of Teaching and Technology to collect data on preservice teachers' self-assessments of the seven knowledge domains within the TPACK framework. The survey was administered via the course website, and the results were analyzed. The instrument designers conducted a first-factor analysis to determine whether the sub-domains aligned with the TPACK constructs. The reliability statistics were calculated to identify problematic items in the subscales, and these items were eliminated since they did not serve any purpose. The second-factor analysis was conducted with the results exhibiting strong internal consistency reliability (ranging between 0.59 and 0.92).

The survey employed the TPACK-M survey instrument (Smith & Zelkowski, 2023). The TPACK-M survey Instrument comprises five components: Technology knowledge (TK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPCK) (See Appendix A for more details). The TPACK-M survey items in each component were used with a 5-point Likert Scale response (1= “Strongly Disagree,” 2= “Disagree,” 3= “Neither agree nor disagree,” 4= “Agree,” and 5= Strongly Agree.

In this study, the TPACK M-survey instrument was administered via Qualtrics software and distributed via email. According to Dillman et al. (2014), data collection through web surveys enables the rapid collection of responses from a large number of people. Additionally, the survey is the preferred mode of dissemination, as Groves et al.(2009) recommend that the cost of each case of the web survey should be close to zero if the survey is entirely electronic (i.e., invitations and reminders are sent via email).

The TPACK survey instrument (see Appendix A) measures participants' technological, pedagogical, and content knowledge, as well as their self-efficacy and acceptance of technology use. Items were adapted from existing validated instruments that measure self-efficacy in teaching with technology.

To establish legitimacy and trust, the pre-notification letter featured official letterhead, contact information, and a signature. Additionally, the researcher requested the undergraduate coordinator of the mathematics education department to communicate with the target population. The coordinator's assistance further reinforced the credibility of the upcoming survey and fostered confidence in it.

The first email was sent by the undergraduate coordinator of the mathematics education department. This email served as an invitation to survey participants. After the prenotification email, the second one was only sent to the sample population. The survey participants received a comprehensive description of the survey's contents and expectations through this email. In this email, the researcher informed the participants about the incentive for participation. The respondents were given a $20 Amazon gift card. This decision is consistent with Dillman et al.'s (2014) study, which indicates that incentives may raise survey response rates. Lastly, the sample population received a reminder email after two weeks. The email reminder was intended to notify recipients of the survey's initial distribution, express gratitude to those who had already completed it, and encourage those who still needed to do so (Dillman et al., 2014).

Interviews

In qualitative studies, researchers aim to understand a phenomenon through the interrelationships between the participants (Stake, 1995). This methodology immerses the researcher in the participants' realistic environments and provides a means to analyze the environments, events, and interviewee perceptions.

The semi-structured interviews used an interview protocol (See Appendix B) to explore participants' perceptions and experiences, providing a deeper understanding of the findings from the survey data. The survey protocol questions were aligned with the interview protocol items using a matrix table (*see Appendix D*) that maps the interview questions to research questions, as Castillo-Montoya (2016) recommended. This mapping allows the researcher to review the interview questions to ensure that they help answer the research questions, hence increasing their utility. The Survey instrument was mapped to the research question intended to help answer.

Drawing on Dewey's (1938) first criterion of continuity, as cited by Clandinin (2000), indicates that,

> Experiences grow out of other experiences, and experiences lead to further experiences. Wherever one positions oneself in that continuum- the imagined now, some imagined past, or some imagined future- each point has a past experiential base and leads to an experiential future (Clandinin & Connelly, 2000, p.20)

Using the narrative inquiry, the researcher presented the experiences of the participants, focusing on their past, present, and future (Butina, 2015). This methodology, therefore, enables the researcher to understand and tell the story of the participants' experiences in using and integrating technology into their classroom practices. This investigation aims to determine "why" preservice teachers use technology and justify their decisions. The "how" and "why" questions work to explain an issue; hence, an explanatory case study was the best approach for the inquiry at hand (Creswell, 2013). The narrative approach, therefore, provides a nuanced way of telling the participants' stories by answering the research questions in relation to their past use of technology and their experiences in the teacher preparation Program (Miles et al., 2014). The participants, who are seniors, also had the opportunity to compare their past and present experiences and reflect on the use and integration of technology in the field.

In-depth interviews were conducted in this study to explore participants' lived experiences with educational technology. The interview questions were developed based on the TPACK and TAM frameworks, focusing on how participants integrate technology into their teaching, their perceptions of its usefulness, and their confidence in using it. Both juniors and seniors were interviewed in the first round to explore their experiences using and integrating technology. The senior CCTSs were further interviewed to explore their experiences with technology use and integration during their teaching placement. The CCTSs were all given an additional incentive of a $30 Amazon gift card for their participation in the interviews.

Lesson Plans

Artifacts analysis was also done to triangulate the results, offering extra evidence for the data collected earlier. According to Seidman (2006), interviews with participants are the most effective way to obtain first-hand information on a phenomenon. They are reflective ways of understanding the details of an individual's experiences.

During the interview, community college transfer students who were on teaching placement were requested to submit some of their lesson plans and any other documents related to lesson planning for analysis. This aligns with Clandinin and Caine's (2013) recommendation of using artifacts like course syllabi, lesson plans, and technology-based projects, which may provide context and serve as story triggers. Surya (2020) adds that artifacts can serve as prompts for telling stories, providing context and detail to the narratives.

Furthermore, artifacts help in situating field texts within a three-dimensional narrative inquiry space, considering the temporal, personal and social, and place aspects (Clandinin, 2006). For instance, a lesson that a teacher used to teach a previous lesson can elicit memories and narratives about how they integrated technology into their lesson. Patton (2014) argues that triangulation is based on the premise that no single method ever adequately solves the problem of rival causal factors because each method reveals different aspects of empirical reality. Therefore, the pre-existing data from documents can be used with other types of data (interviews and surveys) for triangulation, enhancing trustworthiness and providing a deeper understanding of the topic (Creswell & Poth, 2016).

Data Analysis

Survey Analysis

The data were summarized using descriptive statistics, mainly the mean scores of the TPACK constructs. The data was sorted into two categories: the community college transfer students and the traditionally enrolled students. The means of each item in the survey provided background knowledge of how participants can use and integrate different technologies. Additionally, the results of the two groups were compared to identify similarities and differences between them in relation to the various constructs of the TPACK-TAM framework: TK, TPK, and TPACK.

The descriptive analysis's results informed the development of the qualitative phase, identifying critical areas for further exploration during the interviews. Based on the TPACK-TAM framework, the results explained the level of technology acceptance.

Interview Analysis

The interview protocol utilized in this study was researcher-developed and modified by the dissertation committee. To ensure that the interview protocol items were relevant to the study, each was mapped to the research questions to determine its usefulness (***see Appendix C*)**. Any item that did not directly answer any research question was used for eliciting thoughts that acted as a reminder to the preceding items.

Data collected in the survey were analyzed to help understand and identify emerging themes that can be used for further investigation in the qualitative phase. The qualitative analysis involved thematic analysis using coding. According to Saldana (2021), coding is cyclical; thus, it was done in several phases until the themes were refined. The transcripts generated directly by Zoom often contain errors due to disparities in accents and other language-related aspects of the participants. Therefore, all the transcripts were reviewed and edited for accuracy.

Deductive and inductive coding were employed to provide an in-depth understanding of the CCTS's experiences. According to Saldana (2016), deductive coding encompasses the creation of pre-established codes that align with the study and research questions to serve the intended purpose. Deductive codes were derived from the literature and research questions before the start of the coding process, including prior experiences impact, learning to use technology tools, access to technology, support for technology use, adapting to new technology environments, confidence in using technology, plans for future tech integration, motivation to use technology, using technology to support math learning, technical skills, technology experimentation opportunities (*See table 3.2*). Deductive coding was chosen because it is suitable for program evaluation research (Saldaña, 2021). It enables researchers to analyze data, emphasizing specific phenomena and identifying helpful information.

However, using pre-conceived codes may sometimes exclude important information that could enrich the study (Miles et al., 2014). Therefore, the researcher used inductive coding to create codes from the additional information discovered in the data.

Thematic Analysis

The research questions were aligned with the interview protocol items using a matrix table that maps the interview questions to research questions, as Castillo-Montoya (2016) recommended. This mapping allowed the researcher to review the questions to ensure that they help answer the research questions, hence increasing their utility**.** The Survey instrument has been mapped to the research question it is intended to help answer (*see Appendix E*).

The qualitative data were analyzed using a thematic analysis guided by Creswell's (2014) guidelines. Thematic analysis involves identifying and reporting patterns within the data (Creswell, 2014; Terry, 2016).

Initial codes were developed based on research questions to identify key concepts related to technology use, perceived ease of use, usefulness, and self-efficacy. The codes (*see Table 1*) include prior experiences' impact, learning to use technology tools, access to technology, support for technology use, adapting to new technology environments, confidence in using technology, plans for future tech integration, motivation to use technology, using technology to support math learning, technical skills, and technology experimentation opportunities. All the transcripts were uploaded into the Delve Qualitative Data Analysis Software, where the data were examined, and codes were systematically developed. The codes were grouped into broader themes that reflect the participants' experiences with technology integration in their mathematics education.

Table 3.2

Apriori codes

Code	**Definition**	**Examples**	**Source**
Access to technology	Availability of technological resources and infrastructure for teaching and learning	The classroom lacked enough laptops, so we shared	Ali et al,2023; Medina Herera et al., 2024
Confidence in technology use	Self-assessment of readiness to use education technology.	I feel confident incorporating digital tools in my lessons.	Thomas, 2016
Motivation to use technology	Participants' eagerness to integrate technology into their teaching practices.	I want to use technology because it makes lessons more engaging for students.	Ertmer et al., 2012
Support math learning with technology	Utilizing technology to help students engage with and understand math concepts.	Students used GeoGebra to practice solving quadratic equations.	Fabian et al., 2016
Ease of learning new technology	Experience in quick learning and understanding new technology.	I figured out how to use Google Sheets to multiply matrices in one session.	Hew & Brush, 2007

The initial phase of structural coding formed the foundation for an in-depth description of each case and its context. A second coding cycle was undertaken to re-evaluate, re-analyze, and reorganize data initially coded using the first round during structural coding in the first phase (Miles et al., 2014). Performing a second phase of coding enabled the establishment of logical connections between seemingly unrelated information and the organization of categories to create a coherent data synthesis (Saldaña, 2021; Terry, 2016). In the second stage, pattern coding was used to arrange codes into fewer, closely linked themes (*see Table 3.3*).

Table 3.3

Examples of Significant statements and Formulated meanings of technology-related subthemes

Significant Statement	**Formulated meaning**	**Subtheme**
I would say, my perception has definitely changed a lot since community college, just because my sort of understanding of technology in the classroom was pretty much limited to just like smart boards for or like the yeah, pretty much just smart boards pretty much and so I figured that'd be my limit of technology in the classroom. But since then, I have seen I could still use a smart board, but I can also take notes on an iPad, and it show up on the smart board, or I can pull up Desmos and show them on Desmos or I think there's even a graphing calculator like app that you can download onto the computer and do it on there. And so yeah, it's definitely broadened my horizons. And I'm a lot more. I feel like I can use technology more in the classroom now.	Initially, the student had a narrow view of classroom technology until exposure to teaching methods coursework expanded the student's understanding of instructional strategies.	Confidence in technology use
I think the challenge was that since I was a nontraditional student, so I went from not using any of these tools for almost a decade to being introduced to them today and expected to do a whole assignment within the week.	Non-traditional students face steeper learning curves, most likely due to gaps in technology use. Pressured due to limited time.	Transition challenges

Table 3.2 Continued

Examples of Significant statements and Formulated meanings of technology-related subthemes

It has definitely broadened my horizons. I would say just by being in those placements seeing how iPads and laptops are used, and From what I've seen, almost every classroom and how it is. I guess I didn't realize how much it has changed since I was in high school. And so just now, knowing that. Those things are more prominent and used on the daily basis in the classroom, has changed my point of view of how much technology has actually been how much technology is actually used in the classroom.	Feels more confident and capable of integrating various forms of technology into teaching methods coursework.	Confidence in technology use
The program forced me to use the tool as a student and get comfortable with it as a student, you know, before I ask my students to do the same.	Gained self-efficacy through firsthand student use of technology tools, recognizing the value of learning by doing.	Confidence in using technology
Yes, GeoGebra, which I had not used before. It was very, I would say, very hard for me to learn. I think of all the ones I've used. It's not just knowing how to use all those features that come with it, you know. But I did learn how it makes it easier to use for transformations in geometrical figures, and basically, you know how efficient it is. It saves us a lot more time than if we were using a projector, and you know, regular tools.	Despite initial struggles, she learned GeoGebra and appreciated its efficiency and its effectiveness in mathematics visualizations and transformations.	Ease of learning new technology
I honestly like was a little intimidated by the technology aspect, because I didn't know. I didn't know much about it, and I knew, like being older, you know. I knew that going in probably a decade older than these kids. They were probably gonna, you know, quicker than I would. But like I started, you know.	The student was initially anxious as a non-traditional student, but gradually adapted to new technology tools.	Confidence in using technology

Table 3.2 Continued

Examples of Significant statements and Formulated meanings of technology-related subthemes

I think I would be able to launch a lesson. I just I think I would need some more practice with CODAP. GeoGebra, I worked a lot with that with my geometry course. And so that was cool. I feel good about GeoGebra. And so yeah, I would say, all of them I feel really good on, except the CODAP. I could probably use some more practice with that.	Feels proficient with certain mathematics action tools like GeoGebra and identified CODAP as an area that needs further practice.	Ease of learning new technology
But I think it's just a bit more difficult to navigate. I preferred the blackboard collaborated to the original interface more than I did the newer version. But let's see, with South City, we mainly used Microsoft Word and or Microsoft Office products, whereas Wonderful University uses Google and or mostly requires Google and different things. So look, having to switch between the 2 different programs were a bit of a challenge. Because I'm so used to Microsoft. And all of the different functionalities that come with it. Granted, I know that they do have a big overlap of what they can do. The keyboard shortcuts are a bit different, and trying to relearn those to be able to work from 2 different platforms.	Found the differences in software and platforms frustrating.	Transition challenges

Pattern coding was used based on Saldana's (2021) recommendation that it facilitates the examination of individual cases to identify specific insights and find common themes across multiple cases. The data was synthesized into core themes, connecting them to specific research questions to help explain the lived experiences of transfer students and their use of technology. Pattern coding was established as the foundation for cross-case analysis by producing shared patterns across cases, which identified themes in the analysis.

The resulting themes were supported by participant quotes, which are collectively reported in the following section of this paper. The resulting themes from individual cases were compared for similarities and differences to draw conclusions about the experiences of the participants involved in the study.

Document Analysis

According to Miles et al. (2014), the collected documents are analyzed thematically to identify recurring patterns, concepts, and assumptions related to technology integration (Miles et al., 2014). This analysis also helps to corroborate the findings of the narrative inquiry. (Miles et al., 2014) recommend coding the documents for key themes and then organizing the code into broader categories. The content analysis of documents began with a list of specific and related elements. This was done through surface-level reading. Grbich (2013) defines surface-level reading as examining documents at a surface level, highlighting words and phrases that emerge.

Furthermore, Grbich (2013) recommends that narrative analysis, which involves examining the stories participants tell, be applied to documents. This includes identifying narrative elements such as plot, characters, setting, and themes. The lesson plans were analyzed in terms of the goals. Table 2 below gives a summary of the data sources, research questions, and the associated method analysis.

In this study, lesson plans were collected from Senior CCTSs on teaching placement. The lesson plans were requested via email after the second interview had been conducted. The participants were requested to submit a sample of their lesson plans either via email or share via Google Drive. Later, each of the lesson plans was analyzed by the researcher.

Table 3.4

RQs, Data Sources, and Analysis Methods

Research Questions	**Data Sources**	**Analysis Method**
RQ1. How prepared do CCTSs feel to use educational technology in their current mathematics education program?	Survey Excel data files Transcripts	Descriptive analysis for the survey. A priori coding Thematic analysis
RQ2. How does the use of technology in mathematics differ between community colleges and the university, as experienced by CCTSs?	Survey Excel data files Transcripts	Descriptive analysis for the survey. A priori coding Thematic analysis
RQ3. How does self-efficacy for teaching with technology change for CCTSs in their teacher preparation in the program?	Survey Excel data files Transcripts	Descriptive analysis for the survey. A priori coding Thematic analysis
RQ4. How do CCTSs use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?	Survey Transcripts Lesson plans	Descriptive analysis for the survey. A priori coding Thematic analysis

Narrative Analysis

Narrative analysis was employed to interpret the data, focusing on the stories participants shared and how they made meaning of their experiences (Clandinin et al., 2016). The analysis involved identifying key narrative elements, such as plot, characters, setting, and themes, to understand how participants structure their experiences into stories (Grbich, 2013). The analysis considered the social, cultural, and institutional narratives within which individual stories are embedded (Clandinin & Connelly, 2000; Clandinin & Caine, 2013).

The researcher explored how larger social, institutional, and cultural narratives inform our understanding and shape the stories by which researchers and participants live their lives. The researcher sought recurring patterns or narrative types that might reveal common experiences or perspectives among participants (Grbich, 2013).

Reliability and Validity

In qualitative research, validity refers to how data accurately capture what the researcher intends to measure. In contrast, reliability refers to the extent to which the data consistently measure what it is expected to measure (Quintão et al., 2020). This study employed several strategies to follow Creswell's (2014) recommendations for ensuring the validity and reliability in qualitative research. First, the researcher only used validated instruments in the study to ensure validity and reliability. The TPACK M-Survey instrument and the TPACK levels rubric V2.0 that was be used in the study have been validated based on existing literature and research and have been validated. The instruments are, therefore, of good quality (Benson & Clark, 1982) and are aligned with the purpose of my study.

Second, the researcher conducted interviews using a self-constructed interview protocol developed after a literature review. To ensure validity, the interview protocol was reviewed by experts (dissertation committee) and adjusted accordingly. The study used document analysis for triangulation to provide additional information as evidence of the data collected through the survey and semi-structured interviews.

Participants were allowed to review the transcripts of their interviews and provide feedback to ensure their perspectives had been accurately captured. The researcher engaged in peer debriefing with participants to ensure the accuracy and objectivity of the data's interpretation.

Ethical Considerations

All participants provided informed consent before the study commenced by signing a consent form, agreeing to participate. The participants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time.

After each interview, the data was examined for accidental identifiers and locked away securely by storing it on a password-protected Google Drive. All documents with participant signatures were stored in a secure location, and access was granted only to the researcher, except in the event of a legal subpoena (Seidman, 2013).

Confidentiality

Pseudonyms were used to protect participants' identities in all written reports and publications. Finally, when the analysis was complete, participant identities were masked to protect them and ensure that their confidential statements were not shared.

IRB Approval

The researcher has completed CITI training to acquaint himself with research conduct, knowledge, and skills to guide him in conducting human research. The researcher applied for the IRB, which was reviewed by the research Institution IRB board and approved before the commencement of the study. The selected participants were informed about the study's objective, and the researcher obtained their permission to participate in the study before its commencement. The researcher used semi-structured interviews to collect data, critically analyze the data, and present the findings. The researcher adhered to all guidelines set by the Institutional Review Board (IRB) to ensure the ethical treatment of participants throughout the research process.

Positionality

The researcher serves as the primary data collection instrument in mixed methods research for the qualitative research component (Patton, 2014). Thus, the researcher needs to declare any biases, values, or assumptions they bring to the study (Creswell, 2014; Creswell & Poth, 2016). Therefore, I attempt to describe how my personal experiences and my role as a graduate assistant who has interacted with the participants as an instructor and organizer of study abroad events might influence my research process and findings interpretation of the inquiry into the experiences of community college transfer students in using and integrating technology in a mathematics teacher preparation program. To mitigate the potential for unconscious bias to influence my data collection and interpretation, I commit to maintaining a neutral stance, using structured data collection instruments, and applying robust thematic analysis to ensure objectivity.

As an international student with a tertiary college background (equivalent to a community college) and teaching experience in Africa, I have been exposed to a different educational system and teaching practices. Therefore, I recognize that my experiences differ from those of the participants who have navigated the U.S. community college system. My approach in this study is thus open-minded, and I listened actively to the participants’ experiences so that their voices are authentically represented.

Being a late adopter of technology, I resonate with many educators' challenges in integrating technology into their pedagogical practices. This enhances my empathy with those who may encounter such struggles. However, I acknowledge the importance of maintaining objectivity to avoid projecting my experiences onto the participants' narratives. I aim to uphold ethics, transparency, and credibility by continuously reflecting on my positionality during the research process.

Limitations of the study

This narrative case study provides insights into the experiences of CCTSs in using and integrating technology and contributes to the field of mathematics education. However, it has some limitations that should be considered in future similar studies. The limitations are highlighted below.

Small sample size and limited context

The study involved only four community college transfer students (2 juniors and 2 seniors) from a single teacher preparation program in North Carolina. While rich, these narratives provide a narrow view of student experiences and cannot be readily generalized to other regions or programs.

Subjectivity and researcher interpretation

Narratives are shaped by individual perspectives and recalled experiences, which can introduce bias. The researcher's role in selecting excerpts, coding themes and interpreting data can also influence findings; such subjectivity is a common challenge in narrative and case-study research. The study attempted to mitigate this through multiple coding rounds, thematic analysis and cross-case comparison, but the potential for researcher bias remains.

Limited triangulation

Most data were self-reported through interviews and a small number of lesson plans. Only two participants provided lesson plans, so evidence for classroom practice (RQ4) relied heavily on narrative accounts. There was no direct classroom observation or collection of student artefacts, which limits triangulation and the ability to verify participants' claims.

Stage differences among participants

The comparison of juniors and seniors provided interesting contrasts, but differences may partly reflect program stage rather than broader patterns. Juniors had not yet completed methods courses or field placements, whereas seniors had; thus, disparities in confidence and technology use might be attributable to timing rather than other factors.

Short study period

The study period is short, thereby denying the field the opportunity to learn from this group of students' experiences if they were tracked for a longer period, such as from enrollment to program exit.

To mitigate these shortcomings, the study employed a narrative case study design to provide in-depth insights into participants' experiences. Additionally, the researcher utilized three data collection instruments to enhance the credibility and trustworthiness of the study.

CHAPTER 4: FINDINGS

The chapter summarizes this study's results. The results are presented in a way that allows readers to see themselves in the presence of the participants as they narrate their stories. First, I draw on the findings of the quantitative data collected via a self-administered survey. This provides background information on the CCTS's abilities regarding technology use and integration. Next, I use a narrative style to present what the participants shared during interviews, allowing me to present their responses and the emerging themes and subthemes. Additionally, I present a cross-case analysis of the junior versus senior CCTS which gives an insight into how the CCTS feel prepared to use technology, differences in technology use and integration between the community college and the university, how their self-efficacy evolved and how they used technology in their field placements Lastly, I present an analysis of the lesson plans to determine whether they corroborate the earlier findings.

Research Questions

The following research questions guided this study:

1. How prepared do community college transfer students feel to use educational technology in their current mathematics education program?
2. How does the use of technology in mathematics differ between community colleges and the University, as experienced by CCTS?
3. How does self-efficacy for teaching with technology change for CCTS in their teacher preparation in the program?
4. How do CCTS use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?

Survey Results

The survey was carried out to obtain background information that would allow the researcher to understand the participants in relation to technology use and integration. The information also provided a foundation for this study by allowing a comparison between traditional and CCTS students to determine whether there is a difference in their knowledge of technology use and integration. To examine whether there are any significant differences, the researcher computed the mean scores for each survey item and bar plots to visualize the distribution of the students' responses. This analysis consisted of four CCTS and six traditional senior students.

The TPACK-M survey items are based on the TPACK domains Teacher Knowledge (TK), Teacher Pedagogical Knowledge (TPK), and Technology Pedagogical and Content Knowledge (TPACK). Each domain consists of 10 questions: 3-12, 13-22, and 23-32 for TK, TPK, and TPACK, respectively. More details are in the complete survey (see Appendix D). The seniors and junior students were surveyed. Each survey item was averaged to explore students' perceptions of their technology usage and integration.

To understand the survey data, the researcher analyzed it, obtaining descriptive statistics: mean, median, range, and standard deviation. The researcher compared the descriptive statistics of traditional and CCTS students and then compared junior and senior CCTS students. The analysis is presented based on the constructs TK, TPK, and TPACK as follows.

Technology Knowledge (TK)

The survey items in question 3 represent TK (see Appendix D) and are denoted as Q3-12. However, in this analysis, they are represented as Q3.1- Q3.10. Table 4.1 presents the mean scores of the CCTS and traditional students for each survey test item. The survey items are grouped into three domains: TK, TPK, and TPACK, each having 10 test items.

The survey items in question 3 represent TK; they are labeled Q3-Q12. In this analysis, as shown in Table 4.1, the test items are ordered from Q3.1 to Q3.10. The test items are: ability to create PowerPoint, make calculations on spreadsheets, create charts, locate and evaluate online/math software resources, know different technologies, use dynamic geometry software, use a graphic calculator, and create & edit simple images, for Q3.1 to Q3.10. The mean scores of the items are presented in Table 4.1 below.

Table 4.1

Averages of TK items in the TPACK Survey-M USA

Qn Id	Question item	CCTS AVG	Traditional AVG	SD Traditional	SD CCTS	Median Trad	Median Trad CCTS	Range Trad	Range Trad CCTS
Q3.1	Create a PowerPoint presentation.	5.0	5.0	0.00	0.00	5	5	0	0
Q3.2	Make calculations on a spreadsheet.	4.5	4.83	0.41	0.50	5	4.5	1	1
Q3.3	Create charts/graphs.	5.0	5.00	0.00	0.00	5	5	0	0
Q3.4	Locate and evaluate online resources and/or math software applications.	4.0	4.83	0.41	0.43	5	4	1	1
Q3.5	Use dynamic geometry software (e.g., GeoGebra, Geometer's Sketchpad).	4.0	4.50	1.22	0.43	5	4	3	1
Q3.6	Use a graphic calculator.	5.0	5.00	0.00	0.43	5	5	0	1
Q3.7	Create and edit simple images (e.g., Canva, Photoshop).	4.5	4.33	1.63	0.83	5	3.5	4	2

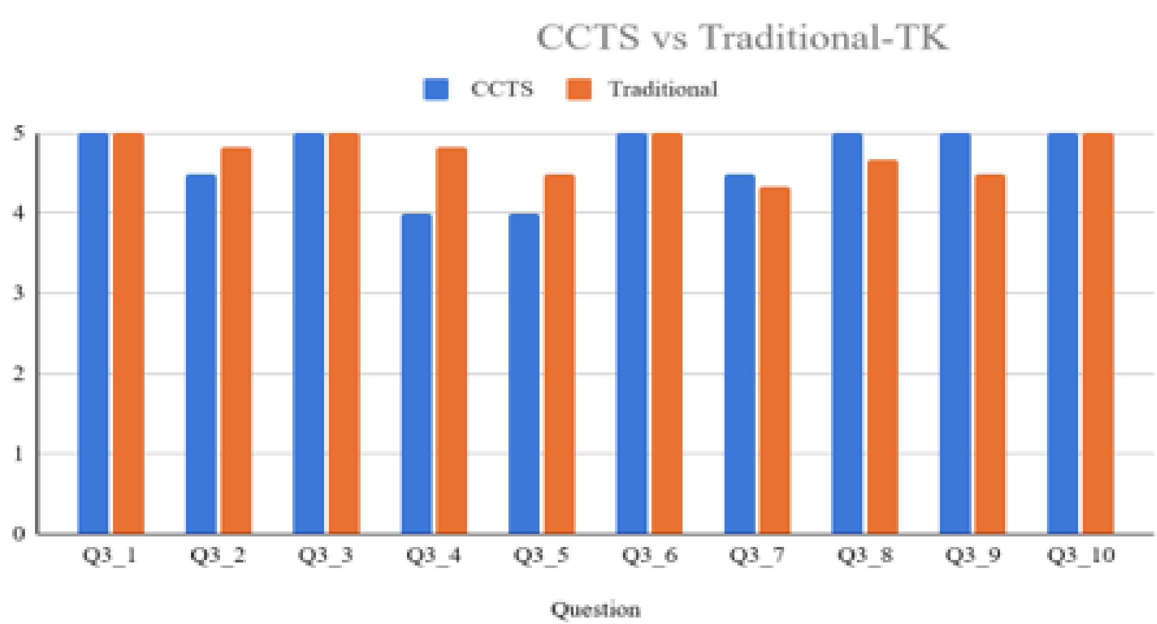
Table 4.1 continued

Q3.8	Network with other colleagues and professional associations using social media.	5.0	4.67	0.52	0.87	5	5	1	2
Q3.9	Select and use specific technologies suiting a particular teaching strategy or goal.	5.0	4.50	0.55	0.83	4.5	4.5	1	2
Q3.10	create and maintain a positive and safe online learning environment.	5.0	5.00	0.00	0.43	5	5	0	1

Comparatively, both groups of students scored an average of 5 on Q3.1, Q3.3, Q3.6, and Q3.10. The traditional students score higher on test items Q3.2, Q3.4, Q3.5, and Q3.9, with CCTSs scoring higher on Q3.7 and Q3.8. Overall, the traditional group scored 4.77, compared to 4.67 for the CCTs. These trends can be visualized in the column plot in Figure 4.1.

Figure 4.1

Averages of CCTS vs Traditional TK items



Technology Pedagogical Knowledge (TPK)

The survey items Q4.1 to Q4.10 in the analysis are represented in the survey (see appendix) as Q13-Q22. The test items are ability to: network with colleagues & professional associations, select and use particular technologies to meet a specific goal, create and maintain a positive and safe online learning environment, teach a concept with interactive whiteboard, mobile devices, manage students behavior when using technology, guide students in use ICTs/ conveyance technologies for learning diversity, provide students with alternative forms of assessment and develop students research skills. The descriptive statistics of these TPK items are presented in Table 4.2.

Table 4.2

Averages of TPK items in the TPACK Survey-M USA

Qn Id	Question Item	CCTS Ave	Traditional Aver	SD Trad	SD CCTS	Median CCTS	Median Trad	Range CCTS	Range Trad
Q4.1	Teach a concept using an interactive whiteboard.	5	4.83	0.41	0.00	5	5	0	1
Q4.2	Teach a section of the curriculum through the use of web resources.	4.5	4.33	0.52	0.50	4.5	4	1	1
Q4.3	Use mobile devices (e.g., iPad, smartphone) in teaching.	4.75	4.83	0.41	0.43	5	5	1	1
Q4.4	Engage students in collaborative learning through online platforms.	4.25	5.00	0.00	0.83	4.5	5	2	0
Q4.5	Create digital learning sequences with sound and video.	3.75	4.33	0.82	1.30	4	4.5	3	2

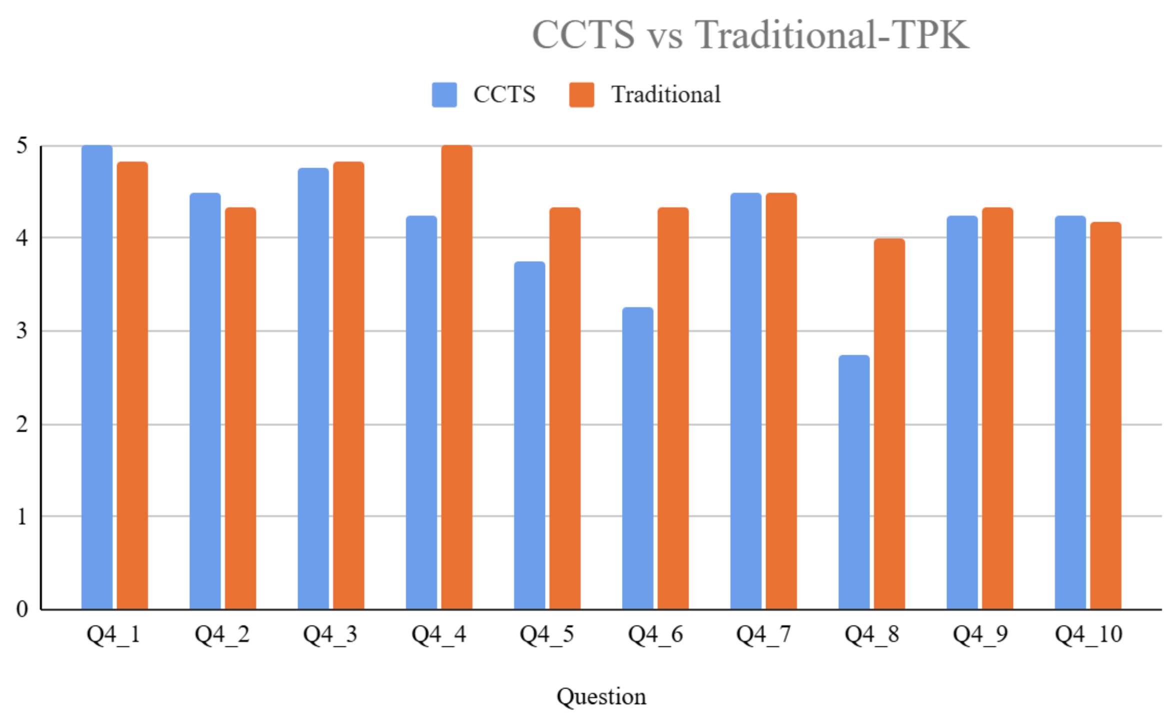
Table 4.2 Continued

Q4.6	Manage students' behavior effectively when using various technologies.	3.25	4.33	0.52	1.48	3.5	4	4	1
Q4.7	guide students in creating their own media presentations.	4.5	4.50	0.55	0.50	4.5	4.5	1	1
Q4.8	Use ICTs (information and communication technologies)/conveyance technologies to cater for diverse learning styles and ability levels.	2.75	4.00	0.63	1.09	3	4	3	2
Q4.9	Provide students with alternative forms of assessment.	4.25	4.33	0.52	1.30	5	4	3	1
Q4.10	Develop students' research skills.	4.25	4.17	0.41	0.83	4.5	4	2	1
Q4.9	Provide students with alternative forms of assessment.	4.25	4.33	0.52	1.30	5	4	3	1
Q4.10	Develop students' research skills.	4.25	4.17	0.41	0.83	4.5	4	2	1

In the survey, both student groups scored at least 80% on Q4.1, Q4.2, Q4.3, Q4.4, Q4.7, Q4.9, and Q4.10, indicating high preparedness and a strong foundation in technological pedagogy. The traditional students scored higher on Q4.3, Q4.8 and lower on Q4.1, Q4.2, Q4.5, Q4.6, Q4.7, Q4.9 and Q4.10. The CCTS scored 4.25, compared to 4.17 for the traditional group, resulting in a difference of 0.58. Overall, the traditional group averaged higher, which may be attributed to their long stay in the program, which allowed them more time to engage with different tools and content. These trends can be visualized in the column plot below.

Figure 4.2

Averages of CCTS vs Traditional TPK items



Technological pedagogical content knowledge (TPACK)

The survey items Q5.1 to Q5.10 in the analysis are represented in the survey as Q23 to Q32. The items from Q23-Q32 are the ability to adhere to copyright when using third party online resources, engage students critically analyze online texts & images, represent mathematical problems, foster higher order mathematical thinking skills, bridge the gap between in-school and out-of- student communication, integrate learning areas, deal with students mathematical miscalculations through simulations and support students mathematical investigations with digital tools respectively.

Table 4.3

Averages of TPACK items in the TPACK Survey-M USA

Qn Id	Question item	CCTS Aver	Trad Aver	Standard deviation Trad	Standard deviation CCTS	Medi an Trad	Media n CCTS	Range Trad	Range CCTS
Q5.1	Adhere to copyright while accessing third-party online resources.	4	4.5	0.75	0.71	4	4	2	2
Q5.2	Engage students in critically analyzing online texts or images.	4	5	0.55	1.22	4.5	4.5	1	3
Q5.3	Help students develop their problem-solving skills.	4	5	0.00	1.22	5	4.5	0	3
Q5.4	Represent mathematical problems where symbolic, numerical, and graphical data can be linked.	4.75	5	0.41	0.43	5	5	1	1
Q5.5	Foster higher-order mathematical thinking skills (e.g., proving, inferring, estimating, explaining, conjecturing, predicting).	4.5	5	0.52	0.87	5	5	1	2
Q5.6	Bridge the gap between in-school and out-of-school mathematics.	4.75	5	0.41	0.43	5	5	1	1

Table 4.3 Continued

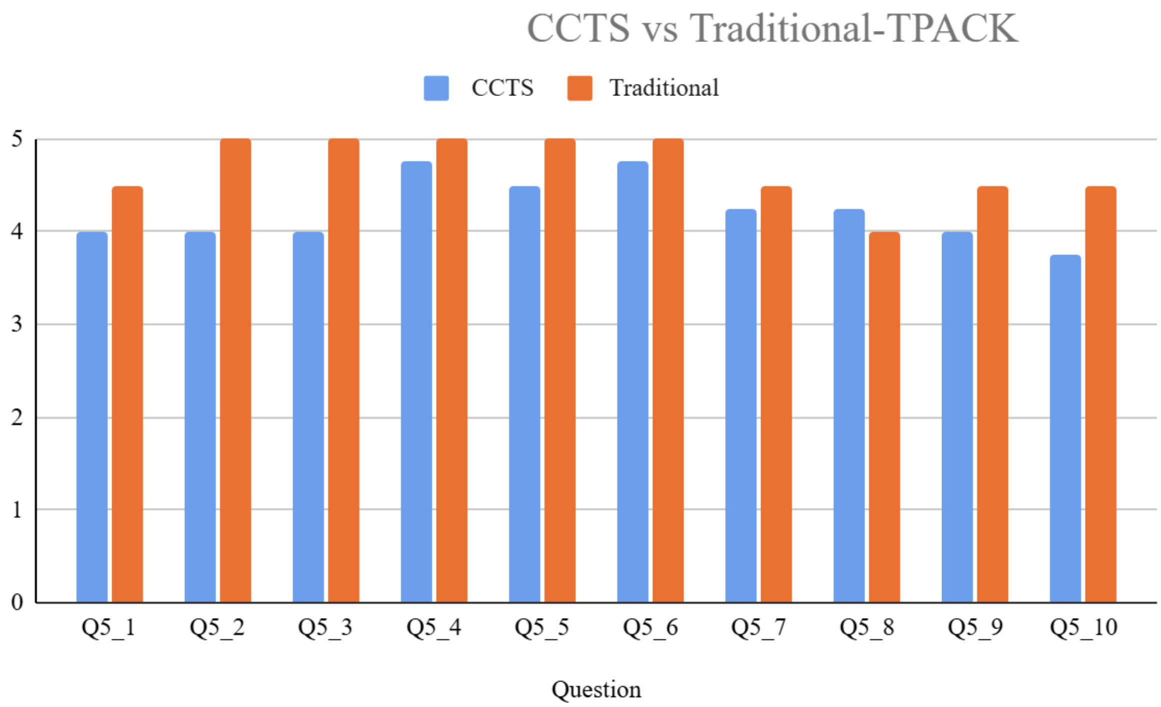
Averages of TPACK items in the TPACK Survey-M USA

Q5.7	Promote substantive student communication in the classroom (e.g., class discussion on multiple methods of solving a problem).	4.25	4.5	0.00	0.43	5	4	0	1
Q5.8	Integrate the study of mathematics with content from other key learning areas (e.g., English, Arts, Science, History).	4.25	4	1.03	0.83	5	4.5	2	2
Q5.9	Deal appropriately with students' mathematical misconceptions by simulating concrete situations.	4	4.5	0.55	0.71	4.5	4	1	2
Q5.10	30. Support students' mathematical investigations with digital collection tools.	3.75	4.5	0.41	1.09	5	4	1	3

The analysis in Table 4.3 reveals that the CCTSs scored lower averages on Q5.1, Q5.2, Q5.3, Q5.4, Q5.5, Q5.6, Q5.7, Q5.9, Q5.10, and higher on Q5.8 compared to the traditional group. However, both groups have medians of at least 4, indicating stability in their reported scores. These trends can be visualized in the column plot in Fig. 4.3 below.

Figure 4.3

Averages of CCTS vs Traditional TPK items



The researcher also analyzed the responses of the junior and senior CCTSs to allow a comparison of the descriptive statistics, as shown below.

Junior Versus Senior Community College Transfer Students Technological Knowledge Domain Items Analysis.

The descriptive statistics of the TK items of the junior and senior CCTS are presented in Table 4.4.

Table 4.4

Junior vs Senior Community College Transfer Students Technological Knowledge Items Analysis

Question	Q3.1	Q3.2	Q3.3	Q3.4	Q3.5	Q3.6	Q3.7	Q3.8	Q3.9	Q3.10
Junior CCTS Aver	5	4.5	5	4.25	3.75	4.75	3.75	4.5	4.25	4.75
Senior CCTS Aver	5	4.5	5	4	4	5	4.5	5	5	5
SD Senior CCTS	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
SD Junior CCTS	0.00	0.71	0.00	0.71	0.71	0.71	0.00	1.41	0.71	0.71
Median Senior CCTS	5	4.5	5	4	4	5	4.5	5	5	5
Median junior CCTS	5	4.5	5	4.5	3.5	4.5	3	4	3.5	4.5
Range Senior CCTS	0	1	0	0	0	0	1	0	0	0
Range Junior CCTS	0	1	0	1	1	1	0	2	1	1

Junior Versus Senior Community College Transfer Students -Technological Pedagogical Knowledge Domain Items Analysis.

The descriptive statistics of the TPK items of the junior and senior CCTS are presented in Table 4.5. The results show that both junior and senior CCTS students scored lowest on Q4.8 (Use ICTs/conveyance technologies to cater for diverse learning styles and ability levels). Junior CCTS students score very low medians on all TPK items except Q4.1, Q4.2, Q4.3, and Q4.7. This may be attributed to the courses they have covered. At this point in the program, they had yet to cover most of the mathematics methods courses.

Table 4.5

Junior vs Senior Community College Transfer Students Technological Knowledge Items Analysis

Question	Q4.1	Q4.2	Q4.3	Q4.4	Q4.5	Q4.6	Q4.7	Q4.8	Q4.9	Q4.10
Junior CCTS Aver	5	4.5	4.75	4.25	3.75	3.25	4.5	2.75	4.25	4.25
Senior CCTS Aver	5	5	4.5	5	5	4.5	5	3.5	5	5
SD Senior CCTS	0.0	0.0	0.7	0.0	0.0	0.7	0.0	0.7	0.0	0.0
SD Junior CCTS	0.00	0.00	0.00	0.71	0.71	1.41	0.00	1.41	2.12	0.71
Median Senior CCTS	5	5	4.5	5	5	4.5	5	3.5	5	5
Median junior CCTS	5	4	5	3.5	2.5	2	4	2	3.5	3.5
Range Junior CCTS	0	0	0	1	1	2	0	2	3	1
Range Senior CCTS	0	0	1	0	0	1	0	1	0	0

Junior Versus Senior Community College Transfer Students: Technological Pedagogical and Content Knowledge Items Descriptive Statistics.

The descriptive statistics of the TPACK items of the junior and senior CCTS are presented in Table 4.6. The junior CCTS students have lower averages for the TPACK construct items Q5.1, Q5.2, Q5.3, Q5.9, and Q5.10 compared to their senior counterparts. Their standard deviations also indicate the disparities between them, even though there are a few. This indicates the differences in their technology use, given that they all have varying community college backgrounds.

Table 4.6

Junior vs Senior Community College Transfer Students: Technological Pedagogical Content Knowledge Items Analysis

Question	**Q5.1**	**Q5.2**	**Q5.3**	**Q5.4**	**Q5.5**	**Q5.6**	**Q5.7**	**Q5.8**	**Q5.9**	**Q5.10**
Junior CCTS Avg	4	4	4	4.75	4.5	4.75	4.25	4.25	4	3.75
Senior CCTS Avg	4.5	5	5	5	5	5	4.5	4	4.5	4.5
SD Senior CCTS	0.7	0.0	0.0	0.0	0.0	0.0	0.7	1.4	0.7	0.7
SD Junior CCTS	0.7	1.41	1.41	0.71	1.41	0.71	0.00	0.71	0.71	1.41
Median Senior CCTS	4.5	5	5	5	5	5	4.5	4	4.5	4.5
Median junior CCTS	3.5	3	3	4.5	4	4.5	4	4.5	3.5	3
Range Senior CCTS	1	0	0	0	0	0	1	2	1	1
Range Junior CCTS	1	2	2	1	2	1	0	1	1	2
Range Junior CCTS	1	2	2	1	2	1	0	1	1	2

Note: Avg-average; SD-Standard deviation

Analysis by Research question

The researcher explored the analysis by research question to establish how the data collected answered each research question.

Research Question One

How prepared do community college transfer students feel to use educational technology in their current mathematics education program?

This research question was answered by the items Q3.1 to Q3.10 and Q4.1. The question assessed students' general ability and perceived preparedness to use various basic technologies. There is an indication of high preparedness for tasks like Q3.1 (create PowerPoint presentation), Q3.3 (create charts/graphs). The median is 5 across all groups, with a range of 0. This trend implies that there is strong agreement and no variability between the two groups. Similarly, Q3.6 (use a graphic calculator) and Q3.10 (create a safe online learning environment) have a median score of 5 and a standard deviation of 0.

However, there is a minor variability in some skills. The item Q3.5 (use dynamic software) exhibits slight variability in the median: whole group (4.5), Traditional (4.5), CCTS (4), and Junior (3.5). Junior CCTS has the lowest median, suggesting less confidence. The item Q3.7 also shows some differences: whole group (5), Traditional (4.33), CCTS (3.75), Senior CCTS (4.5), and Junior (3). The junior CCTS group reports the lowest median (3) with a range of 0. This trend indicates lower self-efficacy in this area. Additionally, for item Q3.4 (locate and evaluate online resources and/or math software applications), CCTS and senior CCTS have a median of 4 and 4.25 for junior CCTS, which are lower than the whole group (5) and the traditional group (4.83). Across all test items, the standard deviation generally ranged from 0 to 0.71 for Q3.1 to Q3.3 across groups, highlighting little dispersion with a high median. Question items like Q3.5 (use dynamic software) have a high standard deviation, indicating differences in perceived skill.

Students across all groups demonstrate a high perceived ease of use (PEOU), which is foundational for TK skills involving commonly used technologies, such as spreadsheets, PowerPoint, and graphic calculators. The high perceived ease of use leads to the general acceptance of these tools. However, PEOU decreases for software such as dynamic geometry, image editing, and professional social media networking among junior CCTSs. Consequently, lower PEOU will act as an acceptance barrier, making it difficult for the students to apply these TK applications.

In summary, CCTS students generally feel confident in using basic educational technology but show lower self-efficacy in more advanced especially during their junior year, compared to traditional students and senior CCTS students in the program. This suggests a need for targeted support in certain areas as they transition into and through their teacher preparation program.

Research Question Two

How does the use of technology in mathematics differ between community colleges and the University, as experienced by CCTS?

None of the survey test items answered RQ2. The only information related to the community college is demographic. Therefore, the descriptive statistics do not address RQ2 pertaining to the use of technology in mathematics to compare the community colleges and the university.

Research Question Three

How does self-efficacy for teaching with technology change for CCTS in their teacher preparation in the program?

To answer this research question, the researcher examined how the self-efficacy of CCTS students in using technology in pedagogical and content-specific teaching contexts evolves over the course of their program preparation.

The findings show that for Q.3.9 (teach and select a specific technology), junior CCTS report a lowest median 3.5, with a standard deviation of 0.71, implying that they perceive less usefulness in aligning technology with pedagogical objective Senior CCTS on the other hand demonstrate a high confidence reporting a median of 5 and standard deviation of 0 in selecting technologies for teaching goals. This demonstrates a positive change in self-efficacy (PEOU & PU for CCTS students as they progress in the program. Similarly, Q3.10 (create a positive online learning environment) has a median of 4.5 and 5 for all groups, while Junior CCTS students have a median of 4.5, indicating a high PEOU and PU. This trend indicates low self-efficacy upon entry, then improves, reflecting growth by their senior year.

Regarding Q4.1 (teach a concept using an interactive whiteboard), all groups report a median of 5 and low standard deviations, indicating very high PEOU and PU, which implies high acceptance across groups. On the other hand, Q4.2 (use tech to teach a curriculum section using web resources), senior CCTS students scored a median of 5 and a standard deviation of 0, indicating improved self-efficacy (PEOU and PU) compared to junior CCTS students, who reported a median of 4, showing a positive change in TPK confidence. Also, the Q4.3 (use mobile devices in teaching) report a median of 4.5-5 and low standard deviations signifying high PEOU and PU. Also, for Q4.4 (online collaborative learning), senior CCTS and traditional students scored a median of 5 and an SD of 0, implying a high PEOU and PU, showing a high acceptance of online collaborative learning. In contrast, the junior CCTS students scored 3.5 and an SD of 0.71, signifying weak PEOU and PU.

A change in TPK occurs in Q4.5 (Use technology to create digital learning sequences with sound and video), where junior CCTS students scored a very low median of 2.5 with a SD of 0.71, implying limited initial PEOU and PU, hence low acceptance. Senior CCTS students reported a median of 5 and an SD of 0, signifying a high self-efficacy and PEOU and PU. The traditional students, on the other hand, report moderate acceptance, but with higher standard deviations, showing varied individual experiences. For Q4.7 (use technology to guide students in creating their own media presentations), junior CCTS students score a median of 2 and an SD of 0. In contrast, the seniors score a median of 5 and an SD of 0. Similarly, Q4.8 (use technology to cater for diverse learning styles and ability levels), the junior CCTS students reported a median of 2 and an SD of 1.41, showing low initial PEOU and PU. The other student groups score medians of 3.0 to 4.0 and higher standard deviations of 1.08 to 1.41, with senior CCTS students scoring a median of 3.5.

In summary, the findings highlight a consistent pattern of growth in self-efficacy for CCTS students as they progress through their teacher preparation program. Initially, their confidence in using technology is low, particularly for more complex tasks. However, by their senior year, they demonstrate significantly higher confidence, reflecting enhanced pedagogical and technological integration skills. This progression highlights the program's effectiveness in developing technological self-efficacy and preparing future teachers for technology-rich classrooms.

Research question Four

How do CCTS use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?

This research question shifts the focus to the practical application of technology in real-world teaching settings during field placements. The self-efficacy statements are interpreted as perceived ease of use (PEOU) and perceived usefulness (PU). The PEOU and PU reflect the preparedness and the likelihood of these students' using technology. However, the interpretation of the survey test items Q3.9 to Q.5.10 explores readiness for practical classroom application within the context of TPACK.

The findings indicate that for Q5.1(use tech to adhere to copyright while using third party online resources), the juniors reported the lowest median (3.5) while the Senior CCTSs and traditional students reported a median of 4 - 4.5 suggesting less preparedness(low PEOU and PU) to navigate using these resources thus affecting students' resource allocation and decisions related to TPACK. In item Q5.2 (use technology to engage students critically analyzing online texts and images), the juniors scored a median of 3 lower than senior CCTS's median of 5 and a median of 0, indicating a lower PEOU and PU for junior CCTS students. The same trend is replicated in Q5.4 (use technology to help students develop problem-solving skills). The findings reveal that junior students reported a median of 3, compared to 5 for the senior CCTS students. In contrast, all groups report a median of 4.5 and 5, indicating higher preparedness, hence readiness for this content integration.

For Q5.5 (foster high-order math thinking skills), the junior CCTS students scored a median of 4 and SD of 1.41, suggesting varied preparedness compared to senior CCTS, who reported a median of 5. There is a shift in the scores for Q5.6 (use technology to bridge the gap between in-school and out-of-school math), where all groups reported a median of 4.5 and 5, implying that they feel highly capable, showing low PEOU and PU. Regarding Q5.8 (use technology to integrate study of math with content from other learning areas), the junior CCTS students reported a median of 4.5, which was relatively high compared to other groups, suggesting moderate PEOU and PU. Finally, in Q5.9 and Q5.10 items, the junior CCTS students reported a median of 3.5 and 3, suggesting low preparedness. This trend contrasts with the senior and traditional students, who had medians of 4.5 and 5, highlighting higher self-efficacy.

In summary, the findings show that junior CCTSs consistently demonstrate lower preparedness for the pedagogical and content-specific applications (TPK and TPACK) due to low PU or PEOU. This trend suggests that they may be reluctant to integrate these technologies, which in turn may limit their pedagogical approaches. Low preparedness is witnessed in creating multimedia content, managing student-mediated student behavior using technology for higher-order thinking skills, and guiding students in media projects. In contrast, senior CCTSs reported high scores, implying higher PEOU and PU; thus, they are more ready and likely to integrate technology into their classes. This trend is replicated by traditional students, who also demonstrate high preparedness across most of the TPK and TPACK survey items. These findings suggest that for successful technology integration in field placements, attention should be given to enhancing PEOU and demonstrating PU of junior CCTSs to boost their confidence and readiness.

To affirm these findings, the researcher explored the study more deeply by analyzing the qualitative data collected via interviews. The next section explores a qualitative inquiry analysis to investigate the experiences of the CCTSs through interviews. The researcher presents the narrative of each participant to help readers understand the participants.

Participant Narratives

This section incorporates qualitative responses from participants who were purposefully selected to participate in the study. The participants' narratives are presented in this section to preserve the integrity of their lived experiences, ensuring that the reader can see the emotion and nuance of the participants' experiences and the story as it was lived and told by them (Elliot & Bonsall, 2018). Additionally, presenting the participants' narratives honors participants as co-constructors of meaning-making (Clandinin, 2022). The co-construction between the researcher and participant demonstrates trust and prevents their voices from being overpowered by the researcher's interpretation.

Incorporation of the qualitative research design aimed at exploring the experiences of four community college transfer students (CCTSs): Kendall, Angelina, Matthew, and Vanessa, who transitioned from community colleges to a teacher-preparation program at Wonderful University. Each participant's narrative shed light on how they navigated the contrasting technology landscapes of their community colleges and the university while completing coursework and field placements in mathematics education. The study addressed four research questions about teacher preparation, institutional differences, self-efficacy, and classroom practice in relation to educational technology. To ensure anonymity, each participant was assigned a pseudonym, and their descriptions were based on the data collected during the interviews. Below is a full description of the four participants. *Table 4.7* gives an overview of the narrative participants.

Table 4.7

Overview of CCTS's Demographics

Pseudonymn	Sex	Community College	Years at Community College	Community College Course	MTPP Enrolled
Kendall	Female	South City CC	3	Engineering, Arts, Science & General Education	Middle grades math
Andrea	Female	Wantam	2	Science	Middle grades math
Mathew	Male	Renton CC	2	Science	Middle grades math
Venessa	Female	Wantam CC	2	Science	Middle grades math

Kendall's Story

Kendall was enrolled at South City Community College for three years. During high school, she was in the dual enrollment program. While at the Community college, Kendall also enrolled in some classes at the four-year institution through the Community College Co-operation (C3). During this period, she had access to some digital resources at the University via the Computer Virtual Lab (CVL). She said,

> I think mainly the things that I learned technology-wise might have been like through Maple as a student from South City. We were able to have access to Wonderful University's virtual computing lab. And in my calc 3 class, we were able to actually download that to our computer instead of having to use the VCL to get logged into here, which I appreciate very much. And we just also used very basic programs like Desmos. And just the I think the calculator itself. No, we didn't really go over that many different forms. I guess at the Community college.

However, while at the community college, Kendall only had access to Blackboard, which was used for coursework access. In the mathematics classes, all problems were done by hand with pen and paper. The technology available to them within the college was for conveyance purposes only. The students used technology to communicate with their instructors or their colleagues. Additionally, instructors used technology to display the learning content so that students could follow along with what the instructors were teaching.

Kendall graduated with four associate degrees: engineering, science, arts, and general education from the community college. The four associate's degrees accumulated 100 credit hours. After graduation, she transferred to the University and enrolled in the middle grades math education program. Her use of technology had not changed significantly. However, she knew other technological tools, such as Kahoot and Quizziz, which she hoped to learn how to use. She notes that one of her aha moments was learning how to use Maple, which was a completely new technology to her.

Comparing her experiences in the two institutions, she said that at the community college, she utilized Microsoft products greatly. However, at the university, she was introduced to Google products, which were initially a challenge to her. Additionally, whereas she used Blackboard at the community college, at the university, she was introduced to Moodle. She had difficulty adapting because at the community college, the apps for all the different events were hosted on one site. In contrast, at the university, each of them is hosted on a different site. In the courses she has taken so far, she has not used technology directly. She had many credit hours from the community college, so she was taking more Education courses.

In summary, Kendall studied at South City Community College for 3 years, beginning through dual enrollment. While attending community college, she took courses at a four-year university through the Community College Cooperation program, which gave her access to technology via the Virtual Computer Lab (CVL). She used technology tools such as Maple, Desmos, and a calculator. Her engagement with technology was for convenience purposes only-communication, accessing coursework through Blackboard, and viewing instructor-presented materials. Kendall earned four associate degrees, totaling 100 hours, before enrolling in the Middle Grades Mathematics program. At the university, Kendall experienced a shift from MS Office-based tools to Google applications. Additionally, she transitioned from using Blackboard to Moodle, finding it hectic since the resources were scattered across multiple platforms. Due to her numerous community college credits, she concentrated on mathematics education courses; therefore, she has not utilized math action tools.

Angelina's Story

Angelina is a senior CCTS enrolled in the middle grades math education program. She studied at Wantam Community College for two years, where she earned an associate's degree in science. She took courses in communications, history, biology, world religion, and Spanish language. To hasten her graduation, she took the Spanish CLEP test. Although education courses were offered at the Community college, she did not take any.

During her studies at Wantam CC, she only utilized conveyance technologies: WebAssign and Blackboard for assignment submission. Additionally, these LMS platforms also provided feedback on submitted assignments. However, taking education methods courses at Wonderful University made her more confident in using technology and gave her the knowledge of when and why to use it. She said,

> In how to use, so I know that I can't just use technology just to use technology, like I can't just use the Desmos. Just to say I'm gonna use Desmos in my classroom, like the purpose of Desmos, needs to know, you know, make learning easier or more efficient or meaningful. Take the string off something. So, we can focus on another area. But not just for just using technology in the classroom? But I learned at Wonderful University the ways in where I can use technology like that, you know, to focus on the learning objective.

Angelina had acquired knowledge not only about different technologies but also about using technology in the classroom objectively.

However, the greatest challenge arose from the fact that she was a non-traditional student. Being required to do assignments using digital technology tools, which she was not up to date with, forced Angelina to learn how to use them. Although she said that they were introduced to the tools in the classroom due to her large class workload, there was no time for anyone with expertise to help her familiarize herself with the new technologies. To address this challenge, she conducted a personal exploration of the new technologies, as she affirmed,

> Yeah, I mean what? YouTube videos, whenever I got stuck on something or I forgot how to do something. I would. Just, you know. Okay, how to do this on Desmos, how to do this on the algebra, and yeah, that's pretty much what I did. Or I would ask follow-up questions. My classmates like, Oh, how do you do this? Using this tool? Since some of my classmates were, you know, just graduating from high school and using these tools. They were a good resource.

The need to learn about new technologies, especially after sharing a space with classmates she considered more tech savvy than her, she employed several strategies to acquaint herself with new technology tools. She consulted her instructors, asked her classmates, or engaged in personal exploration.

While on her teaching placement, she initially faced a challenge in integrating technology. She cited Classroom management as a major problem because “She couldn’t see what the students were individually doing.” Conversely, she was thinking about using technology to teach statistics and Algebra. Interestingly, despite the earlier challenges cited, she mentioned that she was considering using technology in the future. For example, she plans to use CODAP to teach statistics. Additionally, she confirmed using smartboards, document cameras, Google Slides, and projectors. She also noted that her students used IXL to complete assignments, not only allowing them to do the work but also providing adaptable feedback. Thus, it helped the teacher to not only reduce the individual required time but also gave more opportunities for individual follow-up. Discussing her plan to utilize technology, she reflects on her students' learning:

> Yeah, we just entered right now, and we're learning about scatter plots. The line of best fit positive or negative association. I've unfortunately only used CODAP. For you know, a little more advanced skills. You know, more college, high school level. So I need to go back, you know, and see. What can I, how can I, use that tool? Maybe. For this section, or maybe another tool? Maybe you know. I could use Desmos because we had to draw the line of best fit. And you know, one of the most difficult parts that I'm noticing right now is that you know a lot of my students' lines, you know, they're going the right way. They're just, you know. So, they're not straight. So, I'm thinking of a tool like Desmos, you know, Desmos. If they start at a point and then drive to the other point. You know, decimals are going to make sure that line is straight, you know, so they're not. I'm not. They're not going to be focused to focus on drawing a straight line. There'll be more focus on, you know. Is it the best line? If it will, you know. Yeah. So, I might use it for that later on.

Angelina weighed in on using technology in her placement class. She initially had classroom management challenges, although she had some skills with specific technology tools, she was willing to use. Later on, she learned the ropes from her cooperating teacher and finally overcame her fears, managing to integrate technology in her classroom.

In summary, Angelina, a senior community college transfer (CCTS) in the middle grades math education program. She studied at Wantam Community College, earning an associate degree in science. While at Wantam Community College, she used conveyance technologies such as WebAssign and Blackboard for assignment submission and receiving feedback. Her transition to Wonderful University marked a turning point, as taking math education courses helped her understand the purposeful and pedagogical use of technology rather than using it as an add-on. During her teaching placement, she faced classroom management challenges in monitoring students while using technology, but she built confidence gradually after learning from her cooperating teacher how to use technology. She uses Desmos, Google Slides, document cameras, and projectors, and plans to use CoDap in the future.

Mathew's Story

Mathew is currently a junior. Mathew was enrolled at Renton Community College for two years. He is currently enrolled in the middle grades math program. When he got admitted to Wonderful University, he initially enrolled in the high school math program before switching to the middle grades math program. In high school, he utilized Microsoft Word, Microsoft Excel, Google Docs, Desmos, and Google Classroom. Interestingly, he took a research class where he learned about photography and how to use Spreadsheets. While at the community College, he did not take many mathematics courses.

Matthew said that in most of the classes he took at Wonderful University, students were not allowed to use graphing calculators; rather, they were required to use pen and paper. He felt that since enrolling in the middle grades math program, his knowledge of technology use had grown. Mathew's perception of technology was transformed as he spoke below,

> Yeah, so it's definitely grown. Quite a bit, I would say. Just from like some of the placements I've been in for like ED 204 and EMS 204, it has definitely broadened my horizons. I would say just by being in those placements seeing how iPads and laptops are used, and from what I've seen, almost every classroom, and how I it, I guess I didn't realize how much it has changed since I had been in high school. And so just now, knowing that. Those things are more prominent and used on the daily in the classroom, has, changed my point of view of how much technology has actually is how much technology is actually used in the classroom.

His experiences in education and math methods courses, where technology was integrated, brought him into contact with different technologies, changing his perspective.

He was grateful to the Teaching Fellowship Program, which provided him with his first tablet. Mathew was excited that he was able to take his notes and do his scratch work on the tablet just like he would do on paper. He further noted that the tablet had an option for him to save his written work in soft copy form. In the two classes, Calculus 1 and Statistics, he had utilized Desmos and StatCrunch, respectively. He enjoyed graphing and creating visuals in statistics, as well as working with various data sets.

When comparing Renton Community College and University experiences, he noted that he did not utilize much technology in the community college, except for assignments, which were completed on Blackboard. However, at Wonderful University, he had done assignments on Moodle, which was very different from Blackboard. Students were also encouraged to take notes on their iPads or laptops, which he considered a big jump.

At the university, Mathew initially struggled to relate the information presented via technology. He said that "in the beginning it was kind of a struggle for me personally to transfer the information from the screen to the brain". However, after learning how to use technology tools like the tablet, it was easy for him to understand. He felt that he was at a point where he was confident in using technology within the classroom. Additionally, he faced challenges using online learning resources, such as textbooks. To address this challenge, he utilized text-to-speech software to access online textbooks. To utilize other technologies in the classroom, he explored various strategies. For instance, for StatCrunch, he read and used the instruction guide given in class by the course instructor. Additionally, he conducted a personal exploration to learn more about the required technologies.

Reflecting on technology use, Mathew notes that digital technology tools complement pen and paper. He cited a case where he used Desmos to solve a function but found the wrong solution. He resorted to using pen and paper and got the correct answer. He later returned to Desmos to troubleshoot and discovered that Desmos was truncating the values, resulting in a different solution.

In summary, Mathew, a junior in the middle grades math education program, spent two years at Renton Community College before transferring to Wonderful University. He initially enrolled in the high school math education program before switching to the middle grades math education program. In high school, he used MS Word and Excel, Google Docs, Desmos, and Google Classroom. At Renton Community College, he took a research class that introduced him to photography and utilized Google Sheets. He took a few math classes and utilized the Blackboard for assignment submission. Upon joining Wonderful University, his exposure to mathematics and math education courses expanded his view of technology use in the classroom. Although he initially struggled to process digital information, he adapted through the use of text-to-speech software. The Teaching Fellowship program gave him his first laptop, which he used for notetaking, scratch work, besides engaging with tools like StatCrunch and Desmos. Mathew learned to balance traditional and digital problem-solving methods by recognizing that the traditional method remains essential. Over time, he developed confidence in integrating technology and felt prepared to continue learning and experimenting with new tools.

Mathew believed that he had grown significantly in his use of technology, having not only learned more about the technologies he was familiar with but also about new ones. He felt more confident in his ability to use these technologies in the classroom in the future. He also noted that with ever-changing technology, he felt confident that he could easily learn about new technologies and experiment with using them in the classroom.

Vanessa's Story

Vanessa is currently a senior. Vanessa enrolled at Wantam Community College for two years, where she earned her associate's degree in science. After graduation, Vanessa transferred to Wonderful University, where she is currently a senior in the middle grades math education program. At the advice of her community college advisor, she enrolled in several mathematics classes because they were more affordable than those offered at the university.

While enrolled at the community college, Vanessa said that she did not utilize technology extensively, except for one instance in Calculus 2, where she used Desmos to explore the shapes of ellipses. Discussing her experiences at the two educational institutions, she mentioned that she utilized a graphing calculator for computations in both statistics and Calculus 2 at the university. She also used GeoGebra in her geometry class and StatCrunch in Statistics. However, she intimated that when she enrolled in the middle grades math program, she was discouraged by the availability of technology and by using it. Her situation was more aggravated by the presence of classmates who were younger and probably more tech-savvy.

> When I first enrolled in the program, I honestly like was a little intimidated by the technology aspect, because I didn't know. I didn't know much about it, and I knew, like, being older, you know. I knew that going in probably a decade older than these kids. They were probably gonna, you know, be quicker than I would. But like I stated, you know. And then you know, the education courses, especially with Dr. Maryam, is probably like the most that I've actually learned about the technology, the software. Because, you know, I saw this, the Desmos side, the student side, but I never actually got to see the teacher side. So that was really nice to figure out how like that looks and how you can control in the classroom. And so definitely, night and day difference like I said, I had no idea about the technology. And then, you know, I'm able to incorporate the tech in the my placement lessons, like my kids had never done Desmos. They'd never even heard of Desmos. So it was cool to like, say, Hey, okay, well, this is Desmos. I told them a little bit about it. And they said, they have a really cool, online free calculator that you can use. And they have all these cool lessons that are involved. And so we were doing like coordinates on the coordinate plane, and they really enjoyed it because it was something different. It wasn't just out of the workbook.

She added that using Desmos as both a student and a teacher enabled her to understand it even more. She shared how the students at her placement school enjoyed learning about coordinate planes in Desmos. In addition to Desmos, she was familiar with technology tools such as Kahoot, Quizziz, IXL, and Delta Math. She felt that she needed more practice with CODAP to use it in the classroom.

Vanessa considered herself a visual learner, so exploring different shapes in GeoGebra allowed her to visualize the various properties and understand the concepts more deeply. She added that experiencing these technology tools from the teacher's side allowed her to see what students were doing, which provided instant feedback to the teacher regarding students' learning and engagement in the classroom.

Given that most of the technology tools were new to Venessa, whenever she encountered a challenge, she approached her friends for help. Furthermore, in the same circumstances in class, she sought help from the instructor to address any challenges. She considered the final Project in EMS 480 “ mind-blowing”. She said that in the project she learned about many new technologies more deeply because the project entailed different features about the digital tools, for example, associated state standards, availability, user friendliness, student capacity, examples of where to use it, type of technology, website links, and associated resources on how to use the technology. During her placement, she utilized her website to introduce new technologies to other teachers and assist those with whom she was well-versed.

Reflecting on her experiences from pre-admission to teaching placement, Venessa said that her confidence in using technology had increased. She affirmed that her confidence improved over time through practice using technology in the classroom. During her teaching placement, she adopted the rule of thumb from her cooperating teacher that “If you use technology three times, you become good at it”. Looking back at her classroom practices, she appreciated her cooperating teacher for supporting her in using technology and her university supervisor for advising her on classroom management practices.

In summary, Venessa, a senior in the middle grades math education program at Wonderful University, spent two years at Wantam Community College, where she earned an associate degree in science before transferring. On her advisor's recommendation, she took several math courses to reduce the cost of attending university. At the community college, she used little technology; she only used Desmos once in calculus 2 to explore ellipses. At the university, she used Desmos, GeoGebra, StatCrunch, Kahoot, Quizziz, Delt math, and IXL. Initially, she felt intimidated by her age compared to her younger course mates. Through education courses, particularly with Dr. Maryam, she gained confidence and learned to use technology purposefully. As a visual learner, she found GeoGebra helpful during her exposure to digital tools in the EMS 480 final project. She deepened her understanding of the tools. Vanessa credited mentorship, practice, and classroom experience for transforming her into a confident teacher who effectively integrated technology into her instruction.

The participant narratives above, a summary of each participant's story, provide a basis for the analysis. Each participant's transcript was analyzed and coded for emerging common themes and is presented below.

Coding and Thematic Analysis

This process followed the analysis of the TPACK -M USA survey. The results of the survey indicated that the junior CCTS students got into the program with limited exposure to technology and low confidence in technology integration. However, with time, as shown from the results of the senior CCTS who have been in the teacher preparation program longer, improved in developing technology use skills and built their confidence in technology integration. Analyzing the qualitative data collected via interviews with the participants provides an opportunity to look at the first-hand information collected from the participants, which is rich and can also help to understand the survey results.

To understand the data collected from the participants more deeply, the researcher conducted three rounds of coding. Initially, the researcher conducted two rounds of memoing the transcripts to identify emerging patterns and themes related to the core phenomenon of the study. The transcripts were then uploaded into the Delve software for coding. In the initial round, 189 codes were generated by a priori and in vivo coding. During the second round, similar or closely related initial codes were merged and grouped based on the research questions they answered. The researcher created themes and subthemes via axial coding based on codes that were indicative of the core phenomenon (Creswell, 2013) in the findings based on their salience within the participant narratives. The axial codes served as the sub-themes for the study's findings. Nine themes and sixteen sub-themes were generated as shown in *Table 4.8*. An exploration of each theme and related sub-themes follows.

Table 4.8

Themes and Subthemes

RQ1: **How prepared do community college transfer students feel to use educational technology in their current mathematics education program?**	
Themes	**Subthemes**
Competence and confidence building	a. Confidence in using technology b. Ease of learning new technology
Instructional support	
Transition challenges and learning curve	a. Transition challenges b. Learning curve

Table 4.8 Continued

Themes and Subthemes

RQ2: **How does the use of technology in mathematics differ between community colleges and the University, as experienced by CCTS?**	
Themes	**Subthemes**
Institutional differences	a. Institutional differences in technology use
Technology access and exposure	a. Prior exposure to technology
	b. Access to technology
Cultural shift	a. Motivation to use technology
	b. Emotional responses towards technology use

RQ3: **How does self-efficacy for teaching with technology change for CCTS in their teacher preparation in the program?**	
Themes	**Subthemes**
Growth in self-efficacy	a. Confidence in technology use
	b. Support math learning with technology
Experiential learning	a. Independent learning strategies
	b. Peer support
	c. Instructor support

Table 4.8 Continued

Themes and Subthemes

RQ4: How do CCTS use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?	
Themes	**Subthemes**
Teaching placement experience	a. Field placement technology integration
	b. Perceived relevance of technology

Research Question One

How prepared do community college transfer students feel to use educational technology in their current mathematics education program?

In this section, the researcher focused on understanding the perceptions of CCTSs regarding technology use preparation during the teacher preparation program. Exploring these perceptions will highlight the ways the students engaged with technology to make them feel confident in using technology tools in their classes.

Competence and confidence building

The first theme focuses on building participants' competence and confidence in preparing to use technology during their training. Initially, the participants' comfort with technology varied. Whereas some participants reported confidence from the start of the program, others had difficulties and grew in confidence over time. According to all four participants, they had little experience with technology when they enrolled in the mathematics education teacher preparation program. From their stories, one had a high school experience with basic software like Microsoft Office and the Desmos graphing calculator. All participants had encountered learning platforms such as Blackboard and Canvas at the community college. However, one of the participants benefited from the Community College-University partnerships, which enabled her to access the virtual lab digital resources. Therefore, integrating mathematics technology tools into learning was new to three of them because their community colleges did not use them in their mathematics education.

Confidence in using technology.

This subtheme focuses on how the students felt about using technology during their training. Although their experiences differ, they generally had difficulty learning to use the technology they encountered in university for the first time or had not engaged with for a very long time. According to Angelina, the need to engage with different technological tools prompted her to learn about them, as she said,

> The program forced me to use the tool as a student and get comfortable with it as a student, you know, before I ask my students to do the same (Angelina, interview)

Vannessa, on the other hand, felt somewhat intimidated by the technology and the fact that most of the students in the class were younger. She considered them more tech-savvy than her, as Venessa narrated.

> I honestly like was a little intimidated by the technology aspect, because I didn't know. I didn't know much about it, and I knew, like being older, you know. I knew that going in probably a decade older than these kids. They were probably gonna, you know, quicker than I would. But like I started, you know (Vanessa, interview).

Half of the participants started the program with less confidence in their technology use and experienced growth after completing it. The lack of knowledge about some of the new tools made the participants uncomfortable about using them. Whereas the participants initially had varied levels of comfort with technology, their responses indicated that they felt less confident at the start. However, after engaging with the new tools, the CCTSs gained competence with time and were able to use the tools.

Ease of learning new technology.

This subtheme reports on how easy or difficult it was for CCTS students to learn new technology. The students' experiences varied, with a general struggle at the beginning but gradual improvement over time. For example, Angelina found it difficult to use GeoGebra because it was entirely new to her. She attests that, to use it, she had to become familiar with the tool's features. Additionally, she recognizes the importance of the tools, noting that she did not view them merely as used for the sake of it, but rather for serving a specific purpose. Angelina said,

> Yes, GeoGebra, which I had not used before. It was very, I would say, very hard for me to learn. I think out of all the ones I've used, it's not just knowing how to use all those features that come with it, you know. But I did learn how it makes it easier to use for transformations in geometrical figures, and basically, you know how efficient it is. It saves us a lot more time than if we were using a projector and you know, regular tools (Angelina, interview).

Vanessa, on the other hand, was familiar with GeoGebra and felt good about using it. She attributed it to the fact that she had used it intensively in her geometry class. This supports the notion that the more one uses technology tools, the more accustomed they become to them. However, Vanessa noted that her use of CODAP was limited and that she needed more practice. She shared;

> I think I would be able to launch a lesson. I just think I would need some more practice with CODAP, GeoGebra, as I worked a lot with them in my geometry course. And so that was cool. I feel good about GeoGebra. And so yeah, I would say, all of them I feel really good on, except the CODAP. I could probably use some more practice with that (Vennessa, interview).

Vanessa's experience with these tools suggests she found them easy to learn and use. Since she says she felt "good," this indicates that she was comfortable with little to no struggle during the learning.

The statements made by the students reflect their diverse starting points, the challenges they experienced, and their eventual adaptation to university-level technological expectations.

Instructional support

This second theme focused on any support the students received or were provided with in learning how to use new technology tools, thereby preparing them for effective technology use. While the participants were learning how to integrate technology into various mathematical concepts, they either received help from others or took personal initiative to learn how to use the new technology tools.

Students employed personal strategies to cope with learning new technology tools. Angelina, who considered herself a mature entrant into the program, utilized outside resources to learn how to use new technology. Among the strategies she employed was the use of YouTube videos to learn about new technology or when she could not recall a previously taught concept. Similarly, Mathew was new to virtual textbooks and struggled to process the information. He resorted to seeking software that could help him read the materials in the textbooks. He says

> I downloaded a kind of text-to-speech software. And I used that to listen to the textbook or whatever it was, I needed to read just because, since it wasn't that physical copy, it was basically like someone telling me the information. And so that was one sort of workaround that I found that really helped me out with catching up and just making sure I got the proper information (Mathew, interview).

These examples display the individual strategies utilized by the students, showing their autonomy and proactive learning.

Additionally, three of the participants affirmed that whenever they got stuck while using new technologies in class, they would raise their hands and ask questions. This shows the readiness of the instructors to offer learning support to students whenever it is required. On the contrary, Kendall, referring to an experience in one of the math classes, felt that she did not have enough support. She was pained that the instructor told her, "Hey, you are doing so badly in this class. I recommend you drop it." She ended up dropping the class because she did not feel supported enough to continue with the class.

Transition challenges and learning curve

This third theme reports on the transition experiences of the students. Students transferred from different community colleges to the university with varying backgrounds in technology use. Most of these students reported having used minimal technology tools at the community college. However, one of the students was in the dual-enrollment program and thus had access to a university's virtual computer lab. The transition from community college to the University presented challenges to the students as they got prepared for technology use. This theme, therefore, centers on the challenges of transition and a steep learning curve.

Transition challenges

This subtheme focuses on the challenges the students encountered in adapting to the new technology tools in the university. Some students had used some of the technologies before, while some were completely unfamiliar with them. For example, according to Angelina, she had used some of the digital tools in the past. However, having taken time off using the tools was a problem for her because she had to start by learning again. She had to relearn how to use the tools very quickly because there were assignments related to them in class. She shared,

> I think the challenge was that since I was a nontraditional student, so I went from not using any of these tools for almost a decade to being introduced to them today and expected to do a whole assignment within the week (Angelina, interview).

The need for her to use the tools for an assignment was a motivating factor for her to either relearn familiar tools or learn how to use completely new ones.

Similarly, Kendall found it challenging to switch from the MS Office tools she was accustomed to at South City Community College and the Google products used at the university. She attests to having to learn about the new features and functionalities. She shared,

> But I think it's just a bit more difficult to navigate. I preferred the blackboard collaborated like the original interface more than I did. The newer version. But let's see, with South City, we mainly used Microsoft Word and or Microsoft Office products, whereas Wonderful University uses Google and or mostly requires Google and different things. So look, having to switch between the 2. Different programs was a bit of a challenge. Because I'm so used to Microsoft. And all of the different functionalities that come with it. Granted, I know that they do have a big overlap of what they can do. The short keyboard shortcuts are a bit different, and trying to relearn those to be able to work from 2 different (Kendall, interview).

Kendall also shared about not receiving enough support in a mathematics course that she had to eventually drop. Referring to this incident, she felt that at the university, there was little support in some math classes compared to the community college. This being a challenge that she had to deal with by not only consulting her community college instructor about a contradicting math fact but also having to audit the class. She said,

> I would go to her office hours every single day, which would be 3 times a week during a specific hour. She has no, or she did not have any, like an in-person class, because of health-related issues from for her. So I respect that completely. But the very limited time that you could actually interact with your instructor is just very limited. When at South City CC you could quite literally just go over to either your class or go to a different like tutors for that class which there wasn't a tutor for this specific class until about a week before I switched from audit to or graded to audit, and when I attended, or when I went to the instructor or not, the instructor, sorry when I went to the tutor he was trying to tell me that a fraction plus one would not give me a number that was bigger, although I went back to one of my South City teachers and he said, Yeah, never go back to that tutor again (Kendall, interview).

Although the functioning of a university is different from that of a community college, there is a need to orient students to be aware of the expectations of their university instructors. For example, this Kendall does not at any point refer to using other available resources besides her wanting to do a face-to-face consultation. This may suggest that she was not aware of these resources or was not willing to change, as witnessed by her action of consulting her former community college instructor.

These students share varying experiences touching on structural practices and the availability of a range of technology tools, showing a stark contrast between the two institutions. Therefore, there is a need to create a smooth transition for CCTS students so that they can thrive and have a sense of belonging in the university.

Learning curve.

The sub-theme focuses on the students' learning of new technology tools. To three of the students, some of the tools were entirely new. Therefore, these students were learning everything from scratch. For instance, Kendall, who only possessed a Microsoft background, had to learn about Google software products in addition to other educational software used in the university classes. She said.

> We mainly used Microsoft Word and or Microsoft Office products, whereas Wonderful University uses Google and or mostly requires Google and different things. So, look, having to switch between the two different programs was a bit of a challenge.

Similarly, Mathew, who previously did everything in pen and paper, found the use of technology to be a complete shift. He said, "So, this last year has been a little bit of a learning curve, I guess, just trying to adapt to those changes."

Additionally, Kendall felt that switching from the Blackboard Ultra and Moodle learning platforms required her to learn a lot to use them. While reflecting on her experiences, she compares the effort of switching from Blackboard Ultra to Moodle as having required more effort than it took her to navigate learning how to use Blackboard Ultra after using Blackboard. She responded,

> I guess technology groups. I'm sorry. Or I guess. Office set of keys. It's a bit different. And difficult to maintain. All of those things eventually just had to start writing them down for the main functions. With Moodle, that was a big learning curve than it was with Blackboard and Blackboard Collaborate Ultra.

These reflections from the students reveal that they initially started with struggle getting accustomed to the new technologies but rapidly progressed, learning how to use them as first as they could. These student accounts suggest the need for targeted transition support for community CCTS students as they transition to the university's rich technology environment. In this section, they explored the experiences of students as they transitioned into the program. First, I focused on how they build their confidence and skills in technology use. Consequently, I also explored the support these students received, as well as the individual incentives they employed in learning how to use technology in their learning. For all the students, engaging in an array of new technology tools was both a challenge and an exciting endeavor. Although they all began with a struggle with uncertainty about their ability to use technology, after taking university classes they all felt that they had been prepared to handle both familiar and unfamiliar basic technology tools.

Research Question Two

How does the use of technology in mathematics differ between community colleges and the University, as experienced by CCTS?

This section focuses on the differences and similarities between community college and university experiences in relation to technology use.

Institutional differences in technology use

This fourth theme is about the differences in technology use between the community college and the university. The two institutions, the community college and the university, differ in various ways. First, the university has more resources because it receives more money in the form of grants and both state and federal funding to support research, infrastructure, and specific programs. On the other hand, community colleges receive limited funding for research. This implies that there are fewer finances available for acquiring digital tools. This research did not investigate the reasons for the available funding and was therefore confined to the availability and use of technology in teaching and learning. The participants had varied experiences with technology. All four participants interviewed had experience in using the Blackboard learning platform. For example, Kendall was accustomed to using Microsoft Office Suite at South City but had to learn about Google products at Wonderful University, as she said.

> But with South City Community College, we mainly used Microsoft Word and Microsoft Office products, whereas Wonderful University uses Google and mostly requires Google and different things. So look, having to switch between the 2. Different programs was a bit of a challenge. Because I'm so used to Microsoft. And all of the different functionalities that come with it. Granted, I know that they do have a big overlap of what they can do. The short the keyboard shortcuts are a bit different, and trying to relearn those to be able to work from 2 different (Kendall, interview).

Mathew noted that in the community college, all math learning activities were done on paper and pen. In contrast, at Wonderful University, most of the learning was done digitally as he responded, “There is definitely still a lot of pen and paper, and most of the like classwork was on pen and paper, but for most of the classes here at Wonderful University, almost everything's done through Moodle”. At the University, students are required not to submit their assignments via LMS like Moodle, but to use multiple digital resources to attempt their assignments before submission. Comparing the two institutions, community colleges seemed to engage in single resource use, like Blackboard or Canvas for submission, whereas the university employed multiple resources at the same time.

On listening to the students, their responses revealed that in both institutions, math action technologies were employed in math classes for computation purposes rather than conceptual learning. While Mathew was comparing his experiences in the two institutions, he said,

> with Desmos, that was a big one. If we needed a calculator, we could have one for, like, any of the bigger sort of math problems, like with the bigger numbers. But they focus mainly on making sure that we like knew how to do certain problems. Cause I think most of the homework was done through Cengage, kind of like how Wonder also does (Mathew, interview)

Evidently, in both institutions, there was more use of conveyance technology, with the LMS being the most common. More so, the math action tools were used for computation, a similarity between these two institutions. This is contrary to the expectation that, in the teacher program, the use of technology would be modeled in both math content and methods classes.

Technology access and exposure

This fifth theme focuses on any technology the students may have been exposed to prior to admission to the university teacher preparation program. Although some students had been exposed to technologies like DESMOS, they had not explored the mathematical action side of it; they had mainly utilized it as a computational tool. This theme centers on prior exposure to technology and access to technology.

Prior exposure to technology.

This subtheme examines the opportunities that students have engaged in related to technology use prior to university enrollment. This engagement may take place in high school or at a community college. Therefore, as all students enroll in teacher preparation programs, it is assumed that they have some background in the use of technology. However, these students, who had been enrolled earlier in different community colleges, had varied experiences in the use of technology. One out of the four students shared that he had experience using technology in high school, while others had their first experience in community college.

Vanessa reflects that “At Wantam Community College, they didn't really introduce technology at all,” pointing to the fact that there was very low exposure to technology in math classes. While reflecting on the kinds of technology exposed to, Venessa adds that, “But I had no idea about GeoGebra, or any kind of others, so like doing that project with Dr. Maryam, with. Like all the technology, I was amazed because I had no idea those kinds of software were out there.” This is additional evidence that points to the differences between the technology access in the community college and the university. This notion is also corroborated by Kendall, who says, “No, we didn't really go over that many different forms, I guess, at the Community college”.

In contrast to other students, Mathew shared, “as far as like, I guess, like physical technologies like, I learned basic computer skills throughout high school, calculators like the graphing calculators”. He had used some technology tools in his high school mathematics class. He reported that he had used the Desmos graphing calculator and also learned how to use MS Office tools. However, Mathew had never owned a personal computer until he was enrolled at Wonderful University.

These reflections point to the existence of a systemic gap between the community college and the university in digital integration. Community colleges receive far less funding from both federal and state governments. This contributes to the scarce resources, including technology infrastructure, in community colleges.

Access to technology.

This subtheme focuses on the technology resources students were able to utilize because of their availability. These resources may have been available through direct or indirect provision by their community colleges. The participants' reflections revealed a clear divide in the types of technology used at the community college and the university. Angelina explained that “We had WebAssign, basically for homework assignments. We write the answers and submit them, that's all it was”. Similarly, Kendall reported that, “We used it for computing, like vector fields, and just learning how to use the program itself. Solving basic equations and how we would enter those.” Vanessa added that “Okay, I would say, like, precalculus and trigonometry were definitely just like computation in the calculator”. Evidently, not all participants at the community college used math action technology at all. However, Kendall and Mathew had used technology differently. Whereas Mathew used Desmos in high school for computation, Kendall had used Maple, which was accessible to her via the VCL. Vanessa did not use math technology in college completely. But Angelina remembered an instant in the community college when “The only one was Desmos. Where one of my statistics instructors used it one time to show me something, but we really didn't use it. Aside from that day, that was it.” This affirms the point that there was limited exposure to math action technology in the community colleges for these students.

Reflecting on her experiences, Vanessa noted that at the university, they used technology for engagement in the classroom for different purposes, including launching the lesson as she shared.

> “At the community college, it was basically like, I'm teaching up here. I'm talking to the whole class. You're taking notes. You watch me do it, and you try. You know, there was no….., it was very kind of like old school. Versus like, whenever I got to Wonderful University, it was like we would use technology for, just like a padlet,

> how are you feeling today like? And we all share like on the board, like so, like that was a whole night and day experience. It almost felt like I could. So yeah, it was a lot more engagement, for sure. (Interview, Vanessa)"

According to Vanessa, there was a significant difference between the technology access at the university and the community college. Whereas at the community college, there was limited access to technology, with students relying heavily on pen and paper and using some technology for computation, the experiences at the university were different. However, the students do not explicitly say what technologies they used. They portray the use of an array of different types of technology tools for engagement, which is a good way of modeling what is expected of teacher students once they enter the field.

A comparison between community college and university student experiences revealed that students encountered difficulties accessing technology at the community college. At the university, students had access to various technologies, implying that the university had eradicated first-order barriers.

Cultural shift

The sixth theme focuses on the differences participants found in the practices and resource availability between the community colleges and the university. The students' descriptions revealed that there was both a change in technology tools and a shift in how technology was used in the two institutions. The participants reported having used technology for conveyance in the community college, if any. While at the university, the participants used math action technology.

Motivation to use technology.

This subtheme focuses on the factors that led students to use technology. The participants' narratives reveal various reasons for using technology. As future teachers, they recognize that technology is utilized for specific purposes due to its advantages. Additionally, some participants who reflected on how they had to learn and use new technology tools pointed to the need to learn the "how" because these technologies were being used in their mathematics classes. Angelina noted, "I was a nontraditional student, so I went from not using any of these tools for almost a decade to being introduced to them today and expected to do a whole assignment within the week. And then in that week, I have to learn what the tool is". From this narration, Angelina reveals that she had no option but to learn about the new tools because she required them to complete her class assignments. Therefore, her motivation to learn how to use technology stems from the need to use it during her program. Mathew reiterates the same experience. He says that "Because coming to Wonderful University, I kind of had to force myself to use technology more, just because it was more prominent in Wonderful University." Matthew's statement also indicates that, at the university, many technology tools were available and in use, as he notes that technology was more prominent at Wonderful University.

Vanessa also highlights the benefits of incorporating technology into learning. She notes that, as a visual learner, technology enables her to engage with mathematics and visualize the concepts under study. She also notes that technology facilitates the concept of equitable access by providing multiple avenues for learning.

> "like it helped all around, because I am a visual learner, like I don't learn out of a textbook. Like GeoGebra, like having to actually draw and figure out. You know, shapes and stuff and angles and lines like that were really helpful for me, because it was a hands-on approach, for statistics. It was just really cool, like all the data could do. You could. You know. You had all this data, and you could basically do whatever you wanted with it to get. You know what you needed out of it. I

> thought that was really cool, and I just think overall like it helps different learners, like you have some that learn best one way, but then you have some that learn best another way, and like, it's good that you like incorporate technology where you get both (Vanessa, Interview)."

She begins by reflecting on her learning, which is made easier visually. She adds that technology enables learners to experience multiple ways of learning mathematics concepts. Clearly, there was a shift from passive exposure to active use of technology among the students. This shift promoted growth in the students' use of technology.

Emotional responses towards technology use.

This subtheme focuses on the emotions elicited by the experiences students encountered as they navigated their transition from community college to university. The participants viewed the cultural shift in different ways. While some students viewed the shift as a challenge, others saw it as an exciting moment to learn and engage with technology. For Kendall, she felt overwhelmed and struggled to cope because she felt that she did not receive enough support in her math classes as she had received at the community college, as she asserts, "But now, after realizing that there's so much more that's out there, I've been really struggling since I've come to Wonderful University. But part of that is also not specifically to the What's it called, to the technology itself? A lot of it is how the math departments treat their students, especially those with different abilities." Also, Vanessa asserts that,

> " …You know, shapes and stuff and angles and lines like that were really helpful for me, because it was a hands-on approach, for statistics. It was just really cool, like all the data could do. You know you had all this data, and you could basically do whatever you wanted with it to get. You know what you needed out of it. I thought that was really cool (Vennessa, Interview)

This response highlights that Vanessa not only embraced the advantages of technology use in learning but also appreciated that using technology in the classroom was enjoyable. Despite the struggle in learning how to use technology, Vanessa embraces the joy of manipulating data with technology to visualize the data under investigation.

Overall, a comparison of Kendall's experiences between the university and the community college shows that she was unhappy and felt frustrated because she could not receive the help she anticipated at the university. On the other hand, Venessa, who had not used technology in the community college, initially felt intimidated by it. However, after using technology, she became excited and enjoyed engaging with the tasks because of the visualization, an aspect absent in her community college experiences.

Research Question Three

How does self-efficacy for teaching with technology change for CCTS in their teacher preparation in the program?

To answer RQ3, this section focuses on exploring how students engaged with technology and developed the belief in using familiar technology, as well as learning to use new technology tools. To achieve this, I focused on their growth in self-efficacy and how they learned to develop their skills and confidence in using technology in the classroom.

Growth in self-efficacy

This seventh theme emphasizes the belief that students should utilize technology for mathematical purposes and integrate it into their teaching. Therefore, it examines how their confidence in using technology grew during their academic career after admission to the teacher education preparation program. The reflections of the participants provide us with a picture of how they began with limited exposure to technology and low confidence in their use of it.

Confidence in technology use.

This subtheme centers on the confidence of the students to use technology for different purposes. As the participants reflected on their technology learning and use journey, it is evident that they progressed from a point of struggle with new technology tools to a point where they could use different tools in mathematics comfortably. As they continued encountering new technology tools, they were willing not only to learn how to use them but also to use them to teach mathematics.

Angelina said, “My program forced me to use the tool as a student and get comfortable with it as a student, you know, before I ask my students to do the same”. This statement shows some discomfort at the beginning. Still, Angelina puts effort into learning how to use technology so that she has the skills before utilizing it in the classroom with her students.

Mathew had learned that some of the technology tools he had seen used can be utilized in multiple ways. He felt that he could accomplish a lot in mathematics using technology after his enrollment in the program, unlike his experiences at the community college. Engaging with technology in the university had also changed his perception of technology, as he shared.

> I would say my perception has definitely changed a lot since community college, just because so my sort of understanding of technology in the classroom was pretty much limited to just like smart boards for or like the yeah, pretty much just smart boards, pretty much, and so I figured that'd be my limit of technology in the classroom. But since then, I've seen I could still use a smart board, but I can also take notes on an iPad, and it show up on the smart board, or I can pull up Desmos and show them on Desmos, or I think there's even a graphing calculator-like app that you can download onto the computer and do it on there. And so yeah, it's definitely broadened my horizons. And I'm a lot more I feel like I can use technology more in the classroom now.

Mathew attests to his university experiences changing his perspective on technology. After learning about the new vast technology devices and also discovering that some of the familiar technology had multiple roles beyond what he knew.

The experiences of Mathew and Angelina indicate that their self-efficacy in using technology grew significantly. Although Angelina initially struggled with technology use, her engagement with technology, both as a student and a teacher, gave her the confidence and knowledge to not only use it but also integrate it effectively in the classroom. Similarly, Mathew, who enrolled in the MTPP at the university with basic knowledge of technology tools, was exposed to different tools, which led him to appreciate the multiple ways of utilizing technology in the classroom.

Support math learning with technology.

This subtheme focuses on the ways in which participants believe technology can support mathematics learning. Exploring this support will help to understand the different ways participants. The students shared that they had recognized the importance of using technology in the classroom for learning purposes, rather than merely for show. Angelina asserted, "Just to say I'm gonna use Desmos in my classroom, like the purpose of Desmos, needs to know, you know, make learning easier or more efficient or minimum". Angelina reveals that her perception of technology has gone beyond merely using technology in the classroom. She believes it should be used for conceptual reasons, not just convenience. On the other hand, Vanessa revealed that her project in the course "EMS 480" really opened her eyes to the world of technology.

After engaging with technology, both Angelina and Vanessa's use of technology had grown from mere use to purposeful use. Angelina believes in selecting technology appropriately for conceptual reasons. In contrast, Venessa embraces the multiple ways technology can be used in the classroom, especially after her project in one of her methods courses.

Experiential learning

The eighth theme focuses on how the students acquired technology use skills from their experiences. For example, Angelina reported that ‘‘The program forced me to use the tool as a student and got comfortable with it.’ Angelina gained firsthand experience using technology like Desmos and GeoGebra in her coursework during field placement. This firsthand experience constitutes the concrete phase. Also, Angelina said ‘‘It was hard… not using these tools for a decade. Angelina reflected on her past use of technology. Additionally, Kendall added, 'struggling since I have come to Wonderful University… so much more out there.' These participants engage in the reflective phase of learning as they reflect on their technological journeys, from their community college experience to their university studies.

As Matthew reflects on technology use in his math classes, he said, 'StatCrunch … great software to visualize data and see trends.' Vanessa claims, 'GeoGebra was helpful for me as a visual learner.' From these, the participants initially recognize the role of technology and when to use it. This embodies the conceptualization phase of experimental learning.

During placement, the participants practiced integrating technology into their math classrooms. Vanessa says, 'I'm able to incorporate the tech in my field placement lessons.' The CCTSs apply their acquired skills in teaching with technology while integrating it, and they test their strategies and adapt them based on students' feedback.

The participants engaged with technology as learners, then as teachers. They progressed from abstract to concrete experiences, reflection, and integration through independent strategies, peer support, and instructor guidance.

Independent learning strategies.

This subtheme, the participants reported employing personal initiatives to learn how to use technology. One of them resorted to experimenting with different tools to learn how they work. Angelina asserted that " … I have to learn what the tool is. What features does that software have? How to use those features, you know. Just mess around with it, play with it, and then on top of that, you know. Now look at the assignment, see what's expected of me."

Besides learning technology use by directly trying to use it to learn about the different features, Angelina also shared that "...YouTube videos, whenever I got stuck on something or I forgot how to do something. I would. Just, you know. Okay, how to do this on Desmos, how to do this on the algebra, and yeah, that's pretty much what I did."

Mathew also shared how he loved playing around with technology, and so, besides other modes of learning, he self-taught himself how to use the new technologies. As he shared, " ..then doing it myself also kind of helped me understand it better. Thus, yeah, so I just actually doing it like on the computer. Or if I am tinkering with something, like just actually doing something, or someone showing me how to do it is very helpful for me, so." Evidently, Mathew is driven by a passion to learn about technology; hence, self-learning comes naturally to him, in addition to the overview done in class.

The individual initiatives taken by these students were driven by the need to use the new technology tools for assignments. The students progressed from expecting help to accomplish any task with technology to a point where they were able to use technology independently without relying on someone else. This indicates growth in their self-efficacy regarding the use of technology.

Peer support.

The students shared different ways in which students navigated learning about new technology tools. The students had different experiences learning from peers. For example, Angelina said, "But between those classes, other classes, other assignments, scheduling issues. It was very hard to have a one-on-one sit-down with somebody who could teach me exactly how to use those tools." This revelation suggests that she may not have benefited significantly from learning from her peers due to time constraints.

On the contrary, Venessa attests to being helped by friends, she said, " I think I had much good help like friends around me that if I got lost, understand and like they are very helpful.

Thus, that definitely helped just having, you know, supportive people around me." Sometimes, it is easy for students to learn from peers because they communicate at the same level. Since she had more than one friend for this purpose, it suggests that she benefited from the strength in numbers by learning multiple ways to accomplish the same task.

The students recognized that they can also learn from their peers. Venessa and Angelina, who initially viewed themselves as disadvantaged, did not hesitate to seek help from their peers. This change shows growth in terms of being able to seek help and grow a support system of peers in technology use.

Instructor support

This subtheme explores the experiences of students learning to use technology with the support of their instructors. Angelina had shared that the program forced her to learn about new technology. Although it revealed her struggles, she reiterates that "fortunately, the classes did introduce us to the tools and did give us an overview". For her, the instructions and guidance provided in class served as a basis for her learning how to use technology.

Mathew had a similar view. Using an example of how he learned using StatCrunch software, Mathew said, "So with like StatCrunch, the instructor had provided very clear instructions on how to use it and how to use it for what we were learning, and so just doing that kind of like step-by-step process with the instructions and then doing it myself".

Venessa revealed that although her classmates were handy in helping her learn about new technology. She shared that " I would always, you know, raise my hand if I did not understand or just needed some clarification." This implies that the instructor helped her to deal with new technology challenges whenever she felt stuck while learning in class.

These excerpts are evident of the support the students received from their instructors in the classroom on technology use either individually or as a group.

In summary, the students started with limited expertise and confidence in technology use in their courses. Their learning decisions were driven by different factors, ranging from curiosity to the need to use different tools for their assignments. Their experiences suggest growth in their confidence in the use of technology and skills. In their quest to learn about the new technologies, they employed several strategies: learning from peers, instructors, and individual incentives.

Research Question Four

How do CCTS use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?

This research question focuses on exploring the experiences of CCTS students regarding their self-efficacy and preparedness in their field placement classrooms. This exploration allows us to gain insight into how technology was integrated into the field placement classrooms.

Teaching placement experience

This last theme focuses on the experiences of the senior CCTSs during their teaching placement. Being novices in teaching technology, the students used both conveyance and math action technology.

Field placement technology integration.

This subtheme focuses on the technology use experiences of CCTSs in field placement classrooms. The teacher's reports to students reveal that they used both conveyance and math action technologies, with the former being more prominent.

There are instances when they utilized conveyance technology, while other times they utilized math action technology. For example, Angelina used Google Slides to display her lesson content and sometimes used the document camera to display the workbook.

> So I alternated a lot between Google Slides and projecting the workbook because it's possible to just project the workbook and have the students work along or work together before I send them off to do examples or practice problems on their own. But some lessons I did feel it was necessary to use Google Slides just because it was a lot beneficial to be in front of the room at the board (Angelina, interview).

Additionally, Venessa's encounter with technology being supported by her cooperating teacher points to the importance of a more experienced other giving a less experienced colleague guidance. To model what teachers are expected to do in their classrooms, the cooperating teacher allowed Venessa to explore using technology, reassuring her about practicing until she gets it right, as revealed in her response.

> Yeah, I think he helped me like with the cards. He's the one who introduced me to that, you know, when I was looking for Desmos lessons, he helped me like look over to make sure that was, you know, appropriate to use for teaching out of the workbook. So I think he was very supportive, and for sure he like, you know, like I said when things didn't go right, he reassured me. That you know you'll learn after like the 1st 3 times, you know. You'll have it.

In the first interview, Angelina shared having difficulties with using math action technology tools because of struggles with classroom management. She said,

> So at this moment I haven't. I think that's the one part of my observations I'm getting ready to work on. And the only reason is because I do have, you know, lesson planning. I'm learning classroom management. Unfortunately, the thing with technology and classroom management is, I can't see what the kids are doing. And I'm learning how to manage a classroom and introduce technology into that factor. It's just in my head. I can't!

This points to Angelina's low confidence in using technology in her classroom and managing the students at the same time. Novice teachers always struggle to incorporate technology in their lessons because of the belief that technology use in a way hampers classroom management, yet the two can be done together. However, with time, Angelina was able to overcome her fears. She said, "But using Desmos, I could see. Oh, so and so you're drawing, you can drop, but can you first answer the question for me? And I think it kind of got them to actually do their work a little more, knowing that I could see on my screen on my screen. If they answer the question or not”. From her reflection, it shows how she developed confidence and leveraged the teacher monitoring feature of Desmos to manage the students while integrating technology in her lessons.

Evidently, the two students had different experiences in technology implementation in their field placements. Whereas Vanessa was ready and well supported by her cooperating teacher to use technology in her lessons, Angelina initially struggled with classroom control but with practice overcame it in the end.

Perceived relevance of technology.

This subtheme focuses on how much the students thought technology was useful, as experienced by the CCTSs in field placement classrooms. All the students felt that technology was important for teaching. The students acknowledged technology for its convenience, speed, visual representation, and organization of mathematical data and concepts. They have a plan to use technology in their classrooms in the future. Mathew appreciated the availability of technology for accomplishing many tasks in the classroom. He felt that the knowledge he had acquired about technology could enable him to utilize technology in the classroom in the future, as he shared:

> ..Being able to confidently use these technologies, I feel like as a teacher. You can pretty much manipulate any of these technologies to do what you want. And so I feel like, if there is something certain or something in particular, I want to do. There's a technology for it. And so, I feel confident with what I've been given and what I now understand. And confidently use the technologies in the future, for sure. (Mathew, interview).

Vanessa also shared that she co-taught with her cooperating teacher, so when it was her turn to teach, she used Desmos and Clickers, which were not only engaging but also enjoyable. She acknowledged that these technology tools also enabled her to monitor students' work and provide feedback on their responses, as she explained.

> When it was my turn to teach. I tried to implement some other platforms into the classroom. So I exposed them to Desmos, and they really liked that. And then also, like when I introduce like adding integers and subtracting integers. We used this like an online thing where you could add and subtract chips on their computer, and so that was the only technology that I've done. Oh, and then the clicker cards. We had state check-in data. So we took the most missed questions from State Check-in and put them, we did like 2 or 3 a day. And so Clicker is where you print off a class set, and they all have, like, their different QR Codes. So you can't look at your neighbor and see like what they put, and then I would use my phone to scan the room, and it would say, like, if they got it right or wrong.

Vanessa's experiences demonstrate that she not only integrated familiar technologies but also learned how to use and integrate newer technologies, such as clickers. This points to her appreciation for the advantages that come with the use of technology in the math classroom.

In summary, during teaching placements, the senior CCTS students engaged with both conveyance and math action technologies as part of their classroom practice. From their responses, they blended the two for a full classroom experience. For instance, Angelina alternated between presenting lessons in Google Slides and projecting the workbook for students to follow along. Initially, Angelina struggled to manage students effectively while using math action tools like Desmos. However, over time, she gained confidence by leveraging Desmos monitoring features to give students feedback in real time. Another student, Venessa, benefited from support from her cooperating teacher, who refined her practice in the use of Desmos and other technology tools. Working with her cooperating teacher, she experimented on new technologies like clickers and online manipulatives for integer operations. These tools not only engage students but also enable her to check students' understanding and provide immediate feedback.

In conclusion, students perceived technology as an integral part of mathematics teaching and learning because of its convenience, speed, and ability to organize math concepts. Additionally, Mathew expressed confidence that his training was sufficient for him to adapt any technology to classroom needs in the future. This sentiment was also echoed by Vanessa, who noted that combining familiar and new tools enhanced student engagement, reinforcing her intention to use technology in her future classroom. The next section does a cross-case analysis between the junior and senior CCTSs.

Cross-case Analysis

This cross-case analysis compares the experiences of junior CCTSs (Kendall and Mathew) and Senior CCTSs (Angelina and Vanessa). Each case is examined in relation to the research questions to identify similarities and differences.

Junior Community College Transfer Students

These two participants, Kendall and Mathew, had completed fewer university courses than seniors. Kendall transferred to the university with multiple associate degrees and many credits, but with little exposure to mathematical technology. Mathew, on the other hand, enrolled at the university with one associate's degree and some exposure to technology from high school, including Desmos, MS Office, and graphing calculators, but little use of conveyance and no use of math-action technology at the community college.

Senior Community College Transfer Students

Angelina and Ven had completed all the methods courses and were engaged in field placements, given that they had been in the teacher preparation program for a longer time. Both Venessa and Angelina began with limited exposure to technology at the community college, but their experiences at Wonderful University helped build and improve their competence and confidence in using various educational tools.

Research Question One

How prepared do community college transfer students (CCTS) feel to use educational technology in their current mathematics education program?

Mathew transferred from the community college to the university with some exposure to technology. He had knowledge of the use of MS Office and the Desmos graphing calculator. However, at the community college, he “did not take many math courses,” and assignments were submitted via the Blackboard LMS. His technology preparedness grew significantly when he received a tablet and began using StatCrunch, Desmos, and other technology tools in university courses. He observed that his knowledge of technology had “definitely grown”. In contrast, Kendall’s community college classes were almost entirely pen and paper, except for the use of Blackboard for assignment submission and Maple, which she accessed via the virtual computer lab. As Kendall noted, “Almost all problems were done by pencil and paper and the available technology at the CC was for conveyance purposes only.” Reflecting on her university experiences, she shared that her use of technology “had not significantly changed “since she was still taking general education courses. This analysis indicates that although the junior CCTSs initially had limited exposure to technology in their journey to becoming teachers, they experienced gradual growth in both their skills and confidence in using and integrating technology.

The senior CCTSs reported that they started their college academic journey with little to no exposure to mathematics technology at the community college. According to Angelina, she only used WebAssign and Blackboard for homework. Similarly, Venessa reported “they did not really introduce technology at all” in math classes. Notably, once at the university, they were engaged in math action technologies through methods courses. For instance, Angelina observed, "The program forced me to use the tool as a student and get comfortable with it," pointing to a rapid learning curve. Venessa, on the other hand, felt "intimidated by the technology," especially being among younger peers, and she had forgotten about the little technology she had learned as a younger student. Despite this challenge, Venessa gained proficiency through her coursework and assignments. The seniors, therefore, encountered a broad range of tools that they had to self-teach, developing greater readiness for technology integration.

A comparison of juniors and seniors reveals that both cases started with limited preparation, reflecting the limited emphasis on technology in community colleges. Juniors' exposure to technology was limited to LMS and graphing calculators. Similarly, senior CCTSs were underprepared but were rapidly exposed to multiple technology tools. These differences between the two groups can be attributed to the seniors having been in the program longer and hence being exposed to more technology in their courses, compared to the juniors, who have yet to be taught the same concepts.

Research Question Two

How does the use of technology in mathematics differ between community colleges and the University, as experienced by CCTS?

Junior CCTSs recognized differences between technology environments between community colleges and the university, noting that there were very few opportunities to experience their use intensively. For instance, Kendall observed that South City CC utilized MS Office and Blackboard, while Wonderful University used Google products and Moodle, in addition to many other technology tools. Her reflection indicates that these tools were used for conveyance purposes rather than for integrating them into mathematics learning. For Mathew, a comparison between Renton CC and Wonderful University indicated a major shift in technology use. He noted that at Renton CC, most of the classwork was in pen and paper, whereas at the university, “almost everything was done through Moodle”. The students were also encouraged to take their notes on iPads and laptops. However, Mathew’s description emphasizes the volume of technology rather than the conceptual shift.

While reflecting on their experiences between the community colleges and Wonderful University, the senior CCTSs reveal a deep appreciation for pedagogical shifts and the availability of resources, pointing to the difference in how technology is used in these two institutions. Venessa described community college teaching as “Very kind of old school.” She noted that instructors lectured while students took notes with very little student engagement. At Wonderful University, she described it as “a night and day difference.” Angelina remembered submitting homework through WebAssign, but never explored mathematics with technology. Contrarily, at the university, she learned how to use Desmos, GeoGebra, and CODAP, among others, for data manipulation, visualization, and interactive learning.

The two student groups recognized institutional differences, with juniors experiencing an incremental change in software platforms, such as Blackboard versus Moodle, whereas senior CCTSs perceived a major pedagogical transformation. The differences in perception and growth between the two groups may be attributed to the Senior CCTSs’ long exposure and observation, as these students saw the instructors modelling technology integration for conceptual understanding. The seniors, on the other hand, had fewer opportunities to observe these instructional strategies in use and were probably still adapting to the new technology resources.

Research Question Three

How does self-efficacy for teaching with technology change for CCTS in their teacher preparation in the program?

The junior CCTSs experienced a slight growth of confidence in technology use, but faced inexperience. Kendall admitted that her preparedness "Hasn't really grown much" since she had not yet used many technology tools beyond what she already knew. However, she had learned about Kahoot and Quizziz but had not applied them yet. On the contrary, Mathew reported growing confidence as he used Desmos and StatCrunch for calculus and statistics, respectively. More so, he noted that his "point of view" had changed because he had noted the transformational power of technology in the classroom. Conclusively, the junior CCTSs' self-efficacy did not increase significantly. However, their awareness of new math tools had improved, albeit with limited opportunities to practice integrating them, and thus they lacked a deeper conceptual understanding displayed by their senior counterparts.

Reflections of the seniors exhibit substantial growth and reflective practice, demonstrating an increase in self-efficacy. Angelina noted that although she initially struggled learning about tools like GeoGebra, using them as a student built her confidence to teach with them. In her reflection, she observes that technology use should serve a specific purpose, rather than being used for its own sake. Similarly, Venessa recounts being "a little intimidated by the technology." However, a project in a methods course, "EMS 480," had a significant impact on her learning because it not only exposed her to various mathematical tools but also provided her with an opportunity to experience both the teacher and student sides of these tools. Her willingness to experiment and practice with technology was reinforced by her cooperating teacher's mantra: "To be good at technology use, you need to do it three times."

A comparison of self-efficacy between juniors and seniors indicates that juniors' confidence was emerging and fragile, relying on limited exposure. In contrast, seniors were more robust and grounded in multiple experiences from coursework and field placements. The seniors progressed from an initial struggle to purposeful integration, reflecting experiential learning and the development of a professional identity as technology-using teachers.

Research Question Four

How do CCTS use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?

The juniors have not experienced any field placement; thus, their technological integration is confined to coursework. Therefore, there is no worthy comparison between the two groups for this research question.

In summary, the cross-case analysis compares the junior and senior CCTSs experiences as they navigate their math teacher preparation, highlighting how their backgrounds shaped their technology use and confidence in integrating it. The junior CCTSs (Mathew and Kendall) enrolled at the university with limited technology exposure. Kendall's community college experience involved the use of paper and pencil with occasional use of the Blackboard and Maple via the VCL. Mathew, on the other hand, was familiar with MS Office, graphing calculators, and Desmos in high school, but so little technology involvement at the community college. For the senior CCTSs (Angelina and Venessa), their university experiences developed their technology use and integration skills. Angelina reported that being "forced" to use dynamic tools like GeoGebra in her coursework accelerated her learning. On the other hand, Venessa, who initially "felt intimidated" by new technology, overcame her fears through hands-on activities like her coursework project, which entailed researching various types of technologies.

The readiness of juniors to use technology varied. Mathew, who had only interacted with Blackboard for community college assignment submissions, built his confidence in using technology after receiving a personal tablet, which enabled him to engage with StatCrunch and Desmos. In contrast, Kendall felt very minimal change because she was enrolled in general education courses and had therefore not learned any new technology tools at the university. The senior CCTS students, on the other hand, had their technology use and integration transformed by their university experiences, making them feel well prepared for classroom field experiences. Overall, junior and senior CCTS students all began with limited technology preparation, but seniors had made great strides in competence, confidence, and educational technology integration due to their extended time in the program and exposure to coursework.

Document Analysis

The integration of educational technology is a key component of modern pedagogical practice, especially in mathematics education, where dynamic tools can be used to transform abstract concepts into tangible, interactive experiences. In this dissertation chapter, the document analysis is designed to explore the multifaceted landscape of technology utilization in mathematics lesson planning and the perceived technological preparedness of prospective mathematics educators. The increasing emphasis on equipping students with essential 21st-century skills necessitates a deep understanding of how technology is conceptualized and implemented in teaching, especially for teachers entering the profession.

This analysis draws upon some instructional materials and survey data to construct a nuanced portrait of technology integration. Specifically, the documents under examination include Angelina's lesson plan, focusing on "Solving Systems of Equations" for Math 8, and Venessa's lesson plans, comprising a range of middle grades mathematics topics such as rational numbers, coordinate planes, interpreting and operating with negative numbers, and inequalities. These lesson plans offer concrete examples of planned technology use, illustrating the types of digital tools (e.g., Desmos Classroom, Nearpod, Khan Academy, Promethean Board) intended for use in actual classroom settings and their specific pedagogical functions in relation to mathematical content and learning objectives. A summary of the artifacts is presented below (*See table 4.2*).

Complementing these instructional artifacts, the analysis incorporated data from the TPACK-M USA survey. This survey data directly addresses key research questions related to how prepared mathematics transfer students felt regarding educational technology, how the use of technology in mathematics differed between community colleges and universities, and how self-efficacy for teaching with technology evolved during teacher preparation programs, by examining educators' self-reported abilities across several TK, TPK, and TPK applications.

Table 4.9
Lesson plans summary

Lesson plan Name	Title / Topics	Grade/Subject	Learning Objectives	Key Activities	Technology/Materials	Assessment/Evaluation
Desmos Lessons	Points in the Coordinate Plane; Guess My Line; Coordinate Archery; Interpreting Negative Numbers; Adding and Subtracting Rational Numbers	Math Grade 6	Describe a four-quadrant coordinate plane; plot points with negative coordinates; understand the meaning of negative coordinates; compare rational numbers; add and subtract rational numbers; interpret rational numbers in context.	Desmos activity builder with interactive applets: Guess My Line, Coordinate Plane, Coordinate Archery; Student input via Desmos to hit targets; activities on temperature and elevation using negative numbers; Positive or Negative? Phone Inventory; Solar Power tasks.	Desmos Activity Builder links interactive lessons to applets that require devices, number lines, and coordinate grids.	Practice problems for Lesson 16 (p. 129–130) and Lesson 2 (p. 14–15) with answer keys; interactive tasks with immediate feedback.

Table 4.2 Continued

Lesson plans summary

Lessons 18	Interpreting Points on a Coordinate Plane; Finding Distances on a Coordinate Plane; Drawing Polygons; Unit 10 Review and Test	Math Grade 6	Explain rational numbers as balances and interpret points in a four-quadrant coordinate plane; plot points to solve problems; find horizontal and vertical distances; find lengths of segments and draw polygons using coordinates.	Unlabeled Points, Account Balance, High and Low Temperatures; coordinate patterns; sign of numbers in coordinates; drawing and reflecting polygons; practice problems; study guide and test.	Nearpod share link for interactive slides; coordinate plane tasks; practice problem pages 147–148 and 155–157; study guide and unit test materials.	Practice problems (p. 147–148; p. 155–157), study guide and key, Unit 10 test.
Lesson 19: Walking to the Library, Walk-a-thon;	Relationships Between Quantities (distance–time, area, volume); Positive and Negative Numbers; Study Guide and Test	Math Grade 6	Create tables and graphs for relationships with constant speed.	Lesson 20: Which One Does not Belong? Graphs, Making a Banner, Cereal Boxes, Multiplying Mosquitos; practice problems; study guide; test; later lessons on interpreting positive and negative numbers and their contexts.	Graph worksheets; practice problem pages (117–118, 125–126); study guides; tests.	Practice problems, study guide with key, and weekly test.

Table 4.2 Continued
Lesson plans summary

Walk-a-thon; Lesson 20:	Positive and Negative Numbers; Study Guide and Test	Math Grade 6	write equations representing relationships; explore area and volume relationships; understand and use positive and negative numbers; represent relationships in tables, graphs, and equations.	Which One Does not Belong? Graphs, Making a Banner, Cereal Boxes, Multiplying Mosquitos; practice problems; study guide; test; later lessons on interpreting positive and negative numbers and their contexts.	Graph worksheets; practice problem pages (117–118, 125–126); study guides; tests.	Practice problems, study guide with key, and weekly test.

Vanessa's Lesson Plans

Venessa shared 4 lesson plans covering rational numbers and the coordinate plane, interpreting and operating with negative numbers, inequalities, and quantitative relationships. The contents of each are presented below.

Rational Numbers and the Coordinate Plane.

Contents

Students learned to describe and use a four-quadrant coordinate plane, plot points with negative coordinates, and understand what these negative numbers represent in coordinates. They also learned to find horizontal and vertical distances between points on the coordinate plane, including using absolute value. The lessons extended to graphing polygons on the coordinate plane, given coordinates for their vertices. Students also interpreted points and distances in real-world contexts, like account balances and high/low temperatures.

Learning Goals:

Students were to be able to explain how rational numbers represent balances, interpret points in a four-quadrant plane, plot points to solve problems, and find distances. They were also expected to plot polygons and find the lengths of segments in the coordinate plane.

Activities:

The activities included interactive activities like "Unlabeled Points," "Account Balance," and "High and Low Temperatures" (often utilizing Nearpod). Desmos activities like "Coordinate Archery" were used for plotting points and describing them with negative coordinates, including decimals or fractions. Discussions focused on coordinate order, interpreting points not on grid intersections, and patterns of signs in different quadrants.

Interpreting and Operating with Negative Numbers

Content:

This section focused on understanding the meaning of zero, positive, and negative numbers in contexts such as temperature and elevation. Students compared rational numbers, understood the concepts of opposites and absolute value, and learned to perform operations with integers, including addition, subtraction, multiplication, and division.

Learning Goals:

Students were to be able to explain the meanings of positive and negative numbers in real-world contexts, use them to describe temperature and elevation, compare rational numbers, represent negative numbers on a number line, and understand the concepts of number opposites and absolute value. They were also required to add, subtract, multiply, and divide integers.

Activities:

Lessons utilized Desmos ("Using the Thermometer") to explore temperature and vertical number lines. Activities involved discussing concepts like account balance, sea level, and comparing numbers on a number line. Khan Academy videos and practice were frequently referenced for topics like negative decimals, fractions, number opposites, and ordering negative numbers. Teacher-created notes and videos are also used for modeling integer operations.

Inequalities

Content:

Students learned to write and graph inequalities on a number line, determine if a number is a solution to an inequality, and interpret the meaning of solutions in context. This included understanding constraints in real-world problems and the meaning of open vs. closed circles on a number line.

Learning Goals:

Students were expected to graph and write inequalities, determine solutions, and explain what a solution means in a given situation.

Activities:

Lessons involved estimating heights, analyzing stories with numerical constraints, and exploring concepts of minimum and maximum values. Khan Academy videos and practice were used for plotting inequalities and solving word problems. Discussions cover differences between continuous and discrete solutions, and the advantages of using inequalities or graphs over lists. An exit ticket or Khan Academy Quiz 2 could be used for assessment.

Quantitative Relationships

Content:

Students created tables and graphs to represent relationships between quantities, with a particular focus on distance and time at a constant speed, as well as relationships involving area and volume. They also learned to write equations with variables to represent these relationships.

Learning Goals:

Students were to be able to create tables and graphs for constant speed relationships, write equations with variables, and analyze relationships in different representations (context, equations, tables, graphs). They were also required to write equations describing area and volume relationships.

Activities

The activities included "Walking to the Library" and "The Walk-a-thon" for distance/time relationships, emphasizing different representations (tables, graphs, equations). Other activities, such as "Making a Banner" and "Cereal Boxes," focus on area and volume, exploring how quantities multiply to a constant, were incorporated in the lesson plan. Some questions guided students to compare situations, interpret points on graphs, and analyze how variables affect relationships.

Venessa's Lesson Plan Analysis.

Vanessa's lesson plans indicate that she utilized Desmos, Nearpod, and Khan Academy. She emphasizes conceptual understanding through interactive activities, visual representations, and real-world problem-solving, supported by various digital tools like Desmos, and Nearpod. The use of Desmos for interactive graphing, Nearpod for guided activities, and Khan Academy for supplementary video and practice demonstrates a strong application of technological knowledge. Venessa also plans to strategically use technology for teaching and learning by having teacher and student activities that allow students to participate as individuals and as a group, while justifying their answers after interpreting them. The activities promoted higher-order thinking skills and student communication. These activities align with the TPACK items in the TPACK-M survey. The activities and technology resources used in these lesson plans also align with the responses Vanessa provided in the interview. For instance, she reported having used Desmos.

Angelina's Lesson Plan.

Angelina shared a lesson plan titled "Solving Systems of Equations" for Math 8, which is designed to help students understand and solve pairs of simultaneous linear equations by graphing. The lesson was structured with hands-on and interactive activities integrated with technology.

Content:

The primary mathematical content focused on solving systems of linear equations by identifying the point of intersection of their graphs. This point of intersection should be understood as the solution that makes both equations true. Key vocabulary introduced included systems of equations, slope, y-intercept, solutions (one, no, infinite), parallel lines, and intersecting lines. The lesson also reviewed how to determine the number of solutions for different types of linear systems by examining their slopes and y-intercepts and their graphical representations (intersecting, parallel lines). Prior knowledge required for students included plotting points, understanding slope and y-intercept, basic graphing skills using slope-intercept form, and solving linear equations.

Technology Integration:

In this lesson, technology was a central component, primarily utilizing Desmos Classroom and a Desmos Activity “Solving Systems of Linear Equations" accessed via computers with internet. The teacher used the Promethean Board to display the Desmos activity and guide discussions.

In the warm-up, Desmos allowed students to determine if points satisfy equations and to explain their reasoning digitally, with the teacher monitoring responses for misconceptions about ordered pairs. During Activity 2, Desmos was to be used by the students to graph systems of equations interactively, identify solutions as ordered pairs, and visually understand different types of solutions (one, no, infinite) based on online behavior. Sentence starters within the Desmos text boxes were to support students' mathematical explanations. A recap was done to review learning and prompt students to articulate how to determine solutions from both graphs and equations. An assessment was done as a "Cool-down" activity in Desmos served as the exit ticket, providing a digital method to gauge students' understanding.

Learning Goals:

Students are expected to: understand that a solution to a system of equations is the point of intersection that makes both lines true, use precise mathematical language to describe graphing processes, interpret slope and y-intercept, and justify their reasoning through discussions and written explanations, determine the solution to a system of equations by graphing, and Meet NC Math Standard NC.8.EE.8 (Analyze and solve pairs of simultaneous linear equations) and engage in Standards for Mathematical Practice such as making sense of problems and persevering, and reasoning abstractly and quantitatively.

Activities:

The 60-minute lesson is divided into four main components: (1) Warm-up - Activity 1 - Students were required to access a Desmos activity on their computers to decide if given points satisfy two-line equations. The teacher was to model an example and encourage graphical verification. Students explained why statements are false; this activity fostered independent work and peer discussion, with teacher support to clear misconceptions about ordered pairs. (2) Activity 2 - Different Types of Systems -This activity reviewed solutions to linear equations. Students were required to graph systems on Desmos and identify solutions as ordered pairs. The students then progress through the Desmos activity to explain different types of solutions (one, no, many) and require them to graph systems and explain their findings. The activity concluded with a recap and reflection questions on Desmos.

Closure:

A whole-class discussion was to summarize key takeaways, focusing on answering the essential question. Students compared algebraic and graphical methods of solving systems and discussed how to check answers.

Assessment:

Students were to complete an exit ticket, as a "Cool-down" activity on Desmos, to assess their understanding of the number of solutions for different types of graphs.

Lesson Plan Analysis.

An analysis of Angelina's lesson plan shows that she utilized different technologies in her lesson. Angelina's plan to utilize computers with internet to access the Desmos classroom and Promethean board aligns with the survey TK items Q3.4, Q3.5, and Q3.11, confirming preparedness to use technology as established in the survey analysis. Angelina's lesson plan also employs technology to support teaching strategies, encouraging students to work independently as they engage in the Desmos activity, promoting collaborative learning. This aligns with the TPK items Q4.4, Q4.5, and Q4.9. Angelina's lesson plan also demonstrates how technology enhances higher-order thinking, as students were required to represent mathematical problems and engage in whole-class discussion on multiple ways of problem solving. These activities are aligned with the TPACK items Q5.7, Q5.5, Q5.6, and Q5.9 of the TPACK-M survey analyzed earlier. The structured use of the Desmos Classroom, Promethean board, and computers with internet connectivity is a confirmation of the findings of the interviews, where Angelina had said that she planned to use technology.

Chapter Summary

This chapter presented the analysis of the TPACK-M USA survey in terms of column charts and presented descriptive statistics based on each research question. The analysis of descriptive statistics showed that the junior CCTS students were less confident and prepared for technology use and integration. In contrast, the senior CCTS and the traditional group have rather similar scores in most TPACK constructs, suggesting growth after gaining skills and experience within the program.

The narratives of four research participants were then presented, followed by the study's thematic findings. In response to RQ1, was answered by comparing the descriptive statistics of CCTS and traditional student groups then qualitative findings were reported on how the students felt prepared to use technology. The key findings included students' development of confidence and ease of use of technology, instructional support, transition challenges, and how their learning evolved. In response to RQ2, this chapter answered by comparing the descriptive statistics of CCTS and traditional student groups. A report of findings on the differences students encountered between the two student groups in terms of technology use and integration, as well as their access to and exposure to technology, and their emotional responses to tech use experiences. RQ3 was answered by comparing the descriptive statistics of CCTS and traditional student groups. This chapter then reported findings on how the self-efficacy for technology use and integration of students changed for CCTS students over time. Lastly, RQ4 was answered by comparing the descriptive statistics of CCTS and traditional student groups, followed by reporting findings on field placement technology integration and the perceived usefulness of technology. An analysis of the sample lesson plans confirms the narratives of Angelina and Vanessa, who shared their experiences of integrating technology into their classrooms during field placement.

A discussion of the findings in relation to relevant literature and theoretical frameworks used in the study construction will follow in Chapter V.

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CHAPTER 5: DISCUSSION

This narrative case study aimed to provide CCTSs with an opportunity to share their experiences with technology use and integration, as well as their perceptions of self-efficacy. Narrative case inquiry was chosen as the methodology in this study because it allows for a focus on participants' stories and lived experiences (Clandinin, 2022) and utilizes narratives to understand case data (Sonday et al., 2020).

This chapter interprets the findings from Chapter 4 in relation to the literature reviewed in Chapter 2 and the theoretical frameworks guiding this study. The TPACK framework emphasizes that effective technology integration in teaching requires a balance of content knowledge, pedagogical knowledge, and technological knowledge, and their intersections (Mishra & Koehler, 2006). The TAM model, on the other hand, explains the extent to which individuals intend to use technology, which depends on how useful they believe it to be (PU) and how easy they think it will be to use (PEOU) (Davis, 1989). To situate the technologies examined in this study, the researcher distinguishes between the two roles of technology in the mathematics classroom: Conveyance and math-action. Dick and Hollebrands (2011) described conveyance technologies as digital tools used to transmit or receive information, and they are not math-specific. In contrast, Math-action technologies are digital tools that perform math tasks and respond to users' actions in mathematically defined ways (Dick & Hollebrands, 2011).

The discussion on RQ1 explains how prepared participants feel about using educational technology in their current mathematics education program. Discussion of RQ2 focuses on how the use of technology in mathematics differs between community colleges and the University, as experienced by CCTS. Discussion on RQ3 centers on how self-efficacy for teaching with technology changes for CCTS in their teacher preparation in the program. Lastly, the discussion on RQ3 explains how CCTS uses technology in their classroom teaching during field placements, and how this reflects their self-efficacy and preparedness.

Research Question One

How prepared do community college transfer students feel to use educational technology in their current mathematics education program?

This section reports on findings on how students felt prepared to use technology during their program. The findings in this study indicate that students reported moderate to high levels of preparedness; however, their confidence was uneven across different types of technologies in the survey. The quantitative results showed that CCTS students felt competent in basic technology skills, such as creating PowerPoint presentations, graphs/charts, using a graphing calculator, and creating and editing images, with a median score of 5 across groups. However, junior CCTS reported lower medians (less than 4) for tasks such as creating media presentations and using dynamic software. Comparing the traditional, junior, and senior CCTSs, although the traditional group had higher scores, there was a small difference of less than 0.5 between the traditional and senior CCTS scores. A comparison of the three groups, junior, senior, and traditional, generally showed a rise in scores, suggesting that the longer students stay in the program, the more they grow in their technological knowledge and become prepared to use technology in the classroom.

The qualitative findings support the trend revealed in the quantitative results. For instance, Kendall and Mathew, who are juniors, had limited exposure to technology at the community college. Similarly, Venessa and Angelina had limited exposure to technology but developed significant competence through methods courses and field placements. Initially, as these students transitioned to the university, they had very limited exposure to technology.

However, when juniors and seniors were compared, the senior CCTS were more familiar with various technology tools and had developed significant competence through methods courses and field placements. The CCTS participants began the program with less confidence, but they built their skills and gained confidence through hands-on use and practice of technology. The learning curve was steeper for Angelina, who had to relearn the tools after being away from school for several years.

Participant narratives revealed several trends. Kendall, reflecting on her coursework at South City Community College, admitted that "almost all problems were done by pencil and paper, and the available technology was for conveyance purposes only," leaving her with little digital experience. Mathew, who had used MS Office and a graphing calculator in high school, also reiterated that in community college, everything was done "on paper and pen," with assignments submitted through Blackboard. When he transferred to Wonderful University, he found that everything was done online, prompting him to engage with multiple digital tools. Angelina, a senior student returning to the classroom after several years away from school, experienced a steep learning curve: "I went from not using any of these tools for almost a decade to being introduced to them today and expected to do a whole assignment within the week." Vanessa initially felt "a little intimidated by the technology aspect" because she was "older than most of her classmates". However, she gained confidence as she learned GeoGebra and other software. These excerpts demonstrate how CCTSs entered the program with diverse but limited technology experiences but gradually developed new skills through exposure to technology at the university.

When viewed through conveyance and math-action technology, the survey items and participants reveal distinct patterns. The students reported the highest confidence levels in conveyance technology tasks, such as creating presentations, using graphic calculators, making calculations and charts, and maintaining safe online environments. In contrast, the tasks that elicited the lowest confidence among the junior CCTSs among survey tasks such as using DGS, creating and editing media, selecting technologies for specific tasks and networking with colleagues. These tasks require technologies that facilitate mathematical reasoning, thus aligning with math-action technologies as described by Ertmer et al.(2006) (2007). The participants' narratives further illustrate how these students were able to use some technology tools with ease while they struggled with others. Therefore, understanding the category that a tool falls into helps to explain why students were comfortable with some digital tools but hesitant to use others.

Discussion

The variation in preparedness among participants who transferred from different community colleges reflects the digital divide between community colleges and universities. At the first level, access to technology tools varied. The juniors had been exposed primarily to LMS and the use of calculators, a reflection of first-order barriers -limited access to resources and institutional support (Bingimlas, 2009; Brown, 2020; Hew & Brush, 2007). Second-order barriers also emerged as participants expressed doubts about their ability to use unfamiliar tools, while being unsure of their pedagogical value, aligning with findings on resistance and teacher beliefs regarding new technologies (Stein et al., 2020; Pape & Prosser, 2018).

Additionally, from a TPACK perspective the variation in preparedness also reflects an imbalance in the integration of TK, PK and CK. The CCTSs initially possessed isolated technical skills but a limited understanding of how to connect them to pedagogy and content. This scenario echoes Remillard's (2005) concept of the ability to interpret and repurpose instruction tools rather than simply following prescribed use. Similarly, Thurm and Barzel (2020) found that PD improves teachers' technical confidence but not necessarily their belief systems, underscoring that belief transformation is critical to sustaining TPACK growth.

Participants' experiences showed that extrinsic barriers were more pronounced in community colleges. Extrinsic barriers were defined by Ertmer (2006) as physical factors, including a lack of resources, training, technical support, and time. In contrast, intrinsic barriers include teachers' beliefs and confidence. The university mitigated these barriers by providing software, hardware, and institutional support. Nevertheless, intrinsic barriers remained (Brickner, 1995; Ertmer, 1999; Hume, 2025).

The high self-efficacy and confidence in using technology are attributed to the methods courses, and field experiences that increased their PU and PEOU. From a TAM lens, students' intentions to adopt technology depend on their perceptions of its usefulness and ease of use (Worthington, 2021). The CCTS's practical use of technology in the classroom helped develop their self-efficacy. This finding is consistent with Nelson and Hawk’s (2020) findings, which established that demonstrating the real-world benefits of technology increases the intention to integrate technology.

The growth of senior CCTSs in technology use and integration is a testament to how structured experiences can transform attitudes and competence. Methods courses provided explicit instruction on the use of DGS for exploratory activities. This approach resonates with Niess' (2005) findings, emphasizing that developing TPACK requires four components: a conception of teaching with technology, knowledge of technology-enhanced strategies, an understanding of students' technology-mediated thinking, and familiarity with digital curriculum materials. Participants' accounts show progress from reluctance to use technology to planning technology-embedded lessons.

Research Question Two

How does the use of technology in mathematics differ between community colleges and the University, as experienced by CCTS?

As noted earlier, a digital divide exists between community colleges and universities. To answer RQ2, we delve deeper into explaining the revealed differences in technology use and integration between the community colleges and the university. This research question was not directly answered by the survey administered in this study. Therefore, the researcher explored this topic based on the qualitative data collected through interviews and document analysis. The participants contrasted the technology environments of their community colleges and those of Wonderful University.

The results revealed a clear CCTS' contrast between the technology use and integration experiences of community colleges and those of the university. Technology environments differed substantially between the community colleges and the university. The CCTSs reported limited exposure to math-action technology tools in community college classes, where instruction relied heavily on traditional teaching methods. On the other hand, at the university, these students were exposed to a broader range of digital technology tools throughout their studies. Kendall observed that at South City Community College, she relied heavily on MS Office products and Blackboard. In contrast, at the university, she was expected to switch to Google products and Moodle. She described switching between these technologies as "a bit of a challenge" because she was accustomed to Microsoft Office. Mathew shared that at Renton Community College, almost all classwork was "on pen and paper," but at Wonderful University, "almost everything is done through Moodle," and students were encouraged to take notes on their iPads or laptops. This difference in experiences between the two institutions highlights a confidence gap and a sense of being left behind by the CCTSs.

Interestingly, all the CCTSs who had taken math content courses at the university shared that there had been little use of technology in the math classes. This practice is similar to their experiences in the community colleges. Mathew shared that in the community college, "everything was in pen and paper," just "like it is here at Wonderful University." Although it would be expected that technology integration in teaching and learning would be practiced across all subject areas at the university, this study found that very few math content courses model it. Vanessa described her community college experience as "very kind of old school" while at Wonderful University, she experienced "a night and day difference", using interactive technology tools such as GeoGebra, Desmos, and CODAP for data manipulation and exploration. Finally, Angelina recalled that at Wantam Community College, she only utilized WebAssign and Blackboard for homework without exploring mathematics with technology. Contrasting with her university experience, she observed that at Wonderful, the math Education program "forced me to use the tool as a student and get comfortable with it," exposing her to new technology tools. These reveal the existing institutional gap in technology and pedagogical practices, demonstrating how CCTSs must adapt to unfamiliar technology platforms and software as they transition to the university.

Discussion

The gap between community college and university technology use reflects the differences in mission, funding and infrastructure. Two-year colleges prioritize access and remediation over innovation, restricting investment in math-action technologies (Cullen et al., 2020; Taylor & Jain, 2017). In contrast, universities have more funding, which enables them to acquire cutting-edge tools and provide technology-integrated lessons. The findings of this study reveal a second-level divide in digital skills and usage that hinders the adoption and integration of technology. These findings are consistent with Brown's (2022) findings, which established that the second-level digital divide prevents the domestication of technology.

The contrast between community colleges and the university also reflects the role of instructional design. Although Epper and Baker (2009) proposed that technology must be integrated purposefully into developmental mathematics, the findings of this study showed that there is little evidence of its use to support math learning in community colleges. Notably, in university settings, TPACK is modelled, eradicating extrinsic barriers to technology integration and use. Senior CCTS described purposefully integrating technology into lessons and providing access to quality software and peer support. Modelling the integration of technology in the classroom helps students to develop their TPACK knowledge, thus building their confidence to integrate technology in their future classrooms. These results are consistent with Wallace and Smith's (2022) work, which highlighted the systemic inequities faced by community college students in STEM transfer pathways, including access to and exposure to technology.

Additionally, the small differences between the medians and mean scores of the survey items for the traditional and senior CCTSs suggest that, although the CCTSs initially had limited technology exposure, they had caught up with their traditional counterparts by the time of this study. Therefore, consistently providing students with such opportunities is key for them to learn develop knowledge in student learning. These results are consistent with Ertmer and Ottenbreit-Leftwich (2010) who argued that pre-service teachers need structured, guided practice in using technology for teaching and learning purposes.

In conclusion, this study's findings portray a developmental journey in which the CCTSs transition from limited technology exposure at community colleges to developing skills, increasing competence, and gaining confidence in the university setting. A strong focus on traditional instruction and minimal technology exposure contributed to students entering the university unfamiliar with many emerging technologies.

Research Question 3

How does self-efficacy for teaching with technology change for CCTSs in their teacher preparation in the program?

This research focuses on how the self-efficacy of CCTS has evolved since they enrolled in the university's teacher preparation program. Survey results showed that senior CCTSs reported higher confidence in selecting and using technology for teaching purposes, whereas junior CCTSs reported lower confidence, leading to greater variability between the groups. Also, senior CCTS scored higher on TPK and TPACK items, indicating their readiness to integrate technology into content and pedagogy. Demonstrating this growth highlights the impact of prolonged exposure and practical application, and it justifies continued investment in math methods courses, suggesting that the time spent in the program is a crucial factor in developing self-efficacy.

Use of technology in coursework projects and field experiences increased participants' confidence and competence. Angelina remarked that "the program forced me to use the tool and get comfortable with it", which built her confidence and also taught her to use technology for a clear pedagogical purpose rather than for its own sake. Vanessa confessed that she was "a little intimidated by the technology aspect" at first because she was older than most of their classmates. However, practicing with Desmos and GeoGebra tools — particularly in one of her methods courses, which she described as "mind-blowing" — helped her learn to use them effectively. Likewise, Mathew reported that his perception "has definitely changed" after learning to visualize data with StatCrunch and graphing functions with Desmos. He now feels " he can use technology more in the classroom" and sees multiple ways to leverage digital tools. This progression highlights the significance of experiential learning, which fosters both skill development and confidence in one's abilities.

Self-directed learning and peer support were vital strategies for overcoming anxiety and knowledge gaps. Participants reported learning to use technology through individualized strategies and with the support of peers or instructors. Angelina shared that "I learned on YouTube". Mathew said that he learned about new technologies by tinkering with them. Vanessa, on the other hand, shared that "I had friends who helped me". These strategies suggest that metacognitive and collaborative skills, along with collaborative learning communities, are key components of effective technology integration. These can be cultivated by encouraging students to explore new resources and support networks.

Discussion

Self-efficacy is a crucial factor in the integration of technology (Holden & Rada, 2011). Teachers who believe they can use technology are more likely to do so than those who do not. The results of this study established that after all the CCTSs had engaged with technology in their coursework, they were willing to integrate it into their future classrooms in the field. This aligns with Koehler & Mishra's (2009) emphasis on integrating technological, pedagogical, and content knowledge within the TPACK framework. When students developed TPK and TCK through coursework, they learned the importance of technology in shaping perceptions of its usefulness for enhancing conceptual understanding.

The findings of this study showed that growth in teaching with technology followed a developmental trajectory for several participants. Initially, in their early years in the program, participants viewed technology as a technical skill rather than a pedagogical tool. However, as the CCTSs progressed and engaged with the tools in methods courses, such as teaching mathematics with technology, their perception of technology shifted from a technical skill to a pedagogical tool. These results are consistent with Bandura's (1997) self-efficacy theory, which suggests that mastery and vicarious experiences are sources of self-efficacy. Self-efficacy increases after completing a task. These participants engaged with the tools and mastered their use, thereby improving their self-efficacy in using technology.

A comparison of Junior and senior CCTSs showed that seniors, having completed all methods courses and engaged in field placement teaching, viewed technology perceived technology as useful. Although they encountered challenges, they persisted and managed to implement its use in the classroom. This finding is consistent with earlier research, which has shown that teachers with high self-efficacy are more likely to implement the use of digital tools and persist in the face of challenges (Ertmer & Ottenbreit-Leftwich, 2010; Kent & Giles, 2017).

Across participants, self-efficacy showed mixed results. Some of the experiences reported by students on their teaching placement suggested low confidence, with some participants citing classroom management as a significant impediment. This finding supports Rocha's (2020) claim that preservice teachers need consistent, scaffolded opportunities across coursework and fieldwork to sustain themselves during technology integration.

Research Question 4

How do CCTS use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?

To answer this research question, the researcher explored the experiences of senior CCTSs as they integrated technology in their field placement classes. The findings in this study indicate that field placement also played a significant role in shaping the preparedness and self-efficacy related to technology use. When the CCTSs taught using technology, they progressed from a theoretical understanding of its use to practical application in a real classroom setting. The survey findings show that the senior CCTSs scored averages above 4. Generally, these results indicate that their self-efficacy and preparedness to use technology are higher than those of the junior CCTSs. In the qualitative findings, the senior CCTSs narrated how they navigated using both conveyance and math action technology in their field placement classes.

Vanessa reported positive experiences, citing a supportive cooperating teacher who encouraged her to experiment and model technology integration. She used clicker cards and Desmos to monitor students and provide them with immediate feedback. In contrast, Angelina initially struggled to balance classroom management with technology use; she feared losing control because she could not see what students were doing when using computers. However, through practice and guidance, she learned to leverage teacher-monitoring features in math action tools like Desmos and gradually incorporated technology into her classroom. Both senior CCTSs recognized the value of technology for student engagement, differentiation and formative assessment. They also planned to use technology in their future classrooms.

The participants' stories are a testament to concrete examples of how technology tools were used. Angelina explained that she alternated between using Google Slides and projecting the workbook for students to follow along. These experiences of CCTSs suggest that when given opportunities, student teachers can utilize multiple technologies to support diverse instructional purposes, thereby illustrating the practical application of TPACK, which aligns with actual system use (ASU) in the TAM model.

The participants' reports indicated that their confidence was also strongly influenced by the practices of their mentors. For instance, Vanessa recounted that her cooperating teacher introduced her to new technology tools, such as clicker cards. When she was to teach using Desmos, her cooperating teacher only "looked over it to ensure that it was appropriate to use," but also assured her that she would build her confidence with practice. Whereas Vanessa was quick and willing to try using technology in her classroom, Angelina initially avoided math-action tools out of fear of losing control in the classroom. However, Angelina later leveraged the Desmos teacher monitoring feature to keep the students on task. The relationship between Vanessa and her cooperating teacher highlights the importance of mentors in helping new teachers transition to the field.

Vanessa also said that she had received support from her university supervisor during her teaching placement. She acknowledged the feedback she received anytime she consulted her supervisor on issues related to lesson planning and teaching. As pre-service teachers are observed during teaching placements, the goal is always to see them model the theoretical practices taught in class and to develop their classroom practice as they begin their teaching journey. These findings align with Dalling-Hamond's (2012) work, which suggests that when integrated with university coursework and program goals, field experiences are highly effective. The reflections of the participants portray the field teaching placement as a space of opportunity. It is therefore important to establish strong partnerships between the university and schools to ensure consistency between the program's emphasis on technology integration and the practices the CCTSs observe and participate in within real classrooms.

In the first interview, both Angelina and Vanessa shared that they planned to use technology in their classrooms. Angelina was positive about future technology use, saying, "I will probably use it in my own classroom a lot more than I did in my field experience, just because I know there are other tools such as Quizziz, which I never got to use." She is willing to try out new technology tools, indicating a high propensity to adopt technology. Likewise, Vanessa believed "I see it (referring to technology) just like a benefit, you know, like use it to enhance a lesson or use it to introduce something, a new concept, but definitely not just to use it, just to use it like for sure, like with the purpose behind it." Vanessa viewed technology as a conceptual tool as she thought about its future use. Although the frequency and timing of technology use differed between the two students, their lesson plans demonstrate the use of both conveyance and math-action technologies. The positive experiences CCTSs had during field placements fostered their intentions to continue using technology beyond field placement. In teacher preparation, sustained adoption is key; this suggests that authentic practice not only builds competence but also shapes long-term teacher practices.

Although this study shows that students experienced some growth in the use and integration of technology, it also reveals some difficulties encountered by the CCTSs. This revelation suggests that exposure to technological tools does not automatically translate into technological know-how and proficiency across all technologies. For instance, although Angelina had some familiarity with CODAP and attested to its visual capabilities, she desired to use it. Still, she testified that she needed more practice before she could use it with the students. Additionally, the participants' intentional use of technology in placement classrooms demonstrates that self-efficacy extends beyond confidence in using technology tools to include making instructional decisions daily.

Discussion

The self-efficacy of senior CCTSs in technology use and integration increased as they engaged with technology by observing their cooperating teachers in action. This is consistent with Bandura's theory (1986), which proposes vicarious experiences as one of the sources of self-building experiences. During vicarious experiences, individuals build their self-efficacy by observing others (Brown, 2022)

Field placement provides opportunities for PSMT to develop their TPACK knowledge. By designing and delivering technology-integrated lessons, PSMT transitioned from a theoretical understanding to a practical application of their skills, thereby increasing their self-efficacy. This finding is consistent with Bandura's (1986) claim that practicing and accomplishing an activity increases one's self-efficacy. Additionally, when students recognize the power of technology to monitor and engage learners and differentiate instruction, their PU and PEOU increase, strengthening their intention to use technology, thus supporting Worthington's finding that changing an individual's salient behavior also changes their PU. Conversely, without support, PSMTs may be reluctant to integrate technology into their classes, as revealed by one of the senior CCTSs, who took a long time to use technology in her class because she was struggling with class management until she received support from her cooperating teacher. This finding is consistent with Stein et al.'s (2020) assertion that novice teachers may revert to traditional modes of teaching methods if they lack support.

Lastly, the results of this study highlight the importance of motivation during field placement. Venessa, a Senior CCTS, was encouraged by her cooperating teacher to "experiment and persist at least three times". In contrast, Angelina had different experiences with little support, which is a disparity in levels of support. The inconsistencies in mentor experiences underscore the need for mentor training that supports the proposal for standardized mentor training (Bozkurt, 2016; Dockendorff & Zaccarelli, 2024).

Implications

The major goal of this study was to investigate the experiences of CCTSs in technology use and integration in a mathematics teacher preparation program. To effectively serve this population, their perceptions and narratives should be taken into consideration when designing mathematics teacher preparation programs. The implications for community colleges and teacher preparation programs are presented in the next section, based on the participants' narratives.

For Teacher preparation programs

Based on the findings, the researcher proposed the following recommendations for teacher preparation programs.

Bridging the digital divide for CCTSs.

The findings indicated that not all the CCTSs had access to personal technological devices. Although it is easy to assume that all students who enroll at the university own personal computing devices, this may not be true. Specifically, Mathew shared his experiences and was grateful to a fellowship program that had given him his first tablet ever. Therefore, CCTSs could be provided with early access to technology devices and software to mitigate the first-level and second-level divide. This could be done through orientation or nonformal, or bridge courses before this group of students begins using the tools in their classes. This will help reduce transition pressure and the cognitive overload reported by seniors.

Integrating Technology into content courses.

All participants attested to having taken math content courses, and no math action technology tools were used for manipulative purposes; instead, they were used solely for computational purposes. Although there may not be a specific policy on when and which subject areas to integrate technology, it can be assumed that, in this digital age, instructors should integrate technology into their subject areas.

Consequently, when the CCTSs proceed to the field, they are expected to use technology, yet they do not see the tools being modelled. Suppose math action technology is modelled in both content and methods courses at all levels. In that case, students will develop technology-use and integration skills at each level without waiting for methods courses. This integration will enable students to develop their skills through hands-on activities using both conveyance and math action tools relevant to various areas of mathematics, such as algebra, geometry, and statistics, thereby reinforcing the purposeful use of technology.

Transitional advice for CCTSs enrolling in Four-year MTEPP

The experiences of CCTSs in this study revealed that they encountered challenges during their transition. Whereas some had some technological background knowledge, others faced difficulties learning to use new technologies and identifying resources that could have made their transition seamless had they been aware of them. Therefore, my advice to any new students transitioning from the CC is that numerous resources are available at the university, accessible through the websites, monthly newsletters sent to their email, and workshops offered by various university stakeholders.

For Community Colleges

Based on the findings, the researcher proposed the following recommendations for teacher preparation programs.

Strengthening Transfer pathways between community colleges and universities.

The large disparities in technology exposure between community colleges and universities *led CCTSs to transition to universities, often underprepared to handle the university curriculum, particularly in* technology use and implementation. In the analysis, it was revealed that Seniors like Venessa described themselves as “intimidated by the technology aspect” of GeoGebra and Desmos. The juniors, like Mathew, felt a steep learning curve as they transitioned from pen and paper to technology-rich environments.

Community college-university partnerships.

Although this study found that technology use is limited in community colleges, some have articulation agreements with universities. These collaborations can involve aligning curricula and sharing resources, which helps students transfer more smoothly from community colleges to universities. Such efforts could include joint faculty training and the sharing of technology resources, such as software licenses, to provide community college students with access to tools they might not otherwise encounter. According to Chiu (2022)Providing teachers with a supportive, skill-building environment enhances the quality of technology integration. For example, the C3 agreement between Venessa’s community college and the university allowed her to access the virtual computer lab. Expanding access to such resources will greatly improve students’ opportunities to learn about technology.

Embedding targeted Technology use across coursework.

The study's findings showed that the students knew technology cannot be used arbitrarily, but rather to support mathematical conceptual understanding. While Mathew was reflecting on his use of technology, he appreciated how pen-and-paper and technology complement each other, noting that the verification of solutions to a problem was different until he discovered that the Desmos calculator was doing premature rounding. Interestingly, Angelina and Venessa also noted that the use of Desmos should help students focus on mathematical concepts.

Contributions to the field

The results of this narrative case study make several contributions to mathematics education, expanding the existing literature on integrating technology into mathematics education.

First, this study sheds light on an underexplored student population in four-year colleges and universities. By focusing on CCTSs, this study fills a gap in research on how transfer students adapt to new technological tools. The results indicate a significant change in resource access, technology use, and instructional styles.

Second, the cross-case analysis revealed a contrast between the technological environments in community colleges and universities, highlighting an existing institutional digital divide. In this study, participants described how community colleges rely heavily on LMSs and graphing calculators. In contrast, universities have technology such as Desmos, StatCrunch, and GeoGebra integrated into mathematics education courses.

Third, this study offers suggestions to inform program design. These suggestions include pairing junior CCTSs with mentors, offering technology bridging workshops to CCTSs, and fostering CC-university partnerships to align technological expectations. The recommendations can help teacher preparation programs to actualize technology integration.

Lastly, this study's findings reinforce the importance of TPACK and encourage teacher educators to emphasize the purposeful use of technology in the mathematics classroom. In this study, participants chose technologies based on their goals rather than for convenience.

Recommendations for Future Research

While conducting this study, several future research projects emerged from the research questions and findings. This study focused on investigating CCTSs' experiences with the use and integration of technology in a single math teacher preparation program. However, it was limited to a single semester, insufficient time to observe the growth of student teachers as they progressed through the program over multiple years. Additionally, four participants were interviewed, all from a single university in the same state. The study would also have been enriched by adding observations of student teachers in action at their placement schools. After reflecting on my study and embracing its limitations, several new research ideas emerged.

First, the findings of this study revealed that student teachers continue to make deliberate decisions in their use and integration of technology. Future research can therefore examine how such pedagogical judgment develops over time and how it influences student outcomes.

Secondly, a similar narrative case study can be expanded to several universities and states. The results would determine whether the differences between groups are significant.

Third, the experiences of two participants in this study revealed that age and non-traditional factors can affect learning about technology. Therefore, research can examine how factors such as digital literacy, age, and prior career experience influence self-efficacy.

Lastly, self-efficacy can best be studied over a longer period. Therefore, a similar study can be conducted by investigating cohorts of CCTSs from their entry into the program through their completion of the math teacher preparation program. Such a study would help to establish the CCTS's self-efficacy development over time.

Conclusion

The findings show how the technological journey of the CCTSs is an intertwined evolution of beliefs and skills. Their growth from limited exposure to adaptive technology integration demonstrates that teacher preparation goes beyond access and training. The CCTSs engage in meaning-making and curriculum interpretation within an evolving digital ecosystem. Through sustained mentorship, belief transformation, and reflective enactment, CCTSs not only develop their competence but also the agency to teach mathematics with technology in transformative ways.

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APPENDICES

Appendix A: Mathematics Education courses

Area	Course
Introduction to Education	ED 100 Intro to Education
Computing	E 115 Introduction to Computing Environments or COS 100 Science of Change
	CSC 112 Introduction to Computing-FORTRAN, or CSC 116 Introduction to Computing – Java, or MA 116, Introduction to Scientific Programming (Math
Communication	ENG 101 Academic Writing and Research
	COM 112 Interpersonal Communication)
Mathematics core courses	MA 141 Calculus 1
	MA 141 Calculus 1
	MA 241 Calculus II
	MA 242 Calculus III
	MA 225 Foundations of Advanced Mathematics
	MA 351 Introduction to Discrete Mathematical Models or MA 341 Applied Differential Equations I,
	MA 403 Introduction to Modern Algebra
	MA 408 Foundations of Euclidean Geometry.
Statistics	ST 307 Introduction to Statistical Programming – SAS, ST 311 Introduction to Statistics, and ST 312 Introduction to Statistics II
Professional courses	EMS 204 Introduction to Mathematics Education
	ED 204 Introduction to Teaching in Today's Schools
	EDP 304 Educational Psychology
	ELP 344 School and Society
	ECI 305 Equity and Education
	EMS 480 Teaching Mathematics with Technology

Mathematics Education courses continued

	ED 311 Classroom Assessment Principles and Practices
	ED 312 Classroom Assessment Principles and Practices Professional Learning Lab
	EMS 472 Teaching Mathematics Topics in Senior High School
	EMS 470 Methods and Materials for Teaching Mathematics
	EMS 471 Student Teaching in Mathematics
	EMS 490 School Mathematics from an Advanced Perspective
	EMS 495 Senior Seminar in Mathematics and Science Education
	ECI 416 Teaching Students with Disabilities in Inclusive Classrooms
GEP Courses	GEP Humanities,
	GEP Health and Exercise Studies,
	GEP Interdisciplinary Perspectives,
	GEP Global Knowledge (verify requirement), and World Language Proficiency (verify requirement)

Appendix B: Recruitment Email

Hello {{First Name}},

My name is Nixon Igunza, and I am a doctoral candidate in mathematics and Statistics

education program at North Carolina State University. I am writing to request participation in my dissertation research. This study focuses on Investigating Technology Use and Integration: Experiences Among Community College Transfer Students in a Mathematics Education Teacher Preparation Program. This survey will provide insights into the experiences of seniors enrolled in the undergraduate math education program. During my studies I have interacted with students in the technology math education courses. I got interested in learning about the experiences of community college transfer students in the program from the time of admission to their teaching placements period.

To be selected for inclusion in this study, participants must meet the following criteria:

(a) A senior enrolled in the undergraduate math education program at NC State University, and
(b) Be over the age of 18.

Participants who complete the study will be compensated with **a $20 Amazon gift card**. To begin the survey, use this link: https://ncsu.qualtrics.com/jfe/form/SV_bJkykHGrDEYWuQS

.If selected, you will also have a 1-hour interview with me through ZOOM.

If you have any questions while participating in this study, please contact me, Nixon

Igunza at noigunza@ncsu.edu by email or 984-810-9887 by phone.

Thanks in advance for your participation.

Warm regards,

Nixon Igunza

Appendix C: Participant Consent Form

You are being asked to participate in this survey for research purposes only. The survey is about Preservice teachers' experiences using and integrating into the math teacher preparation program. Participation in the study is voluntary, and you can withdraw at any time.

To participate in this study, you must be 18 years or older and a current senior enrolled in a math education course at a large research institute. There are minimal risks associated with your participation in this survey. After the survey, a follow-up interview with a few selected participants about their use and integration of technology experiences was be conducted. If you have any questions, reach out to Nixon Igunza via the email noigunza@ncsu.edu. Or phone number 984 810 9887. You may also contact his supervisor Dr. Robin Anderson via the email randers6@ncsu.edu.

If you have any questions or concerns during the study, please contact the NC State University IRB director at IRB-Director@ncsu.edu or 919 515 8754. If you consent to participate in the study, please click the next page button (the real one had an active "next button").

Appendix D: Survey: (TPACK-M Survey)

Please answer all of the questions by choosing strongly to disagree (1), disagree (2), neither agree nor disagree (3), agree (4), or strongly agree (5). If you are uncertain of or neutral about your response, you may always select "Neither agree nor disagree (3)".

Demographic Information

1. a) Did you transfer from a community college?

☐Yes ☐No

b) If yes, how many years did you attend?

☐ 1 yr ☐ 2 yrs ☐ More than 2 yrs

2. Please indicate your major ____

TPACK Items

Please answer all the questions by choosing strongly to disagree (1), disagree (2), neither agree nor disagree (3), agree (4), or strongly agree (5). If you are uncertain of or neutral about your response, you may always select "Neither agree nor disagree (3)".

Please rate the following statements in terms of how much you agree or disagree with each statement.

I am able to use technology to ....

Table D.1:
TPACK-M USA survey instrument

Technological Knowledge (TK)	
3. Create a PowerPoint presentation.	☐SD ☐ D ☐N ☐A ☐SA
4. Make calculations on a spreadsheet.	☐SD ☐ D ☐N ☐A ☐SA
5. Create charts/graphs.	☐SD ☐ D ☐N ☐A ☐SA
6. Locate and evaluate online resources and/or math software applications.	☐SD ☐ D ☐N ☐A ☐SA
7. I know about a lot of different technologies.	☐SD ☐ D ☐N ☐A ☐SA
8. Use dynamic geometry software (e.g., GeoGebra, Geometer's Sketchpad).	☐SD ☐ D ☐N ☐A ☐SA
9. Use a graphic calculator.	☐SD ☐ D ☐N ☐A ☐SA
10. Create and edit simple images (e.g., Canva, Photoshop).	☐SD ☐ D ☐N ☐A ☐SA
11. network with other colleagues and professional associations using social media.	☐SD ☐ D ☐N ☐A ☐SA
	☐SD ☐ D ☐N ☐A ☐SA

Table D.1:
TPACK-M USA survey instrument continued

12. Select and use specific technologies suiting a particular teaching strategy or goal.	☐SD ☐ D ☐N ☐A ☐SA
13. Create and maintain a positive and safe online learning environment.	☐SD ☐ D ☐N ☐A ☐SA

14. Teach a concept using an interactive whiteboard.	☐SD ☐ D ☐N ☐A ☐SA
15. To teach a section of the curriculum through the use of web resources.	☐SD ☐ D ☐N ☐A ☒SA
16. Use mobile devices (e.g., iPad, smartphone) in teaching.	☐SD ☐ D ☐N ☐A ☐SA
17. Create digital learning sequences with sound and video.	☐SD ☐ D ☐N ☐A ☐SA
18. Manage students' behavior effectively when using various technologies.	☐SD ☐ D ☐N ☐A ☐SA
19. guide students in creating their own media presentations.	☐SD ☐ D ☐N ☐A ☐SA
20. Use ICTs (information and communication technologies)/conveyance technologies to cater for diverse learning styles and ability levels.	☐SD ☐ D ☐N ☐A ☐SA
21. Provide students with alternative forms of assessment.	☐SD ☐ D ☐N ☐A ☐SA
22. Develop students' research skills.	☐SD ☐ D ☐N ☐A ☐SA

Technological Pedagogical Content Knowledge (TPACK)

23. Adhere to copyright while accessing third-party online resources.	☐SD ☐ D ☐N ☐A ☐SA
24. engage students critically analyzing online texts or images.	☐SD ☐ D ☐N ☐A ☐SA
25. Help students develop their problem-solving skills.	☐SD ☐ D ☐N ☐A ☐SA
26. represent mathematical problems where symbolic, numerical and graphical data can be linked.	☐SD ☐ D ☐N ☐A ☐SA
27. foster higher-order mathematical thinking skills (e.g., proving, inferring, estimating, explaining, conjecturing, predicting).	☐SD ☐ D ☐N ☐A ☐SA
28. Bridge the gap between in-school and out-of-school mathematics.	☐SD ☐ D ☐N ☐A ☐SA
	☐SD ☐ D ☐N ☐A ☐SA

Table D.1:
TPACK-M USA survey instrument continued

29. promote substantive student communication in the classroom (e.g., class discussion on multiple methods of solving a problem).	☐SD ☐ D ☐N ☐A ☐SA
30. Integrate the study of mathematics with content from other key learning areas (e.g., English, Arts, Science, History).	☐SD ☐ D ☐N ☐A ☐SA
31. Deal appropriately with students' mathematical misconceptions by simulating concrete situations.	☐SD ☐ D ☐N ☐A ☐SA
32. Support students' mathematical investigations with digital collection tools.	

Q5. End of Survey

Name (First and Last) …………………………………………..

Email ……………………………………………

Appendix E: Qualitative Semi-Structured Interview Guide

Interview 1

Introduction:

The researcher thanked the participants for their time and explained the purpose of the interview as a follow-up to the survey. Emphasis was placed on making the participants understand that the goal is to gain a deeper understanding of their experiences with technology use and integration in their mathematics education teacher preparation program.

Section 1: Preparedness for Using Technology

1. In the survey, you indicated that you felt (prepared/not prepared) to use educational technology when you entered the program. Can you expand on that?

2. What specific experiences in community college prepared you to use technology in your mathematics education courses?

3. How has your preparedness to use technology evolved since you enrolled in the teacher preparation program?

Section 2: Differences in Technology Use Between Community College and University

4. Can you describe the differences you noticed in how technology was used in your community college versus university?

5. How did these differences impact your learning and confidence in using technology for teaching?

6. Were there any challenges in adapting to the technology used at the university?

7. Can you describe how you have integrated technology into your classroom teaching during field placements?

8. How do you think your use of technology reflects your readiness and confidence as a teacher?

9. Is there anything else related to technology use and integration you would like to share?

Interview 2

Researcher/Interviewer: Nixon Igunza

Date: ______________________

Scheduled Time: _____________

Start Time: __________ End Time: ___________

Researcher: Thank you for taking the time to talk with me today. As you know, the purpose of the study is to explore the experiences of technology use and integration among community college transfer students in the mathematics education teacher preparation program. The researcher's aim is that this study will provide insights that will have implications for teaching practices and preparation.

Throughout this interview, I will ask you questions about your experiences with technology use and integration. Please refrain from sharing names or other identifying information about others. I may ask you to elaborate or clarify responses to questions. Please feel free to ask me for

clarification at any point during the interview process if questions are unclear

1. How has your confidence in teaching with technology changed from when you entered the program to now, during your field placement? What parts of the teacher preparation program (e.g., courses, projects, peer collaboration) most influenced your growth in this area?
2. How have you been using technology in your current classroom teaching during field placement?
3. What decisions do you make when choosing whether and how to use a particular tool (e.g., Desmos, CODAP, Google Slides)?
4. How do you think your use of technology during field placement reflects your preparedness and confidence as a future teacher?
5. Have your mentor teacher or field supervisor provided feedback or support related to your technology use? What did you learn from that?
6. What constraints or challenges have you encountered in trying to use technology in a real classroom setting (e.g., student behavior, access, time)?
7. Is there a time when using technology didn't work as expected? What did you learn from that experience?
8. Thinking back to your early experience at community college, how do you now view your journey with technology in teaching?
9. What areas do you still want to improve when it comes to using technology as a math educator?
10. How do you see yourself using technology in your future classroom after you complete the program?

Researcher: Thank you again for taking the time to participate in this interview. During the data analysis process, you will be provided with the opportunity to review your transcript and any code generated from it to ensure accuracy. You will be compensated with a $20 Amazon gift card for completing the survey and another $20 Amazon gift card for participating in the interview if you are selected for the second phase of the study. Please don't hesitate to contact me or Dr. Robin Anderson if you have any questions at any time.

Appendix F: Lesson plans request email

Hello ………….,

Thank you for accepting to participate in my study and for your availability for the interviews. Finally, I am requesting a sample of your lesson plans so I can review how you have used technology in your classes during your teaching placement. Feel free to share as many as possible. None of the personal details will appear in my study. You can reply to this email and attach the files or share via Google Drive.
I look forward to hearing from you.

Warm Regards,

Nixon Igunza

Appendix G: Survey protocol matrix

Table G.1:
Survey Protocol Matrix mapping research and interview questions

	Background information	RQ1: How prepared do transfer students feel to use educational technology in their current mathematics education program?	RQ2: How does the use of technology in mathematics differ between community colleges and the university, as experienced by transfer students?	RQ3: How does self-efficacy for teaching with technology change for transfer students in their teacher preparation in the program?	RQ4: How do transfer students use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?
Q1: a) Did you transfer from a community college? b) If yes, how many years did you attend?	X				
Q2: Please indicate your major	X				
Q3. Create a PowerPoint presentation.		X			
Q4. Make calculations on a spreadsheet.		X			

Table G.1:

Survey Protocol Matrix mapping research and interview questions continued

Q5. Create charts/graphs.	X	
Q6. Locate and evaluate online resources and/or math software applications.	X	
7. I know about a lot of different technologies.	X	
8. Use dynamic geometry software (e.g., GeoGebra, Geometer's Sketchpad).	X	
9.use a graphic calculator.	X	
10. Create and edit simple images (e.g., using Canva or Photoshop).	X	
11. network with other colleagues and professional associations using social media.		X
12. Select and use specific technologies suiting a particular teaching strategy or goal.	X	X

Table G.1:
Survey Protocol Matrix mapping research and interview questions continued

13. Teach a concept using an interactive whiteboard.	X	X
14. To teach a section of the curriculum through the use of web resources.		X
15. Use mobile devices (e.g., iPad, smartphone) in teaching.		X
16. Create digital learning sequences with sound and video.		X
17. Manage students' behavior effectively when using various technologies.		X
18. Guide students in creating their own media presentations.		X
19. Use ICTs (information and communication technologies)/conveyance technologies to cater for diverse learning styles and ability levels.		X
20. Provide students with alternative forms of assessment.		X

Table G.1:
Survey Protocol Matrix mapping research and interview questions continued

21. Develop students' research skills.	X
22. Adhere to copyright while accessing third-party online resources.	X
23. Engage students critically analyzing online texts or images.	X
24. Help students to develop their problem-solving skills.	X
25. Represent mathematical problems where symbolic, numerical and graphical data can be linked.	
26. Foster higher-order mathematical thinking skills (e.g., proving, inferring, estimating, explaining, conjecturing, predicting).	X
27. Bridge the gap between in-school and out-of-school mathematics.	X

Table G.1:
Survey Protocol Matrix mapping research and interview questions continued

28. Promote substantive student communication in the classroom (e.g., class discussion on multiple methods of solving a problem).		X
29. Integrate the study of mathematics with content from other key learning areas (e.g., English, Arts, Science, History).		X
30. Deal appropriately with students' mathematical misconceptions by		X
31. Simulating concrete situations.		X
32. Support students' mathematical investigations with digital collection tools.	X	X

Appendix H: Interview Protocol Matrix
Table H.1:
Interview 1 protocol mapping interview to research questions

	RQ1. How prepared do transfer students feel to use educational technology in their current mathematics education program?	RQ2. How does the use of technology in mathematics differ between community colleges and the university, as experienced by transfer students?	RQ3. How does self-efficacy for teaching with technology change for transfer students in their teacher preparation in the program?	RQ4. How do transfer students use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?
Q1. In the survey, you indicated that you felt (prepared/not prepared) to use educational technology when you entered the program. Can you expand on that?	X			
Q2. What specific experiences in community college prepared you to use technology in your mathematics education courses?	X			

Table H.1:

Interview 1 protocol mapping interview to research questions continued

Q3. How has your preparedness to use technology evolved since you enrolled in the teacher preparation program?	X	
Q4. Can you describe the differences you noticed in how technology was used in your community college versus the university?		X
Q5. How did these differences impact your learning and confidence in using technology for teaching?		X
Q6. What challenges did you face in adapting to the technology used at the university?		X

Table H.1:

Interview 1 protocol mapping interview to research questions continued

Q7. Can you describe how you have integrated technology into your classroom teaching during field placements?	X	
Q8. Can you share a moment when you felt particularly successful or challenged while using technology during your coursework?		X
Q9. How has your confidence in using technology for teaching changed since you transferred to the university?		X
RQ10. Can you describe any specific moments or experiences during your teacher preparation that boosted your confidence in integrating technology?		X

Table H.1:

Interview 1 protocol mapping interview to research questions continued

RQ.11. Are there areas related to technology use where you feel you need more practice or support?	X			
	RQ1. How prepared do transfer students feel to use educational technology in their current mathematics education program?	RQ2. How does the use of technology in mathematics differ between community colleges and the university, as experienced by transfer students?	RQ3. How does self-efficacy for teaching with technology change for transfer students in their teacher preparation in the program?	RQ4. How do transfer students use technology in their classroom teaching during field placements, and how does this reflect their self-efficacy and preparedness?
1. How has your confidence in teaching with technology changed from when you entered the program to now, during your field placement? What parts of the teacher preparation program (e.g., courses, projects, peer collaboration) most influenced your growth in this area?	X	X		

Table H.1:

Interview 2 protocol mapping interview to research questions continued

2. How have you been using technology in your current classroom teaching during field placement?		X
3. What decisions do you make when choosing whether and how to use a particular tool (e.g., Desmos, CODAP, Google Slides)?		X
4. How do you think your use of technology during field placement reflects your preparedness and confidence as a future teacher?		X
5. Have your mentor teacher or field supervisor provided feedback or support related to your technology use? What did you learn from that?	X	
6. What constraints or challenges have you encountered in trying to use technology in a real classroom setting (e.g., student behavior, access, time)?		X
7. Is there a time when using technology didn’t work as expected? What did you learn from that experience?		X

Table H.1:

Interview 2 protocol mapping interview to research questions continued

8. Thinking back to your early experience at community college, how do you now view your journey with technology in teaching?	X		
9. What areas do you still want to improve when it comes to using technology as a math educator?	X		
10. How do you see yourself using technology in your future classroom after you complete the program?			X