6-6-2024

High School Teachers’ Perceptions of the Challenges of Integrating Technology in Math Instruction

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This is to certify that the doctoral study by

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has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

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Walden University
2024

Abstract

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EdS, Arkansas State University, 2018

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

P-20 Self-Designed

Walden University

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Abstract

Although teachers agree that technology is beneficial for enhancing math education and pedagogy, there are concerns about incorporating technology into their teaching practices. The problem addressed in this study was that high school teachers are challenged to integrate technology into math instruction. The purpose of this basic qualitative study was to explore high school teachers' perceptions of the challenges in integrating technology into math instruction to answer the research questions regarding those challenges and viable strategies for infusing instructional technology into math classrooms. The theoretical framework was based on the technological pedagogical content knowledge framework, which combines content knowledge, technology knowledge, and pedagogy knowledge into a comprehensive model leading to efficient technological instructional processes. Data were collected from 10 high school math teachers in Tennessee using semistructured interviews. Data were analyzed using coding and thematic analysis, which revealed that teachers face barriers such as resource shortages and students' reluctance toward technology in math classes. The results uncovered challenges for Tennessee high school teachers with integrating technology into math instruction. Conclusions present available tools and strategies, address response bias in future research, and provide implications for educational professionals, teachers, students, and society. This study may contribute to positive social change by guiding educational experts in designing math programs for technology-rich classrooms and fostering responsible digital citizenship in students.

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Dedication

I dedicate my doctoral study to my beloved family, whose unwavering encouragement has been a constant source of motivation for me to persevere and work diligently. Your love and support have been the foundation upon which I have built this academic journey, and I am profoundly grateful for your presence every step of the way.

A heartfelt thank you goes to my daughter, whose faith in me never wavered. Her frequent words of encouragement, “You can do it,” provided a much-needed boost during challenging times. She dreamed of the day she could proudly call me “Dr. Mom,” and her belief in my abilities has been incredibly inspiring.

To my entire family, I owe my deepest gratitude. Your patience, understanding, and love have made this achievement possible. I love you all more than words can express, and I share this accomplishment with each of you.

Acknowledgments

I thank my Lord and Savior, Jesus Christ, for granting me the strength, opportunity, and determination to achieve this significant milestone in my educational journey.

I can do all things through Christ who strengthens me. [Philippians 4:13]

Special thanks to my committee chair, Dr. John Harrison, and committee member, Dr. Emily Green, for their unwavering support.

Table of Contents

List of Tables

Chapter 1: Introduction to the Study

Technology integration contributes significantly to mathematics instruction. Pedagogy and skill levels should be considered for integrating technology while developing mathematical literacy (Novita & Herman, 2021). As technology use increases in schools, teachers need digital competence training to teach students mathematics (Rodríguez-Muñiz et al., 2021). Becoming digitally competent is more pressing than some issues in the education system (Shonfeld et al., 2021). The current basic qualitative study explored the challenges high school teachers face in using and adopting technology in math instruction. This study was conducted because research on teachers had focused on technology integration and its impacts, technology use, and teachers' beliefs about technology (Thurm & Barzel, 2021). Limited information was available regarding the challenges secondary mathematics teachers face in using and adopting technology in instruction.

Educational professionals have the potential to cultivate a comprehension of the technological tools utilized within high school mathematics classrooms as a result of this research and its significance. As a result of this study, all stakeholders may develop a more profound understanding of the need for technology use in the math classroom. Additionally, this study may promote positive social change for students, allowing them to critically analyze and evaluate information, solve complex problems, and think creatively using digital tools. Students can create digital content, explore innovative solutions, and express their ideas through multimedia, fostering creativity and innovation skills (James et al., 2021).

This chapter provides a brief introduction and background on the topic. The research problem and purpose are also presented. The study was guided by the research questions discussed in this chapter. This chapter includes an introduction to the theoretical foundation of the research and the methodological nature of the study. The key terms, delimitations, and assumptions of the study are highlighted in Chapter 1. Finally, this chapter includes the significance of the study, along with a summary of the chapter.

Background

American society is moving from digital literacy to digital competency (Falloon, 2020). Teachers train to effectively incorporate technologies in teaching and learning, aiding in developing students' digital literacy as a traditional approach; however, it has become essential for teachers to further develop their digital competency (Fulgence, 2020). Digital competence is the effective use of digital technologies to communicate, solve problems, and gather information at work, while learning, and while participating in all aspects of life (Ilomäki & Lakkala, 2018). Technology integration in education refers to using technology tools, resources, and strategies to enhance and support the teaching and learning process (H. Chen et al., 2019).

Although digital competency is familiar, many teacher programs are still developing ways to identify the necessary skills to be digitally competent and encourage technology integration (Fulgence, 2020). The International Society of Technology Education (ISTE, 2017) recognized teaching standards to ensure digital competency is evident in classrooms across the K through 12th-grade band. The standards focus on preparing students to drive their learning while deepening teacher practice, promoting peer collaboration, and challenging teachers to rethink traditional approaches (ISTE, 2017).

The current study addressed a gap in practice regarding digital literacy development and teacher digital competence adoption as a learning delivery model for students. In terms of instructional practice, the goal of the study was to assist in addressing teacher digital competence and consider viable ways to infuse technology into math classroom instruction. Encouraging digital literacy among educators and learners has become an appropriate approach to dealing with learning gaps in math classrooms; its implementation must be more systematic, leading to efficient changes (Falloon, 2020).

The current study was needed because educators and decision makers should be informed regarding incorporating technological teaching practices in high school math. In addition, the study may assist educational professionals in designing mathematics education programs that address the needs of students in high school math technology-enriched classrooms. This study explored high school teachers' perceptions of the challenges in integrating technology into math instruction and discussed viable ways to improve those challenges. This study could advance the current understanding of digitally motivated teaching and learning effectiveness in high school math.

Problem Statement

The problem that was addressed through this study was that high school teachers are challenged in integrating technology into math instruction. In a survey by the Association for Supervision and Curriculum Development [ASCD] and OverDrive Education (2019), 47% of participating teachers expressed fears of being unprepared or uncomfortable or lacking practical skills to incorporate digital tools in learning. Although most teachers have knowledge of technology, many are apprehensive and hesitant to approach technology innovatively so that instruction can break away from traditional practices (Perienen, 2020). In a CompTIA (2021) study, 53% of the participating teachers desired better technology training, digital literacy through professional development, and better materials and resources. Many teacher education programs develop ways to identify the necessary skills to become digitally competent to ensure student success in the classroom (Fulgence, 2020).

In a study by Perienen (2020), 155 mathematics teachers were surveyed on technology integration. Teachers agreed that technology use is beneficial for enhancing math education and pedagogy. However, many teachers were not incorporating technology in their teaching practices due to concerns about inadequate training in the pedagogical implementation of information technologies needed for better computer service, including internet services. Furthermore, Perienen found that teaching experience, apparent accessibility, and technology integration were significantly associated. This showed that teachers who had taught longer used technology less than younger colleagues who perceived technology use as easy. Research literature indicated a consensus that the problem is current, relevant, and significant to education regarding the topic's relevancy (CompTIA, 2021; Keen et al., 2022; Perienen, 2020); limited literature was available regarding the challenges with technology integration in math instruction. Therefore, the current study was needed to provide qualitative information concerning the challenges high school teachers experience in integrating technology in math instruction.

Purpose of the Study

The purpose of this basic qualitative study was to explore Tennessee high school teachers' perceptions of the challenges in integrating technology in math instruction. The high school teachers identified challenges they face integrating technology related to the domains of technological pedagogical content knowledge (TPACK) framework. The research questions guided this study on high school math teachers' perceptions of challenges they experience integrating technology in instruction. Participants included 10 teachers who taught high school math in Tennessee and agreed to complete a semistructured interview.

Research Questions

The following research questions guided this study:

RQ1: What are high school teachers' perceptions of the challenges in integrating technology in math instruction?

RQ2: What do high school teachers consider viable strategies for infusing instructional technology into math classrooms?

Theoretical Framework

In preservice programs, teachers are taught to effectively incorporate technologies in teaching and learning, aiding in developing students' digital literacy as a traditional approach (Fulgence, 2020). Various components have been designed to support educators using emerging technologies during instruction to build students' digital capabilities (Falloon, 2020). The TPACK framework from Mishra and Koehler (2006) combines content knowledge, technology, and pedagogy into a comprehensive model leading to efficient technological instructional processes. It has become vital for teachers to expand their digital competency (Falloon, 2020; Fulgence, 2020). TPACK allows educators to consider important domains of technology integration and use, which were directly connected to the current study's problem, purpose, and research questions. This framework grounded this study and the development of the research questions and is explained in detail in Chapter 2.

Nature of the Study

Quantitative research examines data using statistical methods based on specific hypotheses (Creswell & Poth, 2016; Howitt & Cramer, 2011). This method was unsuitable for the current study. The nature of this study was qualitative. Qualitative research uses inductive reasoning to decode individual encounters, focusing on experiences and actions to infer assumptions or theories (Ravitch & Carl, 2021). A qualitative approach with a basic qualitative design addressed the current research questions. Data were collected through interviews addressing the research problem and purpose and grounded in the TPACK framework. Ten teachers were recruited across several school districts in Tennessee. Qualitative research is consistent with conducting interviews with participants to explore challenges faced in using and adopting technology (Keen et al., 2022). Interviewing participants provides an extensive understanding of interviewees' experiences and viewpoints, proving information related to a topic of concern (Knott et al., 2022). All high school mathematics teachers were recruited from the state of Tennessee. Saldaña's (2016) 3-cycle approach to thematic analysis was used for data analysis. Open and inductive coding assisted in identifying the codes from the data. Interviews with teachers who teach mathematics in high school classrooms were the primary source of data.

Definitions

Throughout this study, the following operational terms were used:

Digital competence: The poised and actual use of digital technologies to communicate, solve problems, and gather information in work, learning, and participation in all aspects of life (Ilomäki & Lakkala, 2018).

Digital literacy: The skill set or use of technical tools and platforms to locate, assess, and share information (Porat et al., 2018).

Information technology: Computers and telecommunications used to store, retrieve, and send information electronically (Tallon et al., 2019).

Technology integration: The effective use of technology tools, resources, and strategies to enhance and support the teaching and learning process (H. Chen et al., 2019).

Assumptions

Assumptions are claims made in a study that are not verifiable by the researcher (Leedy & Ormrod, 2016). While conducting the current study, I made several assumptions related to methodology, theory, and specific topics. I assumed that participating teachers would provide truthful responses. During the data collection process, participants either responded to or declined the invitation to complete the interview. Additionally, I was confident that the study effectively portrayed teachers' experiences with technology integration in math instruction, facilitating the identification of potential challenges and the formulation of solutions for the research problem and questions at hand. The study operated under the assumption that participating teachers comprehended the questions posed during the interview and felt at ease with me asking clarifying questions. In addition, I assumed that teachers applied technological approaches under legislative mandates and peer-reviewed educational literature about technology integration in education. This assumption was necessary because there was no control over how technology was applied in the study context.

Scope and Delimitations

The scope of a study refers to the population used during research and the extent to which the population is studied (Burkholder et al., 2016). The scope of the current study involved teachers who teach students math in Grades 9–12 at high schools in Tennessee. This study was delimited to 10 high school teachers from within multiple school districts in Tennessee. Detailed information on teacher perceptions of challenges in using and adopting technology in math instruction from the study may provide transferable findings in Tennessee and similar states.

Delimitations establish restrictions for research concerning what it investigates and addresses (Theofanidis & Fountouki, 2019). A delimitation of the current study was using high school math teachers in Tennessee. This study did not include high school teachers who teach other subjects. Also, this study did not include teachers from different grade bands or grade levels. As a result of these design choices and delimitations, the results of this study may not be transferrable to other states or regions of the United

States because the experiences of mathematics teachers in Tennessee may differ in fundamental ways from those of teachers in other locations.

Limitations

The potential weaknesses of a study that affect the outcomes due to elements beyond the researcher's control are considered research limitations (Theofanidis & Fountouki, 2019). Interviews are a valuable method for gathering in-depth information and insights from participants. Awareness of limitations in qualitative interviews is crucial for maintaining the credibility and ethical conduct of the study. Response bias refers to participants providing answers they believe the interviewer wants to hear, rather than their true thoughts or experiences, resulting in inaccurate or incomplete data (Ravitch & Carl, 2021). The interviewer must remain focused to maintain integrity and keep the conversation consistent with answering the interview questions (Theofanidis & Fountouki, 2019).

Limiting the generalizability of findings in the current study was the limited sample size and subjectivity due to reliance on participants' perceptions and interpretations. Another limitation included sampling bias that may have caused some participants to agree to an interview if they had strong opinions or experiences related to the research topic (see Burkholder et al., 2020). This could have skewed the data. Mitigating limitations in qualitative interview research is an ongoing process that involves careful planning, ethical considerations, and a commitment to data quality.

Significance

The gap in literature was addressed by providing practical information on challenges high school teachers face in using and adopting technology in math instruction in Tennessee. The gap in practice showed that digital literacy development and teacher digital competence adoption need to be explored as a learning delivery model for students. This study held academic significance with the potential to inspire educational stakeholders to better understand the utilization of technology in high school math classrooms. All educational stakeholders may understand challenges present with technology integration in mathematics instruction. Educational administrators may encourage technology use in math instruction and create systems that ensure technology is incorporated in classrooms. Teachers and students should be trained and understand the need for technological resources. This allows for the development of necessary skills and capabilities that help students to compete effectively with societal and technological advancements. Students may impact their communities by developing skills needed for science, technology, engineering, and mathematics related careers.

The results of this study could foster positive social change by offering qualitative insights into the challenges high school teachers face in integrating technology. This information may guide decision makers in incorporating technological teaching practices into high school math education. Using this study’s findings as a guide, educational professionals could design mathematics education programs that focus on meeting the needs of students in high school math technology-enriched classrooms.

Summary

As educational institutions continue developing and implementing best technology mathematics practices, examining the math concepts and how they are taught is significant. Although digital literacy has been at the forefront, it is more pressing to develop digital competence and understand what it means. Digital competence is the poised and essential use of digital technologies to communicate, solve problems, and gather information in work, learning, and participation in all aspects of life (Ilomäki & Lakkala, 2018). Along with digital competence is the aspect of technology integration in education. Technology integration in education refers to the effective use of technology tools, resources, and strategies to enhance and support the teaching and learning process (H. Chen et al., 2019).

The current basic qualitative study explored the challenges high school teachers experience in integrating technology in math instruction. The high school teachers identified challenges they face integrating technology related to the domains of TPACK. The TPACK framework from Mishra and Koehler (2006) was used to guide the study. This study provided practical data regarding technology integration in mathematics instruction to bridge a gap in the literature. Chapter 2 provides a review of existing literature on mathematics education, achievement, teacher digital competence, and technology integration in mathematics.

Chapter 2: Literature Review

The problem addressed in this study was that high school teachers are challenged in integrating instructional technology in math instruction. The purpose of this basic qualitative study was to explore the high school teachers' perceptions of the challenges of integrating technology in math instruction. Research relating to teacher digital competence affecting student achievement on standardized assessments was less plentiful than the capacity in which student digital competency indicates academic achievement. Teacher digital competence has been found to affect academic achievement among Konya and Ankara students (Akturk & Saka Ozturk, 2019) and elementary and secondary school students in China (Liu et al., 2022). My literature search and review confirmed that the topic is relevant to education but is limited in providing evidence of the challenges high school teachers experience in integrating technology in math instruction. The current study focused on digital literacy and its influence on technology use in the high school math classroom. Also, the study addressed digital competence and its numerous benefits and barriers in math education. The study addressed these concepts separately to address the gap found in the literature review.

Chapter 2 includes the literature search strategies, theoretical framework, and literature review. The summary and conclusion follow the literature review of key concepts of digital literacy, benefits of digital literacy, digital literacy skills, digital literacy barriers, digital competence, digital competence learning domains, digital competence in high schools, digital competence for high school math teachers, and teacher self-efficacy. This study explored high school teachers' perceptions of the challenges in integrating technology in math instruction.

Literature Search Strategy

This section describes the literature search strategies to explain the research process. The following databases in the Walden University Library were used to gather information for the literature review: EBSCOHost, SAGE, Google Scholar, Google, ERIC, and ProQuest. The searches were narrowed to full-text and peer-reviewed journal articles. Searches were also restricted to articles published from 2018 to 2023.

The following key terms were used to search for information: *TPACK*, *TPACK in K-12 education*, *quantitative study*, *digital literacy*, *digital literacy development*, *technology in the classroom*, *applying the TPACK model*, *TPACK and technology in the school*, *math achievement*, *high school math education*, *high school*, *high school math*, *high school math teachers*, *math education*, *digital competence*, and *technology integration in education*. Most sources were published between January 2018 and August 2023. The literature review addressed the TPACK framework, digital literacy, digital competence, and technology integration.

Technological Pedagogical Content Knowledge Framework

Teachers are taught to efficiently incorporate technologies in instruction, aiding in developing students' digital literacy as a traditional approach (Fulgence, 2020). The TPACK framework from Mishra and Koehler (2006) combines content knowledge, technology, and pedagogy into a comprehensive model leading to efficient technological instructional processes. The TPACK framework (Mishra & Koehler, 2006) expanded

Shulman's (1986) pedagogical content knowledge (PCK) framework. Shulman's idea supported learning through pedagogical and content knowledge. Using this idea, Mishra and Koehler added technology to enhance classroom instructional processes. There are seven domains of the TPACK framework, including content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technology knowledge (TK), technology content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPCK), which relate to the combinations of content, technological, contextual knowledge, and pedagogical improving the technology usage by teachers in the instructional process (Mishra & Koehler, 2006; Salas-Rueda, 2019); Wang et al.,2023). Content knowledge (CK) applies to the concepts taught by the teacher and their knowledge. Pedagogical knowledge (PK) deals with how the ability is presented to facilitate learning. Pedagogical content knowledge (PCK) focuses on the tools used to teach various concepts. Technology knowledge uses technology according to the teacher's discretion. Technology content knowledge (TCK) deals with using technology and comprehending the effects of using specific kinds of technology on the course concepts. Technological pedagogical knowledge (TPK) focuses on how technology impacts learning, and technological pedagogical content knowledge (TPCK) combines content, technology, contextual knowledge, and pedagogy, enhancing the instructional process of teachers about technology (Cheng et al., 2022; Koehler & Mishra, 2009; Salas-Rueda, 2019). These seven domains are applied to classroom instruction and allow for the optimal use of technology.

Teachers must extend their digital competency (Falloon, 2020; Fulgence, 2020). In a 2018 study by Kartal and Çinar, the TPACK model was applied to evaluate the relationship of digital tools between technological applications, such as GeoGebra and Mathematica, in math instruction. The information collected shared views of teachers that considered technology as a visualization, simplifier, and motivation tool. Furthermore, implementing the TPACK framework during instruction can help facilitate quality teaching and learning experiences for students (Cheng et al., 2022; Salas-Rueda, 2019).

Content Knowledge

CK refers to the concepts teachers teach and their understanding and ability to distribute those concepts (Mishra & Koehler, 2006; Salas-Rueda, 2019). Mathematics teachers undergo training to develop the knowledge necessary to confidently teach the concepts students need to learn (Kartal & Çinar, 2018; Mishra & Koehler, 2006; Shulman, 1986). CK is one component that influences students' achievement, and teachers' understanding of this concept is vital to success for both teachers and students (Salas-Rueda, 2019). To make an impactful difference in academic achievement, teachers should understand how CK affects several aspects of the classroom, including interpretations of the objectives students should learn. CK allows teachers to recognize the best practice to listen to and answer students' questions. CK involves the teachers monitoring instruction and using questions to stimulate thinking (Kartal & Çinar, 2018; Mishra & Koehler, 2006; National Council of Teachers of Mathematics [NCTM], 2000). With this component, conceptual understanding is derived as a comprehension of concepts, operations, and relationships that helps students avoid critical problem-solving errors and represent mathematical situations differently (NCTM, 2000).

Pedagogical Knowledge

PK deals with how the knowledge is presented to facilitate learning. PCK focuses on the tools used to teach concepts (Mishra & Koehler, 2006; Salas-Rueda, 2019). PK implies that teachers effectively use the best strategies and practices to create instruction for implementing math concepts (Salas-Rueda, 2019; Thurm & Barzel, 2021). Through various professional development opportunities such as readings, group projects, and active learning strategies, teachers gain knowledge of and practice with tools and techniques to increase academic collaboration and maximize their PK (Mannila et al., 2018). With this component of TPACK, teachers provide students with experiences and tasks that will improve learning, differentiate instruction, and include research-based instructional strategies including asking questions, activating prior knowledge, promoting discourse, and identifying misconceptions (Das, 2019; NCTM, 2000), incorporated in the planning process.

Learning objectives and concepts should be clearly defined in the planning process to acknowledge the need for technology implementation to support the pedagogical complexities (Mannila et al., 2018). Designing a technology-enhanced mathematic lesson using a strategic plan allows teachers to increase mathematical thinking and instruction (NCTM, 2000; Salas-Rueda, 2019). These technology-enhanced mathematic lessons give the students a transformed experience and offer flexible learning opportunities for mathematical concepts that are both engaging and exciting. Although mathematics is challenging for many students, academic achievement is promising when technology is used (Mannila et al., 2018).

Technological Knowledge

TK indicates using technology according to the teacher's discretion, focusing on how the teachers use their skills to incorporate various digital resources in instruction to engage students (Cheng et al., 2022; Koehler & Mishra, 2009; Salas-Rueda, 2019). TCK deals with using technology and comprehending the effects of using different kinds of technology on the curriculum concepts. TPK focuses on how technology impacts instruction, and TPCK combines content, technology, contextual knowledge, and pedagogy, enhancing the instructional process of teachers regarding technology use (Cheng et al., 2022; Koehler & Mishra, 2009; Salas-Rueda, 2019). Technology knowledge and its variations impact student achievement as technology promotes student engagement that is flexible and exciting. The NCTM (2015) indicated that digital tools should be implemented to enhance the instructional process, experience, communication, and application related to mathematics for students and educators. Digital tools include the internet, mobile devices, computers, software and gaming programs, and other applications.

Summary of Theoretical Framework

The TPACK framework from Mishra and Koehler (2006) combines TK, PK, and CK into a comprehensive model leading to efficient technology use in instruction that supports and promotes opportunities for learners to engage in enriched, technology-enhanced learning environments. The components of TPACK can support creative thinking and authentic and innovative problem solving, manipulate data, and create possibilities for learners to explore tasks and answer questions that require an elaborate response related to real-world concepts (Hernawati & Jailani, 2019; Hill & Uribe-Florez, 2020; NCTM, 2015). Learning objectives and ideas should be clearly defined to acknowledge the need for technology implementation to support the pedagogical complexities (Mannila et al., 2018). Technology-enhanced mathematic lessons provide teachers with guidelines to strengthen mathematical thinking and improve math instruction (NCTM, 2000; Salas-Rueda, 2019).

Incorporating technology into the classroom has its challenges. However, in previous studies, teachers recognized the need for technology and more professional development to be more efficient in integrating technology into the classroom (Hernawati & Jailani, 2019; Hill & Uribe-Florez, 2020; Liu et al., 2022). With the wave of technology, teachers should develop technology skills that increase student achievement, which is the goal. Further development of TPACK, as presented in a study by Rakes et al. (2022), suggested a need to incorporate technology in mathematics instruction, focusing on theoretical knowledge. Using TPACK as a framework can benefit mathematics teachers and engage students on diverse levels (Rakes et al., 2022). The goal of the current qualitative study was to better understand the difficulties encountered by high school teachers when incorporating technology into their math instruction, focusing on the facets of the TPACK framework.

Literature Review Related to Key Concepts and Variable

Digital Literacy Defined

Gilster (1997) defined digital literacy as understanding and using various technological sources. Spires et al. (2019) argued that digital literacy involves using digital platforms such as Microsoft Word to read and write digitally. Digital literacy is the skill set or use of technological sources to locate, assess, and share information, as defined by Porat et al. (2018). Digital literacy consists of abilities, understanding, and views that allow individuals to use digital media analytically, responsibly, and creatively (Vissenberg et al., 2022). According to researchers, digital literacy provides development opportunities that protect against potential adversity related to online risk (Porat et al., 2018; Vissenberg et al., 2022). Furthermore, digital literacy includes the skills to

- examine information decisively,
- interpret visual platforms,
- manage digital content, and
- use digital technologies (Liza & Andriyanti, 2020).

With new technology on the rise, teachers and students are often considered computer and technically knowledgeable. However, Porat et al. (2018) examined six digital literacy tasks performed by participants to assess their perceived competencies on those tasks compared to their actual performance on appropriate digital tasks. Results showed moderately strong connections with the six digital literacy skills. Porat et al. claimed that participants needed to have understood their basic competencies, although they presented high accuracy in their digital literacies.

Digital skills are an essential part of digital literacy. Digital literacy comprises functional, practical, and more advanced critical and evaluative skills (Helsper et al., 2020). Several researchers noted that there are several types of digital skills, which include communication and engagement, content authoring, and productivity skills (Das, 2019; Helsper et al., 2020; Porat et al., 2018; Vissenberg et al., 2022).

Digital Literacy Skills

Students are immersed in technology daily due to the world around them and the vast access to digital technologies (Lombardi et al., 2020). Students with access to technology and familiarity with various devices may need to learn to use them productively (Porat et al., 2018). Lombardi et al. (2020) determined that more than technical savviness is required so students can succeed in acquiring the skills necessary to perform in school and work. Lombardi et al. stated that digital literacy skills would ensure employers hire students prepared for the workforce, where these skills are helpful in jobs and careers. Though Lombardi et al. and Porat et al. (2018) established the need for these skills, the focus should be on digital literacy skills and being able to implement these skills as students learn them. As technology evolves, students are more productive in society when using technology and digital literacy skills to generate, assess, and communicate (Levano-Francia et al., 2019). According to NCTM (2000), students use digital literacy skills in these significant ways:

- solving a problem and determining which tool to use,
- learn and implement the organization of digital tools (centered on templates),
- engaging in different tools to transform mathematics,

- clarify technological solutions to derive a recommended solution,
- justifying a solution is accurate using technology, and
- digitally supporting work with digital tools.

Although students engaged with ICT tools in several ways, the activities related to these tools can be put into six fundamental areas of use (Das, 2019). Components of digital mathematical literacy include the following:

- evaluate and decide on tools needed with multiple aptitudes,
- using numerous illustrations (notational, graphical, syntactical) to convert between and troubleshoot digital and mathematical contexts,
- developing or accompanying mathematical understanding and using ICT tools, and
- expressing mathematics with ICT tools.

These components involve seven proficiencies related to ICT tools and mathematics.

As a foundation for the education community, digital literacy skills should be developed to establish educational resources to identify students' and teachers' needs. Presenting instruction related to digital literacy skills in various educational resources is beneficial. However, digital literacy skills must develop simultaneously with technological innovations, according to Chetty et al. (2018).

Benefits of Digital Literacy

Digital skills form an essential portion of digital literacy. Digital literacy goes beyond having technical skills but includes cognitive aspects (Audrin & Audrin, 2022).

Digital literacy comprises functional, practical, and more advanced critical evaluative skills (Helsper et al., 2020). Digital literacy, according to Porat et al. (2018), is defined as using various forms of technology to locate, assess, and communicate information. Digital literacy consists of skillsets and understanding that permit people to apply digital media critically, responsibly, and creatively (Vissenberg et al., 2022).

The researchers of Porat et al. (2018) asserted that students must be exposed to and practice digital literacy skills during school instruction to be prepared for their future goals. Digital literacy skills should be attempted and used in real-world settings as early as possible. At the same time, there is still an opportunity to assess and receive more training if necessary (Saux & Cevasco, 2019). Levano-Francia et al. (2019) recognized that today's policy models use more digital components; therefore, these necessary skills, competencies, and literacies must be developed.

Findings showed the importance of implementing technology in high school math school classrooms and observed that high school students were able to use tools for presentational purposes with spreadsheets, databases, or programming (Fasching & Schubatzky, 2022; Hill & Uribe-Florez, 2020). One benefit of digital literacy is that it enables self-paced learning, supports independent study, and improves reading, writing, mathematics, and science (Fasching & Schubatzky, 2022). Researchers showed that digital literacy supported creative thinking and authentic and innovative problem-solving (Hernawati & Jailani, 2019; Hill & Uribe-Florez, 2020; NCTM, 2015). As students and teachers enhance their digital literacy skills, they can engage and explore within flexible, fun, and exciting learning environments that encourage students to engage in their learning actively (Pangrazio et al., 2020; Porat et al., 2018). Digital literacy allows students to understand information and communicate their knowledge through visual and digitally enhanced components (Pangrazio et al., 2020), leading to lifelong learners.

Digital Literacy Barriers

Opeyemi et al. (2019) explored the barriers to incorporating technology to enhance digital literacy in the classroom. The barriers evident were classified as first-order, which are external to the teacher, and second-order barriers are internal to the teacher. Opeyemi et al. (2019) found that the need for adequate and well-trained personnel is the ultimate reason teaching and learning is only equitable for some learners.

The extrinsic, first-order barriers to the teacher are related to the barriers evident in society, the family, and the schools. According to Opeyemi et al. (2019), barriers evident in society include but are not limited to unstable educational curriculum, unbalanced government, and their policies, limited resources and applicable devices, financial constraints, poor or limited internet service, poverty, and scarce subsidy from the government. According to researchers, the teaching frameworks for digital literacy skills need to be revised compared to those available for teaching core subject areas throughout the educational system (Das, 2019; Saux & Cevasco, 2019). Resident in family barriers is myths about parenting, cybercrime and social vices, and inadequate academic training of the students. The barriers resident in schools includes established opposition, uncertainty, inability to maintain, adverse conditions, and insufficient classroom time.

The second-order barriers are related to the teachers' beliefs about digital tools and teachers' digital capability and knowledge and are intrinsic (Hill & Uribe-Florez, 2020; Opeyemi et al., 2019). Barriers related to teachers' beliefs about digital tools are views and views of colleagues and other significant educational professionals, erroneous information, and negative attitude concerning computers. Opeyemi et al. (2019) identified those barriers to competence and digital literacy as an inability to properly apply and use digital tools, teachers' lethargy, and inadequately trained employees. According to the conclusions of researchers, teachers must have the skills necessary to train students to be prepared for college and the workforce; therefore, this information is essential in teaching and learning and understanding the need to improve and apply valuable resources for curriculum and assessment (Hill & Uribe-Florez, 2020; Opeyemi et al., 2019).

In conclusion, the first and second-order barriers included in this section are based on research by Opeyemi et al. (2019). The first-order barriers related to society, family, and schools are external to the teacher. The second-order barriers are those internal and relate to the teacher's beliefs about digital tools and teachers' digital capability and knowledge (Hill & Uribe-Florez, 2020; Opeyemi et al., 2019).

Digital Competence

Different competencies are required when navigating a digital world, including finding relevant information through search engines and databases (Samuelsson & Lindström, 2022). The American Library Association (2021) referred to these competencies as distinct aspects of digital literacy and received increasing attention in schools. Digital competence is one of eight key competencies, including technical competence, creating the capability to use digital applications meaningfully and critically, and participating and committing to the digital culture (Skantz-Åberg et al., 2022). Digital competence and digital literacy are recognized differently because digital literacy is a specific component of digital competence.

He and Li (2019) suggested that various literacies, including digital media, information, ICT, the Internet, and e-skills define digital competence. Digital competence involves a pedagogical concept involving sessions and aspects that encourage technological representations in the classroom, learning, and teacher training (Tárraga-Mínguez et al., 2021). Due to the increase in digital technologies at all levels of education, learning environments have evolved to include online and offline tools for learning. Technology infused in education shifts understanding contexts from paper and pencil formats to digital and hands-on designs (Falloon, 2020).

Frequently accustomed ideas in the literature for digital competence are media competence, information and technology competence, digital literacy, computer competence, and media literacy. These terms appear in different facets of society and within political, research, and media debates, where their meanings overlap (Falloon, 2020; He & Li, 2019). To further develop an understanding of digital competence, there are different frameworks and models where digital competence coincides. The UNESCO (2018) model has three levels: basic notions, acquisition, knowledge deepening, and knowledge generation, focusing on criteria related to the course of study and assessment, instruction, ICT, structure and administration, and the teacher's professional learning. The four competency levels of the National Educational Technology Standards for Teachers Model are initial, medium, expert, and transforming. The competency levels are settled in five scopes: student learning and creativity, learning experience and evaluation, work and learning in the digital age, digital citizenship and responsibility, and professional development and leadership (National Educational Technology Standards for Teachers (NETS-T), 2008; Tárraga-Mínguez et al., 2021). The European Union Model, called "DigCompEdu," concentrates on 22 specific competencies classified into six areas with various levels of competence development (Redecker, 2017). These models pursue to move beyond mere technical skill conceiving digital competence as an intricate idea (Lucas et al., 2021; Tárraga-Mínguez et al., 2021).

According to a study by He and Li (2019), digital competence follows a three-component approach. A model of digital competence proposed by the European Commission with an extensive literature review follows three elements: instrument skills and knowledge, advanced skills and knowledge, and attitudes to social-ethical knowledge and skills (Guitert et al., 2021). Instrumental skills and knowledge (ISK) are used for technical tools and media. Advanced skills and knowledge (ASK) refer to collaborating, creating content and information, communicating, solving problems, knowledge, and active involvement. Attitudes to social-ethical (ASE) knowledge and skills are for involvement with digital tools in intercultural, analytical, innovative, accountable, and self-directed practices (He & Li, 2019).

Technology Integration in High Schools

For schools to support students with a comprehensive educational experience, educational professionals must encourage the integration of technology to reinforce and foster a positive educational setting (Bingimlas, 2018). NCTM (2000) addressed technology integration in math classrooms and supports strategic implementation for teaching and learning. In 2015, NCTM issued a statement claiming that purposeful utilization of technology in mathematics instruction includes implementing digital and physical tools that are thoughtfully and critically designed to enhance learning, application, experience, and communication for students and teachers. Technology can support teaching and learning of mathematical objectives and pedagogy and efficient instructional strategies that are consistent with research in instruction (NCTM, 2015)

Digital technology includes laptops, desktops, printers, scanners, and telephones. In mathematics, teachers and students could use digital activities that form digital calculators, interactive games, tools to create equations, graphs, formulas, and interactive videos. Game-enhancing tools assisted in developing skills for solving word problems that support students in internalizing math concepts (Hill & Uribe-Florez, 2020). Technology should be infused into the math classroom. Teachers should use this opportunity to engage students on various levels and meet them where they are. The several types of technology implemented in the school can assist students in gaining and increasing the analytical abilities and tools needed to become lifelong learners (Criollo-C et al., 2021). Engaging in these technologies helps to develop skills required to use different software and programs that are accessible with technology, for example, Microsoft Office, Google, and the Internet. Various software enforces and reinforces knowledge (Hernawati & Jailani, 2019; Hill & Uribe-Florez, 2020; NCTM, 2015).

There must be a strategic approach to implementing technology in mathematics classrooms. Research showed that technology can assist students in solving problems by attending to precision modeling mathematics and finding patterns (Wilkinson et al., 2018). NCTM (2015) encouraged educators to incorporate digital tools to enhance the instructional process, experience, communication, and application related to mathematics for students and educators. This supports the teaching and learning of mathematical objectives and effective teaching practices. With technology, whether game-enhanced tools or other digital technologies, students gain a deeper understanding of mathematical concepts and assist with applying concepts (Hill & Uribe-Florez, 2020). By incorporating technology, teachers provide students with experiences and tasks that promote individual learning, differentiate instruction, and include research-based instructional strategies to assist students with internalizing mathematical concepts (Das, 2019; NCTM, 2000). Research showed that digital technology could support creative thinking, authentic and innovative problem-solving, manipulate data, and create opportunities (Hernawati & Jailani, 2019; Hill & Uribe-Florez, 2020; NCTM, 2015). Although mathematics is challenging for many students, incorporating technology is crucial to educational attainment (Mannila et al., 2018).

As it relates to education, digital competence includes (1) teachers and learners utilizing technology as a pathway to apply and retrieve information, (2) understanding how to manage, gain, and assess gathered information using technology, and (3) producing and sharing information with technological tools (He & Li, 2019). In conclusion, technology integration requires people to be digitally competent, which means that they know how to make decisions on how to use different devices and software pedagogically (Tárraga-Mínguez et al., 2021).

Technology Integration for High School Math Teachers

Since the millennial or digital native generation lives with and has access to many digital technologies, it is imperative to meet the need for digital technologies in the classroom (Liza & Andriyanti, 2020). Literature supports the consensus that researching student digital competence is pertinent to facilitating academic achievement among higher education students in Iran (Mehrvarz et al., 2021), engineering students (Salimi et al., 2022), as well as among university students in Korea (H. J. Kim et al., 2019). Teacher digital competency has been found to determine the effectiveness of academic achievement among Konya and Ankara students (Akturk & Saka Ozturk, 2019) and elementary and secondary school students in China (Liu et al., 2022). Therefore, teachers should be trained and prepared to incorporate these competencies in the instruction to assist students in continuing to develop skills (S. Kim et al., 2019).

Technology-enhanced mathematic lessons provide teachers with guidelines for expanding and improving mathematical knowledge and instruction (NCTM, 2000; Salas-Rueda, 2019). These technology-enhanced mathematic lessons give the students a transformed experience and offer flexible learning opportunities for mathematical concepts that are both engaging and exciting. Digital competence is needed to efficiently utilize technology and advance students' digital skills within the education process

(Melash et al., 2020). As technology evolves, teacher training programs should also develop the approach to ensure student teachers have digital experiences to increase the digital competence that allows them to incorporate technology effectively and efficiently in classroom instruction (Basilotta-Gómez-Pablos et al., 2022; Melash et al., 2020; Miguel-Revilla et al., 2020; Starkey, 2020). The impact is pivotal when teachers support technology use during instruction (Das, 2019). Using technology makes mathematics more simplified, enhances creativity, and allows teachers to provide timely formative feedback (Awofala & Olaniyi, 2023; Das, 2019; National Academies of Sciences, Engineering, and Medicine, 2018). Incorporating technology contributes to pedagogical strategies fostering mathematical skills development (Freiman & Tassell, 2018; Sarı & Bostancioglu, 2018).

With the ever-growing focus on technology implementation, teachers must review current and relevant information related to student learning to enhance the educational environment (Attard & Holmes, 2020). Different frameworks and models were formed to develop the concept of digital competence and the competencies teachers need (ISTE, 2017; Redecker, 2017; UNESCO, 2018). The DigCompEdu (Redecker, 2017), ICT competency framework for teachers (UNESCO, 2018), and TPACK (Mishra & Koehler, 2006) represent frameworks that focus on digital competence and technology integration. These frameworks help to classify the several aspects surrounding the instructional practices moving beyond digital literacy skills as a basis for understanding digital competence is a more multifaceted skill (Lucas et al., 2021; Melash et al., 2020; Tárraga-Mínguez et al., 2021). The implications of digital competence are more inclusive, intricate, and challenging for the teaching profession than for other occupations (Basilotta-Gómez-Pablos et al., 2022; Melash et al., 2020; Starkey, 2020). For teachers, this includes having the ability to incorporate technology into instructional practices effectively by consuming and accessing information, understanding how technology works, and the ability to create and exchange information with digital technology (He & Li, 2019).

The research findings indicated various areas where teachers across all grade levels in schools could enhance their digital competence (Rice, 2021). Although mathematics teachers use technology regularly and go beyond personal use to simplify and expand instructional practices, technology still needs to be used more to teach mathematical standards (Perienen, 2020). Teachers present difficulties adopting technology due to anxiety, stress, hesitation, and apprehension when exploring innovative computer-mediated teaching that requires them to move away from traditional teaching practices (Fernández-Batanero et al., 2021; Perienen, 2020). When teachers lack digital competence, it affects the many aspects negatively related to student achievement, enhanced student skills, increased areas of concern in the education system, and academic progress (Chetty et al., 2018; Novita & Herman, 2021).

Two factors impacting technology integration among teachers are perceived effortlessness in using technology and setting up environments that influence computer usage, as Perienen (2020) reported in a study. It is recommended that teachers should have access to classrooms equipped and ready for technology-based teaching that includes preloaded learning software and access to training to use the software (Jadhav et al., 2022; Perienen, 2020). When teachers have high digital competence, integrating technology into instructional practices facilitates student learning, improves learning quality, increases motivation, and ensures students have skills needed for future educational and career goals (Alabdulaziz, 2021; Çebi et al., 2022; Hill & Uribe-Florez, 2020).

Summary and Conclusions

Chapter 2 contained the literature search strategy, the conceptual framework, and the literature review on TPACK, applying the TPACK model, quantitative study, technology in the classroom, TPACK in K-12 education, digital literacy, digital literacy development, TPACK and technology in the school, math achievement, high school education, high school, high school math, high school math teachers, math education, digital competence, and technology integration. Digital competence requires people to be digitally competent, which means that they know how to make decisions on how to use different devices and software pedagogically (Tárraga-Mínguez et al., 2021). Reviewing models and frameworks related to digital competence is necessary to understand the concept of digital competence and its connection to technology integration. Technology integration in education refers to the effective use of technology tools, resources, and strategies to enhance and support the teaching and learning process (H. Chen et al., 2019).

The literature review contained a background of the concepts associated with this study and shows a research gap that was addressed by this study. The gap in practice that was discussed was integrating technology in math instruction and technology integration challenges. This current qualitative study addressed the gap in practice regarding the high school teachers' experiences and challenges with integrating technology into math instruction. Chapter 3 provides an exploration of the research method for this study.

Chapter 3: Research Method

The purpose of this basic qualitative study was to explore high school teachers' perceptions of the challenges in integrating technology into math instruction. After the introduction of this chapter, there is a discussion of the research design and its rationale, which includes the research questions, a definition of the central concepts, a review of the research tradition, and the rationale for choosing the research tradition. The role of the researcher is explained in this chapter, along with the population, sampling strategy, procedures for recruitment, participation, data collection, and data analysis. An explanation of trustworthiness is also shared in this chapter. The ethical procedures section provide guidelines that were followed to protect respondents. The last section of Chapter 3 is a summary.

Research Design and Rationale

Qualitative research includes inductive reasoning to decode individual encounters focusing on experiences and actions to infer assumptions or theories (Ravitch & Carl, 2021). There are various qualitative designs, such as basic, grounded theory, ethnography, and phenomenology (Lichtman, 2023). Ethnography, grounded theory, and phenomenology were not used in the current study. This study did not focus on cultural groups and their real-life experiences, so an ethnographic design was not appropriate. A grounded theory design involves developing a theory or conceptual framework based on empirical data (Creswell & Poth, 2016) and did not align with my study. Like case studies, phenomenological studies allow the researcher to gain an understanding of a specific phenomenon from the viewpoint of the participants' experiences (Creswell & Poth, 2016). This focus was not appropriate for my study.

A basic qualitative design was appropriate to answer the research questions focused on teachers' perceptions of challenges in integrating technology in math instruction and what they consider to be viable options to address those challenges. Data were collected through teacher interviews that provided a wide range of responses regarding experiences and challenges with integrating technology in math instruction. Answers to the research questions were provided by analyzing the data collected. The results of this study may lead to an understanding of teacher perceptions of challenges in integrating technology in math instruction. These results have the possibility to improve future math instruction for high school math teachers and students. The study was conducted among high school math teachers in Tennessee from Grades 9–12.

The basic qualitative design in this study is consistent with other studies performed in the education discipline. Baran et al. (2019) examined 215 preservice teachers' perceptions of support received from their teacher education programs as it related to their TPCK. The themes identified included using teacher educators as role models, reflecting on the role of technology in education, learning how to use technology by design, collaborating with peers, scaffolding authentic technology experiences, and providing continuous feedback. The results from this study connected the teacher education strategies and the need to develop preservice teachers' TPACK in teacher education programs. My study aligned with previous studies and may contribute to knowledge in education.

For this study, data from interviews were collected to provide a descriptive analysis. Therefore, a qualitative approach was appropriate for this study. Quantitative designs include numerical data and require statistical analysis. Therefore, quantitative methods, such as experimental, correlational, and surveys, were not appropriate for this study. The following research questions guided this study:

RQ1: What are high school teachers' perceptions of the challenges in integrating technology in math instruction?

RQ2: What do high school teachers consider viable strategies for infusing instructional technology into math classrooms?

Role of the Researcher

In this basic qualitative study, I assumed the role of the interviewer. There was no relationship with the participants. As a math teacher mentor, I had witnessed the challenges high school teachers experience when incorporating technology into classroom instruction. Eliminating bias based on my personal experience was essential for maintaining the integrity and credibility of the study. To achieve this, I kept a research journal, also known as a reflexive journal, as a valuable tool. This journal helped me identify assumptions, reflect on firsthand experiences, monitor interactions, and record decision making related to the study. Semistructured remote interviews were conducted via the Zoom online videoconferencing platform with 10 high school math teachers. The teachers were recruited via several Facebook private groups, including Tennessee Teachers and Teachers of West TN. The goal was to focus on the information provided by the interviewees during the interviews and reduce unintended bias.

Methodology

Participant Selection

The population for this study consisted of approximately 2,200 high school math teachers in Tennessee (see Collins & Schaaf, 2020). About 25% of these teachers are members of social media groups on Facebook. This made up the target population who were invited to participate (see Appendix C). From this target population, a sample of 12 teachers (to account for attrition) was sought. Ten were obtained.

The two general sampling method techniques most used are probability and nonprobability. According to Berndt (2020), probability sampling techniques include random, systematic, stratified, and cluster. The nonprobability sampling techniques are snowball sampling, quota sampling, self-selection sampling, and purposive sampling (Berndt, 2020). Ravitch and Carl (2021) referred to purposeful or purposive sampling as a deliberate selection of individuals and research settings. According to Patton (2002), purposive sampling leads to a greater depth of information from a smaller number of carefully selected cases. In addition, purposive sampling is used to select units (e.g., individuals, groups of individuals, institutions) based on specific purposes of answering a study's research questions.

A purposeful sampling strategy was implemented in the current study. Participants were high school math teachers throughout Tennessee. Ten high school teachers were recruited via Facebook private groups. The guidelines of the Walden University Institutional Review Board (IRB) were followed throughout the recruitment phase. After giving informed consent, teachers completed a demographic questionnaire (see Appendix

A) via Google Form. The participants were given 1 week to respond to the consent form and demographic questionnaire. High school teachers who teach mathematics were recruited from the participant pool. Recruited teachers were contacted by email concerning their selection in the study.

Instrumentation

Interview questions from a researcher-designed protocol were used as the main data collection instrument. Participants were asked interview questions, and responses were recorded via Zoom. The transcription service available on Zoom was used. The interview questions (see Appendix B) addressed participants' perceptions of the challenges in integrating technology in math instruction related to the domains of TPACK, which aligned with the research questions, purpose, and problem of the study. There are seven domains of the TPACK framework: CK, PK, PCK, TK, TPK, and TPCK. Interview questions designed to address the domains of TPACK were noted with the domain in parentheses following the question. Additional questions related to experience with integrating technology and benefits, recommendations on viable strategies, and perceptions of the advancement of integration of technology in math instruction. These questions addressed the high school teachers' perceptions of challenges in integrating technology into math instruction.

Procedures for Recruitment, Participation, and Data Collection

Each teacher received an invitation to participate in the social media private group that contained a description of the study (see Appendix C), my information, and the suggested time frame to complete the study. When the teachers clicked the link, they proceeded to the informed consent form. After completing the consent form and a demographic questionnaire, teachers were contacted by email concerning their selection in the study and scheduling of their interviews.

Informed Consent

The informed consent form encompassed the study's purpose, procedures, sample question, voluntary nature (respondents' right not to participate), risks and benefits, payment, description of privacy, and contact information to ask questions or share concerns. Agreement with the informed consent and its contents established that the teacher had decided to participate in this study. To complete the demographic survey and to schedule the interview, the participating teacher clicked an electronic icon stating "I agree" to give consent.

Data Collection and Exiting the Study

After the participating teacher agreed to the terms of the informed consent form, they were directed to a brief demographic survey and a scheduling link for the interview. The scheduling link allowed the participants to select a time that fit my and participants' schedules. Interview times and dates were scheduled within 1 week of their response, whenever possible. Interviews were conducted remotely through Zoom, with a request for teachers to avoid any distractions during the interview. Teachers were alerted before beginning the interview of their ability to exit it at any point. Data collection was completed in 2 weeks.

Ravitch and Carl (2021) stated that interviews are a valuable qualitative research method for gathering in-depth information and insights from participants through the experiences and perceptions of the interviewees. Before the interview, I introduced myself and discussed the expectations and purpose of the study. Then, confidentiality was reviewed, including the participant's name and other identifying information. Participants were reminded that they were free to refrain from answering any question and to stop participating at any time.

The interviews were recorded using Zoom's recording feature. Reflexive journaling occurred during the interview, and the interviewing platform's transcription service was used to ensure that all participants' responses were accurately captured. During the interview, participants were asked to clarify their responses, and follow-up questions were asked. Table 1 shows the interview steps that were followed for all participants.

Table 1

Interview Protocol

Step	Procedure
1	Researcher and participant introduction
2	Clearly state the purpose of the study and the expectation
3	Confidentiality review
4	Questions and clarifications from participant
5	Ask interview questions
6	Opportunity for follow-up questions or clarifications
7	Thank the participant for their time

Once the interview was complete, the participant was thanked for participating in the study. Participants received compensation in the form of an electronic $20 gift card. Participants were asked to review my summary and interpretation of the data. A transcript was emailed within 1 week of the interview. Participants were asked to return any corrections within 5 business days, after which the data were considered accurate as transcribed. The participating teacher was provided with my contact information in case of any questions or concerns.

Data Analysis Plan

Data analysis is the systemic process of analyzing, organizing, and examining data (Kalpokaite & Radivojevic, 2019). The research questions for the current study were the fundamental aspects that guided the data collection. Research questions drive the interview questions that align with the purpose, problem, theory, framework, and data collection (Lester et al., 2020).

The data analysis of the current study followed Saldaña’s (2016) 3-cycle approach to thematic analysis. The notes and interview data were organized and reviewed to prepare for data analysis. Coding is the connection between data collection and data analysis (Rogers, 2018). According to Ravitch and Carl (2021), coding is a way to organize and consolidate data into manageable pieces to engage logically. Codes highlight a word, phrase, sentence, or paragraph describing a specific topic from the collected data. Ravitch and Carl (2021) stated that all data can be coded, including transcripts, field notes, archival data, photographs, videos, research memos, and research journals.

First-cycle coding includes open and inductive coding, meaning that codes from the data are identified and labels are assigned to words or phrases in the data. The coding process is not entered with a set of predetermined codes. Second-cycle coding encompasses axial coding, which means that the data are reviewed more than once using one or more types of coding. Codes are categorized, which means synthesizing the codes into consolidated meaning. After the second-cycle coding in the current study, the thematic analysis took place. The category is one level higher than code in the hierarchy of classification in qualitative data analysis in the process of thematic extraction (Ravitch & Carl, 2021). Each category should have similar characteristics for data grouping. Categories are moved into themes, which are phrases or sentences that describe a process derived from the categories. Themes are response patterns identified from data that have been coded. Themes are substantive and reflect the substance of what was said (Ravitch & Carl, 2021). If a theme is identified, it can become a code to which text (or other material) expressing that theme is assigned.

Trustworthiness

In qualitative research, minimizing bias of the researcher is crucial for maintaining the rigor, credibility, and reliability of the study (Kalpokaite & Radivojevic, 2019). Trustworthiness or rigor of a study refers to the degree of confidence in data, interpretation, and methods used to ensure the quality of the study. Researchers should establish protocols and procedures necessary for a study to be considered worthy of consideration by readers (Stahl & King, 2020). It is necessary to answer several questions about the study to ensure the quality of qualitative research. The answers to the questions should identify the perspectives that have been presented in the research and other perspectives that challenge current thinking and add new knowledge in the context of that challenge (Burkholder et al., 2020). Lincoln et al. (1985) identified four components of trustworthiness: credibility, transferability, confirmability, and dependability.

Credibility

The credibility of the study or confidence in the study's truth and, therefore, the findings is an essential criterion in establishing trustworthiness (Shenton, 2004). Credibility is parallel to internal validity for quantitative research (Burkholder et al., 2020). Internal validity refers specifically to whether an experimental treatment/condition makes a difference or not and whether there is sufficient evidence to support the claim (Bhandari, 2022). According to Burkholder et al. (2020), for qualitative research to be credible, the findings of the study must be believable based on the data presented. Member checks are used to bolster and explore a study's credibility, also known as participant or respondent validation (Shenton, 2004). Data or results are returned to participants to check for accuracy and resonance with their experiences (Shenton, 2004). Member checking can be done during the interview process, after the study, or both to increase a qualitative study's credibility. In this study, member checking occurred following the interview as previously described. It is not limited to creating a research design that seeks complexity and attends to real-life complexities that exist in a group (Ravitch & Carl, 2021). Another important concept is understanding and engaging in patterns recognized in the data (Ravitch & Carl, 2021).

Transferability

Transferability relates to the external validity of the results of the study. External validity is generalizing the treatment/condition outcomes (Burkholder et al., 2020; Creswell & Poth, 2016). External validity should be evident in the study and the results should transfer to different settings, groups, or populations (Burkholder et al., 2020). To ensure and improve transferability, thick descriptions can be implemented with the findings. A thick description refers to providing detailed accounts of the participants' perceptions, experiences, views, intentions, implications, and understandings. (Younas et al., 2023).

Dependability

According to Burkholder et al. (2020), dependability means that evidence of consistency in the data collection, analysis, and reporting and any adjustments or shifts in methodology are documented and explained. A strategy to establish this aspect of trustworthiness is audit trail. Audit trail refers to the process of maintaining detailed records of the complete research process, including data collection, coding, and analysis decisions. This audit trail allows other researchers to refer to the study notes and assess the trustworthiness of the study (Lester et al., 2020).

Confirmability

According to Burkholder et al. (2020), confirmability refers to the level that a qualitative study is confirmed or corroborated by others. A strategy to establish this aspect of trustworthiness is through documentation of an audit trail. To accomplish this the researcher will document every phase of the research process, including perceptions of each step of the study (Ravitch & Carl, 2021). This documentation assists in confirming and justifying the study, focusing on neutrality.

Ethical Procedures

This study complied with the Walden University IRB process (Walden IRB approval no. 12-15-23-1072170). IRB approval was received prior to data collection. A written informed consent form was provided to teachers before participating in this study, acknowledging their rights as study participants. Participants did not disclose any personal information, assuring confidentiality and information was deidentified and anonymous. All files related to the study will be secured on a non-internet accessible computer in the researcher's home for five years after the completion of the study and will then be deleted per university protocols.

Summary

The purpose of this basic qualitative study is to explore the high school teachers' perceptions of the challenges in integrating technology in math instruction. A thematic analysis was used for this study. Theme was used to answer the main research questions. Categories are different responses addressing or responding to the main theme. According to Ravitch and Carl (2021), coding is a way for data organization, consolidating information into manageable pieces to engage logically.

The research questions explored high school math teachers' perceptions of the challenges they experience and viable strategies for integrating technology into classroom instruction. In this study, the population consisted of teachers in Tennessee schools who teach high school math. I gathered the data with interview questions reflecting on the perceptions of the challenges in integrating technology in math instruction related to domains of TPACK, which aligned with the research questions, the purpose, and the problem of the study. This study complied with the Walden University IRB process and observed all expected ethical practices.

The findings from the study are reviewed in Chapter 4. The data analysis process details are specified, along with the results of each phase. This process resulted in the emergence of themes that were used to answer research questions.

Chapter 4: Results

The purpose of this basic qualitative study was to explore high school teachers' perceptions of the challenges in integrating technology into math instruction. Understanding challenges present with technology integration in mathematics instruction may allow educational administrators to encourage technology use in math instruction and create systems that ensure technology is incorporated in classrooms. The goal of the study was to answer the following research questions:

RQ1: What are high school teachers' perceptions of the challenges in integrating technology in math instruction?

RQ2: What do high school teachers consider viable strategies for infusing instructional technology into math classrooms?

After the introduction of this chapter, there is a discussion of the setting, which includes participant demographics and characteristics. The data collection process is also explained in this chapter. The data analysis section includes the codes, categories, and themes that emerged from the data. The results of the study are shared in this chapter. The evidence of the trustworthiness of the study follows, which includes credibility, transferability, dependability, and confirmability. The last section of Chapter 4 is a summary.

Setting

Semistructured interviews were conducted via Zoom with 10 high school mathematics teachers from Tennessee high schools. A purposeful sampling strategy was used to recruit high school mathematics teachers throughout Tennessee via Facebook private groups. On average, the 10 interviews took 33 minutes each. The interviews were completed over a 9-day period. The interviews were recorded using Zoom's recording features and transcribed verbatim. Following transcription, the interview transcripts were downloaded. The accuracy of the transcripts was verified with proofreading. The information from these interviews served as the primary data for the study.

Demographics

Ten high school math teachers from Tennessee high schools participated in this study. All participants were experienced and certified in teaching math, with their experience ranging from 11 to 34 years. All participants had experience integrating technology in math instruction. The participants also taught different educational levels, ranging from Grade 9 to Grade 12. To protect the identity of the participants, I assigned each participant an identification code from P1 to P10. Table 2 summarizes participants' demographics, including participant number, grade level taught, years of experience with teaching math, and years of experience integrating technology in math instruction.

Table 2

Summary of Demographics

Participant number	Grade level taught	Number of years of experience teaching math	Number of years of experience implementing technology in math instruction
1	9	18	5+
2	9–12	18	5+
3	10–12	12	5+
4	9–12	17	5+
5	9–10	17	5+
6	9–12	11	5+
7	12	34	1–5
8	9–12	11	5+
9	9–10	18	1–5
10	9	15	5+

All participants had at least 5 years of experience teaching high school math. The average teaching experience was 17.1 years. Most participants (80%) had 5 or more years of experience incorporating technology into math instruction.

Data Collection

Ravitch and Carl (2021) stated that interviews are a valuable qualitative method for gathering in-depth information and insights from participants through the experiences and perceptions of the interviewees. In the current study, qualitative data were gathered from 10 high school (Grades 9–12) mathematics teachers using a semistructured interview protocol. After receiving IRB approval, I posted a recruitment flyer on Facebook private groups. After the participating teachers completed the informed consent form, they were directed to complete the demographic survey. Once a notification was received that the participant had completed the survey, the Zoom scheduling link for the interview was sent via email.

After the participants scheduled an appointment, the Zoom meeting link and scheduled time for the interview were sent to each participant via email. No issues arose with available interview times and dates, and all interviews were scheduled within 1 week. Interviews were conducted remotely through Zoom. Data were collected over a 9-day period from January 6 to January 14, 2024, with semistructured interviews lasting an average of 33 minutes. The interviews were recorded and saved in an audio file. All files were password protected to maintain confidentiality.

Following each interview, debrief sessions with the participants were conducted to outline the subsequent steps in the study. Additionally, participants were encouraged to review the interview transcripts and adjust their responses, if necessary. After the interviews, the participants were thanked for participating in the study. The collected data will be securely stored in a password-protected folder on a secure computer for 5 years beyond the study’s conclusion. Table 3 summarizes interview information, including participant number, date of interview, number of interview minutes, and number of interview transcript pages. The interview transcripts were typed in single-spaced Times New Roman 12-point font.

Table 3

Summary of Interview Information

Participant	Date of interview	Number of interview minutes	Number of interview transcript pages
1	January 6, 2024	24 minutes	9
2	January 7, 2024	60 minutes	15
3	January 8, 2024	55 minutes	15
4	January10, 2024	46 minutes	10
5	January 11, 2024	37 minutes	8
6	January 11, 2024	23 minutes	7
7	January 11, 2024	27 minutes	8
8	January 12, 2024	33 minutes	8
9	January 12, 2024	15 minutes	5
10	January 14, 2024	21 minutes	7

Data Analysis

Data analysis is the systemic process of analyzing, organizing, and examining data (Kalpokaite & Radivojevic, 2019). The research questions for the current study were the fundamental aspects that guided the data collection. Research questions drive the interview questions that align with the purpose, problem, theory, framework, and data collection (Lester et al., 2020). The data analysis of the current study followed Saldaña's (2016) 3-cycle approach to thematic analysis. The notes and interview data were organized and reviewed to prepare for data analysis. The interview transcriptions were analyzed. The data were analyzed into codes, categories, and themes.

While listening to the audio recordings, I reviewed the transcripts to obtain an initial understanding of the data. This approach allowed me to comprehend the participants' responses. According to Ravitch and Carl (2021), coding is a way to organize and consolidate the data into manageable pieces to engage logically. The codes highlighted a word, phrase, sentence, or paragraph describing a specific topic from the data. The generation of initial codes was initiated and listed. Following this phase, noteworthy features of the data were systematically coded. This involved revisiting the collected data, segmenting the text, and labeling specific portions during open coding. Using the outcomes of the open coding, I conducted axial coding. To achieve this, I reviewed the codes alongside the underlying data, seeking codes that could be grouped. Subsequently, categories were established by building on existing codes. Tables 4 and 5 represent the open codes established in categories for RQ1 and RQ2.

Table 4

Open Codes in Categories for RQ1

Code	Category
Microsoft translating equations and symbols properly	Inadequate and poorly working resources
Lack of 1-to-1 devices for students	Lack of resources
Power outages Internet issues Lagging quality when multiple programs, devices, or platforms are used at once Computer memory low	Lack of proper equipment
Ability to see student thinking while working on problems	Lack of resources
Pulling all technology components into one lesson with limited time	Limited time to incorporate technology properly
Students using technology but do not understand math content Students struggle but do not ask for help Students do not understand how to use the technology tool or platform	Students using technology but struggling Students do not understand how to use the technology tool or platform
Compatibility of technology tools, programs, and software Connecting between Microsoft, Google, and Apple Technology updates needed	Lack of compatibility
Students buy-in and willingness Gaining student attention Students being lazy Students' lack of participation Students do not bring charged laptops when in class	Student willingness, participation, and buy-in
Technology is inoperable Breakout room mediocre quality Technology does not adapt to mathematics standards, concepts, and content Poor quality in technology tools and programs	Poor quality in technology

Table 5

Open Codes in Categories for RQ2

Code	Category
Doodle Notes Blooket Classkick Nearpod Desmos Kahoot Geometer Sketchpad Educational websites Edulastic Math Excel IXL Platforms for online practice problems Platforms for online notes Moby Max Delta Math Formative assessments Mastery Connect Social media groups Savvas curriculum All Things Algebra curriculum	Technology tools and programs integrated into math instruction
Loom for video recording Canva for presentations Adobe Connect Zoom	Technology tools and programs used for presentations, recordings, and class sessions
Google Classroom Google Slides for group work and online notes Google Form for assessments Google Games Google Docs	Google applications
Calculators (graphing and scientific) Texas Instruments products Document camera Chromebook Smartboards Screens placed around the classroom Screenshare (Reflector App)	Technology tools used to enhance instruction
Change it up Using color and highlights Play games Project-based learning Procedurally generated online problems Visuals Interactive platforms Puzzles/mazes/scavenger hunts Coteaching Internet research Manipulatives Online card sort Real-world connections Drawing with technology Instant feedback using technology tools	Strategies and techniques used in instruction

The categories were sorted and arranged into coherent themes. Themes are response patterns identified from data that have been coded. Themes are substantive and reflect the substance of what was said (Ravitch & Carl, 2021). Identifying themes involved bringing together components that exhibited similarities or codes that reflected comparable ideas or experiences among participants. This pursuit of themes was conducted manually. The codes were compiled into a Word document and structured into themes, aligning with the interrelation between codes and themes. To achieve this alignment, I revisited and thoroughly analyzed the transcripts from the interviews , facilitating the clustering of codes into themes. This iterative process of revisiting the transcripts aimed to enhance comprehension of the collected data, thereby facilitating the establishment of relationships among different codes. Tables 6 and 7 represent the themes that emerged for each research question.

Table 6

Overview of Categories Organized Into Themes for RQ1

CATEGORY	THEME
Lack of resources	Theme 1: Lack of resources, compatibility, and proper equipment needed to efficiently integrate technology into math instruction
Poor quality in technology	
Lack of proper equipment	
Limited time to incorporate technology properly	
Lack of compatibility	
Students using technology but struggling with the math content	Theme 2: Students lacking the skill, will, desire to participate, and the ability necessary to effectively incorporate technology into math instruction
Students using technology tools inefficiently and inappropriately	
Student willingness, participation, and buy-in are poor	

Table 7

Overview of Categories Organized Into Themes for RQ2

CATEGORY	THEME
Technology tools and programs integrated into math instruction poor quality in technology	Theme 3: Technology tools and programs used to enhance and integrate into math instruction
Technology tools and programs used for presentations, recordings, and class sessions	
Google applications	
Technology tools used to enhance instruction	
Strategies and techniques used in instruction	Theme 4: Different strategies and techniques using technology tools and programs in math instruction

Results

This basic qualitative study explored high school teacher perceptions of the challenges in integrating technology into math instruction. Two research questions were investigated. The first research question was: What are high school teachers' perceptions of the challenges in integrating technology in math instruction? In this section, the findings of this study will be reported. Using the semistructured interview protocol (Appendix B), 10 high school math teachers from Tennessee schools could give open-ended responses regarding their perceptions of the challenges in integrating technology into math instruction. The interviews took place on Zoom. The open and axial coding cycles were completed from these perceptions, and four themes emerged from this study.

Research Question 1

The first research question was: What are high school teacher perceptions of the challenges in integrating technology in math instruction? Two themes related to the first research question. The first theme was lack of resources, compatibility, and proper equipment needed to efficiently integrate technology into math instruction. The second theme was students lack the skill, will, desire to participate, and the ability necessary to effectively incorporate technology into math instruction.

Theme 1

Theme 1 was lack of resources, compatibility, and proper equipment needed to efficiently integrate technology into math instruction. This theme emerged from the perceptions of Participants 2, 3, 5, 6, 7, and 8, who described concerns with technology tools and programs during math instruction. This study identified participants' experience with technology, including inadequate and poorly working resources, lack of resources, lack of compatibility among different programs, poor quality in technology tools, lack of proper equipment, and limited time to incorporate technology properly. Participant 8 shared concerns related to the previously mentioned experiences by saying,

> We can look at the technical side of things and just the issues that students have at the moment. Not everyone can access it quickly. The computer does not have enough memory, or they are having internet issues that day, or something is going on. So, there is that downfall because you are going to miss some kids. And it seems to happen just about every day you are going to miss somebody. Somebody is having some kind of problem somewhere.

Theme 1 created an understanding of what high school math teachers perceived as challenges experienced with integrating technology tools and programs efficiently into math instruction. When asked about challenges encountered when integrating technology in math instruction, there was a similarity in all responses. For example, Participant 1 described challenges with the lack of resources by saying that:

> We are one to one. So, each of our students is issued a laptop…and they do not charge them at night, or they leave them at home. You know, and that is an issue, because I do not have one. We do not have any extras. So then, if they do not have their laptop, they cannot participate. I usually just pair them up with somebody, but then they still do not get the full experience. So, that is a frustrating thing.

Participant 5 had a similar perspective, saying,

> So frustrating is that every department has a cart and laptops. … one year, I applied and got a grant…Well, that is cool and all until the lesson I want to do. The other freshman teacher wants to use them. Well, wait a second. There is only one set of computers. So that does not work. So, then I am like, okay, we need more computers. Where are we going to get the money to do it? Well, our school was not one-to-one, and so it is like, I am trying to teach the kids how to do all these cool things on the computer. But I do not have the computers to teach the kids things, and I could not keep them in my room.

Many participants also talked about the lack of proper equipment. A pattern emerged regarding teachers having issues with internet connectivity, computer memory, and lagging quality when multiple programs, devices, or platforms are used simultaneously. Participant 6 used a program that lags during instruction and restricts the use of all program components. Participant 7 also expressed concerns with lagging quality and noted occasional delays they encountered, particularly when using their camera during virtual sessions. Although cameras are suggested but not mandatory, except for Bridge and Star Testing, they strive to keep theirs on. However, they acknowledged that this practice could potentially hinder system performance. Consequently, Participant 7 mentioned their willingness to deactivate their camera if it began to affect the session, opting instead to share visual aids like notebook paper or graphs to facilitate understanding.

Participant 3 expressed compatibility concerns between using various programs and products like Microsoft and Apple as a tool during instruction. Other participants shared concerns with transitioning between Google and Microsoft. Participant 1, a fairly new to Tennessee discussed that their current district, is a Microsoft district. Microsoft tools are predominantly used, whereas their previous district relied on Google applications. Consequently, the teacher faces challenges in transitioning materials from Google to Microsoft platforms. Despite efforts to integrate their existing resources, such as scavenger hunts created using Google Forms, into the Microsoft environment, they have encountered limitations due to compatibility issues. While they can incorporate slides from Google into PowerPoint presentations, transferring forms between the platforms has proven impossible. As a result, the speaker has been unable to utilize certain materials to the same extent as before.

A pattern emerged in the perceptions of high school math teacher related to poor quality in technology tools and programs. Specifically, Participant 8 shared experiences of this challenge by saying,

> There is also a concern that the platforms that we are using are not aligning perfectly with the lesson itself, anyway. Just meaning the topic might be already preset in Delta Math or I could say IXL, whereas Connexus may teach it extremely differently. And so, there is this huge challenge of trying to overcome that hump of, you know, trying to reinvent the wheel… it does provide some challenges.

Participant 3 further voiced their experience with technology that does not align to mathematics standards, concepts, and content. This participant emphasized the perpetual challenge of aligning instructional tools with the required curriculum. They expressed doubt about the creation of customized math technology solely for Tennessee. Aligning the IXL content with their teaching objectives proved difficult, as it didn't sufficiently prepare students for their End-of-Course assessments. This process of realignment, particularly when standards are integrated into technology, was described as grueling. The participant highlighted the ongoing struggle faced by Mastery Connect in updating their item banks to match new standards. They emphasized the significant time teachers spend on this task and underscored the importance of ensuring that educational technology aligns with mandated standards.

Another pattern in the data that was prevalent among participants was the limited amount of time to incorporate technology properly. Interestingly, the study participants who integrate technology into math instruction do not feel they have enough time during class to efficiently use all resources available. For instance, Participant 8 said "I definitely see the challenges of trying to pull all of the technology we're trying to use into any one lesson. It is kind of 50-50 if I can get it all in there or not. Some days are great. Some days it does not happen." The high school math teachers consistently shared experiences related to the lack of resources, compatibility, and proper equipment needed to efficiently integrate technology into math instruction.

Theme 2

Theme 2 was students lacking the skill, will, desire to participate, and the abilities necessary to effectively use the technology incorporated into math instruction. The perceptions about how high school math teachers described their experiences with challenges integrating technology in class instruction were surveyed. This theme emerged because many participants stated that there were concerns with students and technology integration into math instruction. Participants expressed that students use technology but struggle with the math content, students use technology tools inefficiently and inappropriately, and student willingness, level of participation, and buy-in was poor.

Several participants mentioned the issue of students not being prepared for instruction with proper tools such as a charged laptop, high speed internet, and a calculator. Even more, a few other participants spoke about technology integration as it related to student lack of participation and willingness. Participant 6 said, “The biggest challenge is just getting kids to do it.” Participant 5 shared about student willingness by highlighting a prevalent issue regarding students’ reluctance to learn how to utilize technology effectively. Despite efforts to impart knowledge, they encountered instances where students confidently provided incorrect answers when using calculators. In one particular session, held towards the end of the semester, the teacher focused on quadratic equations during a remedial instruction (RTI) session. They instructed the students to input equations into their calculators, only to discover that one student was unable to do so, having never been taught the process. This incident accentuated the cognitive aspect of students’ willingness and ability to utilize technological tools effectively. The participant emphasized that while tools like Desmos are valuable, they require prior knowledge and understanding to be used successfully, especially in algebraic contexts.

Some participants cited having issues with lazy students. While Participant 4 discussed that students are not attentive:

> The most struggle is just getting them to get into it, to do it and then of the ones who come in. Most of them tend to play along with me, and most of them will do that engagement piece with me. Some of them just open it to say they opened it and then they minimize the screen and walk off. That is more of an attention issue.

In line with the pattern of expressing concerns about students and technology integration, Participants 2 and 7 identified that students use technology but struggle with the math content as an issue. Participant 1 exclaimed that,

> The only thing that I could really think would cause an issue with understanding the content and the technology is if they do not know how to use the technology. It becomes a hindrance. So, they are so focused on learning how to use the technology they do not focus on the actual content involved.

Students using technology tools inefficiently and inappropriately was a problem that the high school teachers identified during the interview. Some participants think that students are fearful of manipulating technology tools and platforms. Participant 4 said, “there is an issue when students are fearful of just manipulating in the program.” Participant 4 went on to say in regard to this challenge:

> The biggest one I had was trying to teach the kids which tool did what? So, I had a live lesson on that one where I went through and said, okay, let’s look at what this tool does. And I clicked on the button. And I would just start doing stuff. And they’re like, oh, that’s what that does. So, I was trying to teach them that it is okay to click on things to see what happens.

Both Theme 1 and 2 expressed participants' responses to Research Question 1: What are high school teacher perceptions of the challenges in integrating technology in math instruction? The pattern that emerged for theme 1 is that high school math teachers feel there is a lack of resources, compatibility, and proper equipment needed to efficiently integrate technology into math instruction. The pattern that emerged for theme 2 is that high school math teachers feel that students lack the skill, will, desire to participate, and the ability necessary to effectively incorporate technology into math instruction. The next research question revealed data about what high school math teachers consider as viable strategies for infusing instructional technology into math classrooms.

Research Question 2

The second research question was: What do high school teachers consider viable strategies for infusing instructional technology into math classrooms? Two themes related to the second research question. The first theme was several technology tools and programs used to enhance and integrate into math instruction. The second theme was different strategies and techniques using technology tools and programs in math instruction.

Theme 3

Theme 3 was technology tools and programs used to enhance and integrate into math instruction. This theme emerged from most participants that described technology tools and programs integrated into math instruction. The teachers in this study stated that their experience with technology includes various tools, programs, and applications, for example, Google applications, calculators, Kahoot, IXL, Math Excel, Delta Math, Moby Max, and Nearpod.

Theme 3 generated an understanding of what high school math teachers perceived as their experiences with integrating technology tools and programs efficiently into math instruction. When asked about strategies for infusing technology in math instruction, there was a similarity in all responses. For example, Participant 2 stated, "So, with the kids, I have the TI-30, and I have gotten Desmo. In the classroom, because you know, the two calculators on the test are the TI-30 and the Desmos, and so I flip and flop back and forth between them." Participant 2 also said, "I use Desmos a lot. And other online platforms, too." Participant 4 had a similar perception saying,

> I think, with today's age, and especially with the fact that we are virtual teachers. We have to do everything technology, with these students. And even in brick and mortar. These students tend to be more fascinated with anything that is electronic versus pen and paper. You hand them a piece of paper and they look at it like, what do you? What do you want me to do with this thing? You put a screen in front of them and they are like, hey?

Many participants also talked about Google applications. A pattern emerged regarding teachers using Google Classroom, Slides, Forms, and Docs. Participant 6 expressed experience with Google by stating their perception as:

> Google slides, for example, different groups would have a different Google slide presentation to work on where I wouldn't necessarily have to be in different

> breakout rooms. But they are working on a different thing and communicating on that.

Participant 10 said "I use Edulastic for homework. The Edulastic is there for them because they have 10 checks per question. So, as they're doing their homework, they can check their own answers as they go." Participant 3 further expressed experiences with technology programs by saying,

> I either put my lesson itself together on Google Slides or Nearpod, one or the other, depending on if I am going to use the activities in Nearpod or not. So, let's say, in non-Nearpod Day, a Google slides day. I would create my slides ahead of time, and I always build in pieces in the slides where we have an opportunity to switch over to Delta Math and practice.

Other participants shared experiences with using technology tools for presentations, recordings, and class sessions. Participant 6 described it by saying, "A Loom … I use it to teach. But that is where I record all my videos." Participant 4 further exclaimed the technology tools infused into math instruction by saying,

> Classkick is one of the ones I like to use a lot because they can interact with it. It was really good at letting the students really interact, especially being able to move around like doing the angles and such. They were able to move the lines around and see where the lines actually intersect and be able to play with that. Usually, I draw a lot.

The high school math teachers consistently shared experiences related to the technology tools and programs used to enhance and integrate into math instruction.

Theme 4

Theme 4 was different strategies and techniques using technology tools and programs in math instruction. This theme emerged from most participants that described strategies and techniques using technology tools and programs integrated into math instruction.

Theme 4 generated an understanding of what high school math teachers perceived as their experiences with different strategies and techniques using technology tools and programs in math instruction. When asked about experiences with different technology integrated in math instruction, there was a similarity in all responses. For example, Participant 6 modified instruction to tailor towards catering to students who require more visual aids. For instance, during a session, this teacher focused on concepts like exponential to logarithmic forms, utilizing varied colors and incorporating drawings to enhance comprehension. They actively emphasized vocabulary, employing techniques such as highlighting while preparing notes and recordings. Acknowledging the challenges posed by new curriculum, the teacher adopted a guided notes approach, offering students options like PDF versions for printing or interactive versions via Nearpod, allowing them to follow along and take notes synchronously during video instruction.

Participant 9 had a similar perception acknowledging a strategy to infuse technology by incorporating competitive elements into activities as a common strategy to engage their students. This approach not only taps into their competitive nature but also facilitates learning in a manner that feels enjoyable and effortless. By capitalizing on this,

this teacher enhances the learning experience. Additionally, the teacher employs guided notes with students a few days later to ensure focused learning and comprehension.

Many participants also talked about other techniques including grouping, project-based learning, and manipulatives. A pattern emerged regarding teachers using interactive platforms. Participant 6 expressed experience with interactivity by stating their perception as:

> It's hard sometimes to get them to connect to our activities, especially on the high school level. So, I work with geometry. For the last couple of years, I've been working with geometry, and I think some of the things that allowed them to be motivated or to be engaged in the lesson are anything that we do that's interactive. So, I think strategies that I have used as I try to incorporate something that they can do with me in the moment.

Participant 1 further expressed experiences with strategies by saying "Just try and have more fun with it in the games. We will do puzzles, like mazes and scavenger hunts."

Both Theme 3 and 4 expressed participants' responses to Research Question 2: What do high school teachers consider viable strategies for infusing instructional technology into math classrooms? The pattern that emerged for theme 3 is that high school math teachers feel there are several technology tools and programs used to enhance and integrate into math instruction. The pattern that emerged for theme 4 is that high school math teachers used different strategies and techniques using technology tools and programs in math instruction.

Evidence of Trustworthiness

Trustworthiness or rigor of a study refers to the degree of confidence in data, interpretation, and methods used to ensure the quality of a study. In qualitative research, minimizing assumptions of the researcher is crucial for maintaining the rigor, credibility, and reliability of research (Kalpokaite & Radivojevic, 2019). Lincoln and Guba (1985) derived four components of trustworthiness. The components of trustworthiness as delineated by Lincoln and Guba are credibility, transferability, confirmability, and dependability.

Credibility

The credibility of the study or confidence in the study's truth and, therefore, the findings is an essential criterion in establishing trustworthiness (Shenton, 2004). Credibility is parallel to internal validity for quantitative research (Burkholder et al., 2020). According to Burkholder et al. (2020), for qualitative research to be credible, the findings of the study must be believable based on the data presented. Member checks are used to bolster and explore a study's credibility, also known as participant or respondent validation (Shenton, 2004). For this study, the data or results were returned to participants to check for accuracy of responses. Member checking was completed after the interview process to increase this qualitative study's credibility.

Transferability

Transferability relates to the external validity of the results of the study. External validity is generalizing the treatment/condition outcomes (Burkholder et al., 2020; Creswell & Poth, 2016). External validity should be evident in the study and the results should transfer to different settings, groups, or populations (Burkholder et al., 2020). To ensure and improve transferability, rich descriptions were implemented with the findings. A rich description refers to providing detailed accounts of the participants' perceptions, experiences, views, intentions, implications, and understandings. (Younas et al., 2023). Each interview was audio-recorded and transcribed to capture the detailed accounts of the perceptions of each participant.

Dependability

According to Burkholder et al. (2020), dependability means that evidence of consistency in the data collection, analysis, and reporting and any adjustments or shifts in methodology are documented and explained. To establish dependability, an audit trail was implemented. During each interview, notes were taken to capture any additional feedback from the participants. Audit trail refers to the process of maintaining detailed records of the complete research process, including data collection, coding, and analysis decisions.

Confirmability

According to Burkholder et al. (2020), confirmability refers to the level that a qualitative study is confirmed or corroborated by others. A strategy to establish this aspect of trustworthiness is through documentation of an audit trail. To accomplish this the researcher documented every phase of the research process, including perceptions of each step of the study (Ravitch & Carl, 2021). This documentation assisted in confirming and justifying the study, focusing on neutrality.

Summary

In Chapter 4, the results of the study were provided based on the two research questions. After thematic analysis of feedback from interviews completed by 10 participants, four major themes emerged. In this study, high school math teachers' perspectives regarding challenges with integrating technology into math instruction in Tennessee was explored. For research question 1, participants felt there is a lack of resources, compatibility, and proper equipment needed to efficiently integrate technology into math instruction and students lack the skill, will, desire to participate, and the ability necessary to effectively incorporate technology into math instruction. For research question 2, participants identified several technology tools and programs used to enhance and integrate into math instruction, as well as different strategies and techniques using technology tools and programs in math instruction. In Chapter 5, a discussion of findings, limitations of the study, and researcher recommendations will be provided.

Chapter 5: Discussion, Conclusions, and Recommendations

In this basic qualitative study, high school math teachers' perspectives regarding challenges with integrating technology into math instruction were explored. In addition, viable strategies for infusing instructional technology into math classrooms were explored. The data for the study were gathered from semistructured interviews with 10 high school math teachers from Tennessee high schools. The interviews were conducted and audio recorded through Zoom. The participants had experience teaching math and integrating technology into math instruction.

The data were analyzed using thematic analysis. From the thematic analysis, four themes emerged that were used to answer the research questions:

- lack of resources, compatibility, and proper equipment needed to efficiently integrate technology into math instruction
- students lacking the skill, will, desire to participate, and the ability necessary to effectively incorporate technology into math instruction
- technology tools and programs used to enhance and integrate into math instruction
- different strategies and techniques using technology tools and programs in math instruction

Understanding challenges present with technology integration in mathematics instruction may allow educational administrators to encourage technology use in math instruction and create systems that ensure technology is incorporated in classrooms. In this chapter, a discussion of the results of this study is provided. This chapter also includes the interpretation of findings, limitations of the study, recommendations based on findings, implications for social change, and a conclusion.

Interpretation of the Findings

The data collection commenced after the approval by the Walden University IRB. Semistructured interviews were conducted with 10 high school math teachers from Tennessee. The interviews encouraged the participants to share responses that would answer the following research questions:

RQ1: What are high school teachers perceptions of the challenges in integrating technology in math instruction?

RQ2: What do high school teachers consider viable strategies for infusing instructional technology into math classrooms?

Using thematic analysis, I analyzed the data obtained for themes. The key themes represented my interpretation of the findings of this study. The findings were then interpreted using the current literature and TPACK, which was the theoretical framework guiding this study.

Theme 1: Lack of Resources, Compatibility, and Proper Equipment Needed to Efficiently Integrate Technology Into Math Instruction

The categories related to challenges to efficiently integrate technology into math instruction led to the theme related to the lack of resources, compatibility, and proper equipment. Participant 1 shared a desire to have an ample supply of devices to implement into math instruction. The challenges that teachers face also included limited time to incorporate technology properly. Participants 1, 2, 3, 7, and 8 felt that technology equipment was sometimes inoperable or incompatible when desiring to implement into math instruction. The findings are supported by the existing literature. According to Kaminskienė et al. (2022), teachers are frustrated with the technological challenges that arise affecting the efficient integration in math instruction.

Theme 2: Students Lacking the Skill, Will, Desire to Participate, and the Ability Necessary to Effectively Incorporate Technology Into Math Instruction

Participants expressed that challenges with students were a major issue when attempting to effectively incorporate technology into math instruction. The challenges that teachers shared included students' lack of skill and will. Many participants stated this concern with students using technology but still struggling with the math content. Also, participants expressed that students use technology tools inefficiently and inappropriately with low buy-in. Several participants mentioned the issue of students not being prepared for instruction with proper tools such as a charged laptop, high speed internet, and a calculator. Consistent with existing literature, integrating technology with challenges directly related to the students decreases the levels of student engagement with math instruction (Rone et al., 2023).

Theme 3: Technology Tools and Programs Used to Enhance and Integrate Into Math Instruction

Participants in the current study reported their perceptions of technology tools and programs used to enhance and integrate into math instruction. Participants also mentioned that their experiences with technology included various tools, programs, and applications (e.g., Google applications, calculators, Kahoot, IXL, Math Excel, Delta Math, Moby Max, Edulastic, and Nearpod). Participant 10 stated

> I use a couple of different platforms. I use Edulastic for homework. The Edulastic is there for them because they have 10 checks per question. So, as they are doing their homework, they can check their own answers as they go. If they are continuing to get the wrong, they can get help, or along the lines if they are at home and they get the green and they get the green check mark. They know that they are on the right track. It is kind of like a personal tutor for them in a way, or a temperature check is what I say. You know, this is your temperature check. Are you on the right track, or do you need a little intervention? Because I can't be with all 85 students at the same time, it's hard for me to know where they are. But this is a way for them to be self-aware of where they are and get help, and for the most part, my kids do that if they keep getting wrong answers when they enter it in. They can ask, "What am I doing wrong?" And we look at it together. And I fix a lot of problems that way.

Research confirmed that digital technology could support creative thinking and authentic and innovative problem solving, manipulate data, and create opportunities (Hernawati & Jailani, 2019; Hill & Uribe-Florez, 2020; NCTM, 2015). The current findings could be attributed to similarities in responses among the participants when asked about strategies for infusing technology in math instruction, which align to domains of TPACK as explained by Mishra and Koehler (2006).

Theme 4: Different Strategies and Techniques Using Technology Tools and Programs in Math Instruction

The category related to strategies and techniques used in instruction formed Theme 4. Participants identified several techniques and strategies to incorporate technology into math instruction. Such techniques and strategies included using color and highlights with technology, playing games, project-based learning, online practice problems, interactive platforms, electronic puzzles/mazes/scavenger hunts, internet researching, using manipulatives, real-world connections, drawing with technology, and using technology tools that provide instant feedback. A variety of teaching strategies including gamified learning enhances student learning and motivation and reduces anxiety (M. Chen et al., 2023). Consistent with literature, Participant 9 said

> playing some sort of game because my students are very competitive, and we introduce things that bring out their competitiveness. But it is also helping them learn without them knowing that they are learning because they just want to win, according to their brains. You have to use that. And then a few days. I like to do guided notes with students so that way they can be focused.

There are several different strategies and techniques using technology tools and programs in math instruction that high school math teachers used.

Limitations of the Study

Interviews were a valuable qualitative research method for gathering in-depth information and insights from participants. The potential weaknesses of the study that affect the outcomes due to elements beyond the researcher’s control are considered research limitations (Theofanidis & Fountouki, 2019). One limitation of the present study was response bias. Response bias refers to participants providing answers they believe the interviewer wants to hear, rather than their true thoughts or experiences, resulting in inaccurate or incomplete data (Ravitch & Carl, 2021). To mitigate the limitation of response bias during the interviews, I remained focused to maintain integrity and kept the conversation consistent with answering the interview questions.

Recommendations

Based on the results of the study, several recommendations may be made for future research. The current study involved the participation of secondary math teachers selected as subjects from various high schools within the state of Tennessee. As a result, it is recommended that future studies in the field should broaden their participant pool to include educators from diverse school districts, preferably spanning different states.

Furthermore, the current study relied on a single data source, specifically semistructured interviews. It is recommended that future research endeavors employ multiple data sources to enhance the strength of the findings. Triangulating data through the integration of diverse methodologies such as focus groups, document review, or qualitative questionnaires could be beneficial. This approach would not only provide a more comprehensive understanding of the subject matter but would also contribute to the validation and reliability of the research outcomes. Future researchers exploring the same thematic domain are encouraged to adopt a multifaceted approach to data collection to enrich the depth and breadth of their investigations.

I employed a purposeful sampling technique to explore the perspectives of secondary high school teachers regarding their challenges in integrating technology into math instruction. However, there was a notable gap in the understanding of elementary and middle school teachers' viewpoints on the challenges associated with incorporating technology in math instruction. Consequently, it is recommended that future research focus on elementary and middle school educators, given their pivotal role in integrating technology into classroom teaching and learning.

Moreover, researchers are encouraged to explore a broader spectrum of thematic areas, including digital technology, innovative teaching methods, the impact of mathematics education on student achievement, inquiry-based learning, games and gamification, and issues related to equity, diversity, and inclusion—topics identified as contemporary trends in math education by Hussein (2023). To ensure a representative sample, alternative sampling strategies such as stratified sampling may be employed in future studies.

Furthermore, diversifying research designs and methodologies is advised. Although I adopted a basic qualitative approach, future investigations may benefit from the incorporation of quantitative methodologies. This shift would facilitate the collection of numerical data, enhancing the precision and neutrality of the results. Additionally, researchers are encouraged to explore alternative qualitative research designs beyond the basic qualitative approach, such as the case study design. This multifaceted approach will contribute to a more comprehensive understanding of the challenges associated with integrating technology in math instruction across various educational levels.

Implications

Potential Impact for Positive Social Change

The current study has the potential to facilitate positive social change by exploring high school teachers' perceptions of challenges integrating technology and informing decision makers regarding incorporating technological teaching practices in high school math. Using this research as a guide, educational professionals could design mathematics education programs that focus on meeting the needs of students in high school math technology-enriched classrooms. This would allow for developing necessary skills and capabilities that help students compete effectively with societal and technological advancements.

This study may promote positive social change for students, allowing them to critically analyze and evaluate information, solve complex problems, and think creatively using digital tools. Students can create digital content, explore innovative solutions, and express their ideas through multimedia, fostering creativity and innovation skills (James et al., 2021). Existing literature on technology integration in math instruction supported students' engagement, growth of critical thinking skills and problem-solving abilities, and academic achievement (Ali et al., 2023). Furthermore, students may impact their communities by developing skills needed for science, technology, engineering, and mathematics related careers.

Methodological and Theoretical Implications

Exploring high school math teachers' perceptions of integrating technology within the framework of TPACK holds significant methodological and theoretical implications.

Methodologically, adopting the TPACK framework provides a structured lens through which to examine the complex interactions between TK, PK, and CK in the context of math instruction. Researchers can employ mixed-method approaches, combining qualitative techniques such as interviews or observations with quantitative measures to assess teachers' TPACK levels and their impact on instructional practices.

Furthermore, using TPACK as a theoretical framework would allow researchers to delve into various components, such as teachers' technological proficiency, pedagogical strategies, and understanding of mathematical concepts. This holistic perspective would enable a comprehensive analysis of the challenges and opportunities associated with technology integration in math education. Moreover, investigating high school math teachers' perceptions through the TPACK lens would facilitate the identification of specific areas in which educators may require additional support or professional development. By pinpointing gaps in TPACK knowledge, educational stakeholders may design targeted interventions to enhance teachers' competencies and foster more effective integration of technology in math instruction.

Theoretical implications of this study lie in its contribution to the ongoing discourse surrounding the application of TPACK theory in different subject areas, particularly mathematics education. By examining how high school math teachers conceptualize and represent TPACK principles in their teaching practice, researchers may contribute empirical evidence to enrich and refine the theoretical framework. Additionally, the current study may shed light on the unique challenges of integrating technology in the domain of math education, informing the development of context-specific models and theories within the broader TPACK framework. Insights gained from this research may advance the understanding of how technology can be effectively leveraged to enhance mathematical learning experiences and outcomes for high school students. In conclusion, investigating high school math teachers’ perceptions of technology integration through the lens of TPACK offers valuable methodological and theoretical insights that may inform both research and practice in mathematics education. By interpreting the intricate dynamics between TK, PK, and CK, this study has the potential to shape future efforts aimed at promoting innovative and impactful teaching practices in high school math classrooms.

Recommendations for Practice

To enhance the integration of technology into math instruction, it is advisable for high school teachers to engage in ongoing training programs, workshops, and seminars tailored specifically to platforms like Classkick, Nearpod, Desmos, and Kahoot. While many educators already utilize these tools, there is a pressing need for further skill development and proficiency to effectively integrate them into math curriculum. High school math teachers would benefit from refining their time management abilities to maximize the efficiency of technology integration in their instructional practices. Moreover, students should receive training and guidance emphasizing the importance of utilizing technological resources, aiming to address issues stemming from a lack of skills, motivation, or willingness to engage with technology in math education.

Furthermore, educational administrators and leaders are encouraged to establish systems that ensure the proper integration of technology in classrooms. This may entail providing support structures, resources, and incentives for both teachers and students to embrace technology-enhanced learning environments effectively. District leaders play a crucial role in this endeavor by ensuring that technological tools, programs, and software align with state standards, fostering coherence and consistency in technology integration efforts across schools and classrooms. By implementing these recommendations, educational institutions can create an environment conducive to leveraging technology to its fullest potential in math instruction, enhancing student learning outcomes and preparing them for the demands of the digital age.

Conclusion

The aim of this basic qualitative study was to explore the high school math teachers' perceptions of the challenges in integrating technology in math instruction. In this basic qualitative study, the high school math teachers' perceptions of the challenges in integrating technology in math instruction were examined. The literature review revealed that digital competence is necessary to understand connection to technology integration. Technology integration in education refers to the effective use of technology tools, resources, and strategies to enhance and support the teaching and learning process (H. Chen et al., 2019). Through this study, there was an attempt to fill the gaps in literature and practice by exploring high school teachers' perceptions of the challenges in integrating technology in math instruction. The data for the study were collected through semistructured interviews with 10 high school math teachers. The research questions explored high school math teachers' perceptions of the challenges they experience and viable strategies for integrating technology into classroom instruction. Thematic analysis of collected data identified the following four major themes,

- lack of resources, compatibility, and proper equipment needed to efficiently integrate technology into math instruction
- students lacking the skill, will, desire to participate, and the ability necessary to effectively incorporate technology into math instruction
- technology tools and programs used to enhance and integrate into math instruction
- different strategies and techniques using technology tools and programs in math instruction

The four themes answered the two research questions and met the purpose of this study. The findings also filled the gap in the literature by providing insight into high school teachers' perceptions of the challenges in integrating technology in math instruction in Tennessee. The findings increased the understanding of viable strategies that high school teachers consider when integrating technology into math instruction. The findings of this study also supported positive social change by highlighting the challenges that high school math teachers experience. The limitation of this study is related to response bias. A follow-up study on the same topic using more participants and a more comprehensive geographical location is recommended. The results of this study have implications for educational professionals, teachers, students, and societies.

References

Akturk, A. O., & Saka Ozturk, H. (2019). Teachers' TPACK levels and students' self-efficacy as of students' academic achievement. *International Journal of Research in Education and Science (IJRES)*, *5*(1), 283–294.

Alabdulaziz, M. S. (2021). COVID-19 and the use of digital technology in mathematics education. *Education and Information Technologies*, *26*(6), 7609–7633. https://doi.org/10.1007/s10639-021-10602-3

Ali, M., Yasmeen, R., & Munawar, Z. (2023). The impact of technology integration on student engagement and achievement in mathematics education: A systematic review. *International Journal of Computer Integrated Manufacturing*, *6*, 222–232.

American Library Association. (2021). *Digital Literacy*.

Association for Supervision and Curriculum Development [ASCD] and OverDrive Education. (2019). *The 2019 K–12 Digital Content Report*. https://doi.org/10.4135/9781412958806

Attard, C., & Holmes, K. (2020). "It gives you that sense of hope": An exploration of technology use to mediate student engagement with mathematics. *Heliyon*, *6*(1). https://doi.org/10.1016/j.heliyon.2019.e02945

Audrin, C., & Audrin, B. (2022). Key factors in digital literacy in learning and education: A systematic literature review using text mining. *Education and Information Technologies*, *27*(6), 7395–7419. https://doi.org/10.1007/s10639-021-10832-5

Awofala, A., & Olaniyi, A. (2023). Assessing teachers' formative evaluation strategy as related to senior secondary school students' achievement in mathematics. *ASEAN Journal for Science Education*, *2*(2), 77–86. https://ejournal.bumipublikasinusantara.id/index.php/ajsed/article/view/228

Baran, E., Canbazoglu Bilici, S., Albayrak Sari, A., & Tondeur, J. (2019). Investigating the impact of teacher education strategies on preservice teachers' TPACK. *British Journal of Education Technology*, *50*(1), 357–370. https://doi.org/10.1111/bjet.12565

Basilotta-Gómez-Pablos, V., Matarranz, M., Casado-Aranda, L.-A., & Otto, A. (2022). Teachers' digital competencies in higher education: A systematic literature review. *International Journal of Educational Technology in Higher Education, 19*(1). https://doi.org/10.1186/s41239-021-00312-8

Berndt, A. E. (2020). Sampling methods. *Journal of Human Lactation*, *36*(2), 224–226. https://doi.org/10.1177/0890334420906850

Bhandari, P. (2022). *Internal validity in research | Definition, threats & examples.* Scribbr. https://www.scribbr.com/methodology/internal-validity/

Bingimlas, K. (2018). Investigating the level of teachers' knowledge in technology, pedagogy, and content (TPACK) in Saudi Arabia. *South African Journal of Education*, *38*(3), 1–12. https://doi.org/10.15700/saje.v38n3a1496

Burkholder, G. J., Cox, K. A., & Crawford, L. M. (Eds.). (2016). *The scholar practitioner's guide to research design.* Laureate Publishing.

Burkholder, G. J., Cox, K. A., Crawford, L. M., & Hitchcock, J. H. (Eds.). (2020). *Research designs and methods: An applied guide for the scholar-practitioner.*

SAGE.

Çebi, A., Bahçekapılı Özdemir, T., Reisoğlu, İ., & Çolak, C. (2022). From digital competencies to technology integration: Re-formation of pre-service teachers' knowledge and understanding. *International Journal of Educational Research*, *113*, 101965. https://doi.org/10.1016/j.ijer.2022.101965

Chen, H., Liao, L., Chang, Y., Hung, C., & Chang, L. (2019). Factors influencing technology integration in the curriculum for Taiwanese health profession Educators: A mixed-methods study. *International Journal of Environmental Research and Public Health (Online)*, *16*(14), 2602. https://doi.org/10.3390/ijerph16142602

Chen, M., Chen, Y., Zuo, P., & Hou, H. (2023). Design and evaluation of a remote synchronous gamified mathematics teaching activity that integrates multi-representational scaffolding and a mind tool for gamified learning. *Education and Information Technologies*, *28*(10), 13207–13233. https://doi.org/10.1007/s10639-023-11708-6

Cheng, P.-H., Molina, J., Lin, M.-C., Liu, H.-H., & Chang, C.-Y. (2022). A New TPACK Training Model for Tackling the Ongoing Challenges of COVID-19. *Applied System Innovation*, *5*(2), 32. https://doi.org/10.3390/asi5020032

Chetty, K., Qigui, L., Gcora, N., Josie, J., Wenwei, L., & Fang, C. (2018). Bridging the digital divide: measuring digital literacy. *Economics*, *12*(1). https://doi.org/10.5018/economics-ejournal.ja.2018-23

Collins, E., & Schaaf, K. (2020). Teacher retention in Tennessee. Tennessee Department of Education.

CompTIA. (2021). *Technology Education and Digital Literacy Trends*. https://www.comptia.org/content/research/technology-and-digital-literacy-education-trends/

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Criollo-C, S., Guerrero-Arias, A., Jaramillo-Alcázar, Á., & Luján-Mora, S. (2021). Mobile Learning Technologies for Education: Benefits and Pending Issues. *Applied Sciences*, *11*(9), 4111. https://doi.org/10.3390/app11094111

Das, K. (2019). Role of ICT for Better Mathematics Teaching. *Shanlax International Journal of Education, 7*(4), 19–28. https://doi.org/10.34293/education.v7i4.64

Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development*, *68*(5), 2449–2472. https://doi.org/10.1007/s11423-020-09767-4

Fasching, M., & Schubatzky, T. (2022). Beyond truth: Teaching digital competences in secondary school against disinformation: Experts' views on practical teaching frameworks for basic digital education in Austria. *Medienimpulse, 60*(3), 65-Seiten.

Fernández-Batanero, J.-M., Román-Graván, P., Reyes-Rebollo, M.-M., & Montenegro-Rueda, M. (2021). Impact of Educational Technology on Teacher Stress and Anxiety: A Literature Review. *International Journal of Environmental Research and Public Health*, *18*(2), 548. https://doi.org/10.3390/ijerph18020548

Freiman, V., & Tassell, J. L. (2018). Leveraging Mathematics Creativity by Using Technology: Questions, Issues, Solutions, and Innovative Paths. *Creativity and Technology in Mathematics Education*, 3-29. https://doi.org/10.1007/978-3-319-72381-5_1

Fulgence, K. (2020). Developing digital fluency among teacher educators: Evidence from Tanzanian Schools of Education. *International Journal of Education and Development using Information and Communication Technology (IJEDICT), 16*(2), 158–175.

Gilster, P. (1997). *Digital literacy* (p. 1). New York: Wiley Computer Pub.

Guitert, M., Romeu, T., & Baztán, P. (2021). The digital competence framework for primary and secondary schools in Europe. *European Journal of Education*, *56*(1), 133-149. https://doi.org/10.1111/ejed.12430

He, T., & Li, S. (2019). A comparative study of digital informal learning: The effects of digital competence and technology expectancy. *British Journal of Educational Technology*, *50*(4), 1744-1758. https://doi.org/10.1111/bjet.12778

Helsper, E. J., Scheider, L. S., van Deursen, A. J., & van Laar, E. (2020). The youth Digital Skills Indicator: Report on the conceptualization and development of the ySKILLS digital skills measure.

Hernawati, K., & Jailani. (2019). Mathematics mobile learning with TPACK framework. *Journal of Physics: Conference Series, 1321*(2), 022126. https://doi.org/10.1088/1742-6596/1321/2/022126

Hill, J. E., & Uribe-Florez, L. (2020). Understanding Secondary School Teachers’

TPACK and Technology Implementation in Mathematics Classrooms. *International Journal of Technology in Education, 3*(1), 1. https://doi.org/10.46328/ijte.v3i1.8

Howitt, D., & Cramer, D. (2011). *Introduction to research methods in psychology*. Prentice Hall.

Hussein, H. (2023). Global Trends in Mathematics Education Research. *International Journal of Research in Educational Sciences*, *6*(02), 309- 319. https://iafh.net/index.php/IJRES/article/view/400

Ilomäki, L., & Lakkala, M. (2018). Digital technology and practices for school improvement: innovative digital school model. *Research and Practice in Technology Enhanced Learning*, *13*(1). https://doi.org/10.1186/s41039-018-0094-8

International Society for Technology in Education. (2017). ISTE standards for educators. Washington, DC: International Society for Technology in Education.

Jadhav, P., Gaikwad, H., & Patil, K. (2022). Teaching and Learning with Technology: Effectiveness of ICT Integration in Schools. *ASEAN Journal for Science Education*, *1*(1), 33-40. https://ejournal.bumipublikasinusantara.id/index.php/ajsed/article/view/33

James, C., Weinstein, E., & Mendoza, K. (2021). Teaching digital citizens in today's world: Research and insights behind the Common Sense K–12 Digital Citizenship Curriculum. (Version 2). San Francisco, CA: Common Sense Media

Kalpokaite, N., & Radivojevic, I. (2019). Demystifying Qualitative Data Analysis for

Novice Qualitative Researchers. *The Qualitative Report*, *24*(13), 44-57. https://doi.org/10.46743/2160-3715/2019.4120

Kaminskienė, L., Järvelä, S., & Lehtinen, E. (2022). How does technology challenge teacher education? *International Journal of Educational Technology in Higher Education*, *19*(1). https://doi.org/10.1186/s41239-022-00375-1

Kartal, B., & Çinar, C. (2018). Examining Pre-Service Mathematics Teachers' Beliefs of TPACK during a Method Course and Field Experience. *Malaysian Online Journal of Educational Technology*, *6*(3), 11-37.

Keen, S., Lomeli-Rodriguez, M., & Joffe, H. (2022). From Challenge to Opportunity: Virtual Qualitative Research during COVID-19 and Beyond. *International Journal of Qualitative Methods*, *21*, 160940692211050. https://doi.org/10.1177/16094069221105075

Kim, H. J., Hong, A. J., & Song, H.-D. (2019). The roles of academic engagement and digital readiness in students' achievements in university e-learning environments. *International Journal of Educational Technology in Higher Education*, *16*(1). https://doi.org/10.1186/s41239-019-0152-3

Kim, S., Raza, M., & Seidman, E. (2019). Improving 21st-century teaching skills: The key to effective 21st-century learners. *Research in Comparative and International Education*, *14*(1), 99-117. https://doi.org/10.1177/1745499919829214

Knott, E., Rao, A. H., Summers, K., & Teeger, C. (2022). Interviews in the social sciences. *Nature Reviews Methods Primers, 2*(1). https://doi.org/10.1038/s43586-022-00150-6

Koehler, M. J., & Mishra, P. (2009). What Is Technological Pedagogical Content Knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*, 60-70.

Leedy, P., & Ormrod, J. (2016). *Practical Research: Planning and Design*, (11th ed.). Boston: Pearson.

Lester, J. N., Cho, Y., & Lochmiller, C. R. (2020). Learning to do qualitative data analysis: a starting point. *Human Resource Development Review*, *19*(1), 94–106. https://doi.org/10.1177/1534484320903890

Levano-Francia, L., Sanchez Diaz, S., Guillén-Aparicio, P., Tello-Cabello, S., Herrera-Paico, N., & Collantes-Inga, Z. (2019). Competencias digitales y educación. *Propósitos y Representaciones*, *7*(2). https://doi.org/10.20511/pyr2019.v7n2.329

Lichtman, M. (2023). Qualitative Research in Education: A User's Guide (4th ed.). Routledge. https://doi.org/10.4324/9781003281917

Lincoln, Y. S., Guba, E. G., & Pilotta, J. J. (1985). Naturalistic inquiry. *International Journal of Intercultural Relations*, *9*(4), 438-439. https://doi.org/10.1016/0147-1767(85)90062-8

Liu, Y., Zhao, L., & Su, Y.-S. (2022). The Impact of Teacher Competence in Online Teaching on Perceived Online Learning Outcomes during the COVID-19 Outbreak: A Moderated-Mediation Model of Teacher Resilience and Age. *International Journal of Environmental Research and Public Health*, *19*(10), 6282. https://doi.org/10.3390/ijerph19106282

Liza, K., & Andriyanti, E. (2020). Digital literacy scale of English pre-service teachers and their perceived readiness toward the application of digital technologies. *Journal of Education and Learning (EduLearn)*, *14*(1), 74-79. https://doi.org/10.11591/edulearn.v14i1.13925

Lombardi, A., Rifenbark, G., Tarconish, E., Volk, D., Monahan, J., Buck, A., Izzo, M., & Murray, A. (2020). Main and Moderating Effects of an Online Transition Curriculum on Career Readiness. *Career Development and Transition for Exceptional Individuals*, *43*(3), 146–156. https://doi.org/10.1177/2165143419900952

Lucas, M., Bem-Haja, P., Siddiq, F., Moreira, A., & Redecker, C. (2021). The relation between in-service teachers' digital competence and personal and contextual factors: What matters most? *Computers & Education*, *160*, 104052. https://doi.org/10.1016/j.compedu.2020.104052

Mannila, L., Nordén, L.-Å., & Pears, A. (2018). Digital Competence, Teacher Self-Efficacy, and Training Needs. *Proceedings of the 2018 ACM Conference on International Computing Education Research.* https://doi.org/10.1145/3230977.3230993

Mehrvarz, M., Heidari, E., Farrokhnia, M., & Noroozi, O. (2021). The mediating role of digital informal learning in the relationship between students' digital competence and their academic performance. *Computers & Education*, *167*, 104184. https://doi.org/10.1016/j.compedu.2021.104184

Melash, V. D., Molodychenko, V. V., Huz, V. V., Varenychenko, A. B., & Kirsanova, S. S. (2020). Modernization of Education Programs and Formation of Digital

Competences of Future Primary School Teachers. *International Journal of Higher Education, 9*(7), 377. https://doi.org/10.5430/ijhe.v9n7p377

Miguel-Revilla, D., Martínez-Ferreira, J. M., & Sánchez-Agustí, M. (2020). Assessing the digital competence of educators in social studies: An analysis in initial teacher training using the TPACK-21 model. *Australasian Journal of Educational Technology*. https://doi.org/10.14742/ajet.5281

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record: The Voice of Scholarship in Education, 108*(6), 1017-1054. https://doi.org/10.1177/016146810610800610

National Academies of Sciences, Engineering, and Medicine (NASEM). (2018). *English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25182.

National Council of Teachers of Mathematics. (2000). Principles and Standards for School Mathematics. Reston, VA: NCTM

National Council of Teachers of Mathematics (NCTM). (2015). Strategic Use of Technology in Teaching and Learning Mathematics. Reston, VA.

National Educational Technology Standards for Teachers (NETS-T). (2008). International Society for Technology in Education, Washington DC, USA.

Novita, R., & Herman, T. (2021). Digital technology in learning mathematical literacy, can it helpful? *Journal of Physics: Conference Series, 1776*(1), 012027. https://doi.org/10.1088/1742-6596/1776/1/012027

Opeyemi, D.-A., Ayodele, V., Alufa, O., Anderson, E., Strachan, R., & Emembolu, I. (2019). Barriers and Identified Solutions to the Integration of Digital Technologies in the Classroom: A Case Study of Teachers in Nigeria. 2019 IEEE Global Engineering Education Conference (EDUCON) https://doi.org/10.1109/educon.2019.872516

Pangrazio, L., Godhe, A.-L., & Ledesma, A. G. L. (2020). What is digital literacy? A comparative review of publications across three language contexts. *E-Learning and Digital Media*, *17*(6), 442–459. https://doi.org/10.1177/2042753020946291

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Perienen, A. (2020). Frameworks for ICT Integration in Mathematics Education - A Teacher's Perspective. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(6). https://doi.org/10.29333/ejmste/7803

Porat, E., Blau, I., & Barak, A. (2018). Measuring digital literacies: Junior high-school students' perceived competencies versus actual performance. *Computers & Education*, *126*, 23-36. https://doi.org/10.1016/j.compedu.2018.06.030

Rakes, C. R., Stites, M. L., Ronau, R. N., Bush, S. B., Fisher, M. H., Safi, F., Desai, S., Schmidt, A., Andreasen, J. B., Saderholm, J., Amick, L., Mohr-Schroeder, M. J., & Viera, J. (2022). Teaching Mathematics with Technology: TPACK and Effective Teaching Practices. *Education Sciences (Basel)*, *12*(2), 133. https://doi.org/10.3390/educsci12020133

Ravitch, S. M., & Carl, N. M. (2021). *Qualitative research: Bridging the conceptual,* *theoretical, and methodological* (2nd ed.). Sage Publications.

Redecker, C. (2017). European Framework for the Digital Competence of Educators: Digcompedu. https://ideas.repec.org/p/ipt/iptwpa/jrc107466.html

Rice, M. F. (2021). Reconceptualizing teacher professional learning about technology integration as intra-active entanglements. *Professional Development in Education, 47*(2-3), 524–537. https://doi.org/10.1080/19415257.2021.1891953

Rodríguez-Muñiz, L. J., Burón, D., Aguilar-González, Á., & Muñiz-Rodríguez, L. (2021). Secondary Mathematics Teachers' Perception of Their Readiness for Emergency Remote Teaching during the COVID-19 Pandemic: A Case Study. *Education Sciences*, *11*(5), 228. https://doi.org/10.3390/educsci11050228

Rogers, R. (2018). Coding and Writing Analytic Memos on Qualitative Data: A Review of Johnny Saldaña's The Coding Manual for Qualitative Researchers. *The Qualitative Report (Online)*, 23(4), 889-892. https://doi.org/ 10.46743/2160-3715/2018.3459

Rone, N., Guao, N. A., Jariol, M., Acedillo, N., Balinton, K., & Francisco, J. (2023). Students' Lack of Interest, Motivation in Learning, and Classroom Participation: How to Motivate Them?. *Psychology and Education: A Multidisciplinary Journal*, *7*(8), 636-646.

Salas-Rueda, R. A. (2019). TPACK: Technological, Pedagogical and Content Model Necessary to Improve the Educational Process on Mathematics through a Web Application? *International Electronic Journal of Mathematics Education*. https://doi.org/10.29333/iejme/5887

Saldaña, J. (2016). The Coding Manual for Qualitative Researchers. Sage Publications Inc.

Salimi, G., Heidari, E., Mehrvarz, M., & Safavi, A. A. (2022). Impact of online social capital on academic performance: exploring the mediating role of online knowledge sharing. *Education and Information Technologies*, *27*(5), 6599-6620. https://doi.org/10.1007/s10639-021-10881-w

Samuelsson, L., & Lindström, N. (2022). Online Surveillance and Education for Digital Competence. *Athens Journal of Education*, *9*(4), 545–558. https://doi.org/10.30958/aje.9-4-1

Sarı, M., & Bostancioglu, A. (2018). Application of Technological Pedagogical Content Knowledge Framework to Elementary Mathematics Teaching: A Scale Adaptation Study. *Journal of Theoretical Educational Science. 11.*

Saux, G., & Cevasco, J. (2019). Decoding Digital Literacy. *Literacy Today.* http://dx.doi.org/10.13140/RG.2.2.34638.41287

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22(2), 63–75. https://doi-org.ezp.waldenulibrary.org/10.3233/EFI-2004-22201

Shonfeld, M., Cotnam-Kappel, M., Judge, M., Ng, C. Y., Ntebutse, J. G., Williamson-Leadley, S., & Yildiz, M. N. (2021). Learning in digital environments: a model for cross-cultural alignment. *Educational Technology Research and Development*, *69*(4), 2151–2170. https://doi.org/10.1007/s11423-021-09967-6

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching.

Educational Researcher, *15*(2), 4-14. https://doi.org/10.3102/0013189x015002004

Skantz-Åberg, E., Lantz-Andersson, A., Lundin, M., & Williams, P. (2022). Teachers' professional digital competence: an overview of conceptualisations in the literature. *Cogent Education, 9*(1). https://doi.org/10.1080/2331186x.2022.2063224

Spires, H. A., Medlock Paul, C., & Kerkhoff, S. N. (2019). Digital Literacy for the 21st Century. *Advances in Library and Information Science*, 12-21. https://doi.org/10.4018/978-1-5225-7659-4.ch00

Stahl, N., & King, J. (2020). Expanding approaches for research: understanding and using trustworthiness in qualitative research. *Journal of Developmental Education*, *44*(1), 26-28.

Starkey, L. (2020). A review of research exploring teacher preparation for the digital age. *Cambridge Journal of Education*, *50*(1), 37–56. https://doi.org/10.1080/0305764x.2019.1625867

Tallon, P. P., Queiroz, M., Coltman, T., & Sharma, R. (2019). Information technology and the search for organizational agility: A systematic review with future research possibilities. *The Journal of Strategic Information Systems*, *28*(2), 218-237. https://doi.org/10.1016/j.jsis.2018.12.002

Tárraga-Mínguez, R., Suarez-Guerrero, C., & Sanz-Cervera, P. (2021). Digital Teaching Competence Evaluation of Pre-Service Teachers in Spain: A Review Study. *IEEE*, *16*(1), 70–76. https://doi.org/10.1109/RITA.2021.3052848

Theofanidis, D., & Fountouki, A. (2019). Limitations And Delimitations in The Research Process. *Perioperative nursing (GORNA)*, *7*(3), 155–162. http://doi.org/10.5281/zenodo.2552022

Thurm, D., & Barzel, B. (2021). Teaching mathematics with technology: a multidimensional analysis of teacher beliefs. *Educational Studies in Mathematics 109*, 41–63. https://doi.org/10.1007/s10649-021-10072-x

UNESCO. (2018). ICT Competency Framework for Teachers Version 3.0. http://en.unesco.org/open-access/terms-use-ccbysa-en

Vissenberg, J., d'Haenens, L., & Livingstone, S. (2022). Digital literacy and online resilience as facilitators of young people's well-being? A systematic review. *European Psychologist, 27*(2), 76–85. https://doi.org/10.1027/1016-9040/a000478

Wang, J., Wang, J., Kim, E., & Kim, E. (2023). The Development and Validation of an Instrument to Collaborative Teaching Assessment under the Impact of COVID-19 through the SECI Model. *Sustainability*, *15*(12), 9540.

Wilkinson, L. C., Bailey, A. L., & Maher, C. A. (2018). Students' Mathematical Reasoning, Communication, and Language Representations: A Video-Narrative Analysis. *ECNU Review of Education*, *1*(3), 1–22. *https://doi.org/10.30926/ecnuroe2018010301*

Younas, A., Fàbregues, S., Durante, A., Escalante, E. L., Inayat, S., & Ali, P. (2023). Proposing the "MIRACLE" Narrative Framework for Providing Thick Description in Qualitative Research. *International Journal of Qualitative Methods, 22*. https://doi.org/10.1177/16094069221147162

Appendix A: Participant Demographic Survey

1. Name
2. Email Address
3. Phone Number
4. Grade Level
    a. 9
    b. 10
    c. 11
    d. 12
5. Number of years of experience with teaching math instruction?
    a. 0-less than a year
    b. 1-5 years
    c. 5+ years
6. Number of years of experience integrating technology in math instruction?
    a. 0-less than a year
    b. 1-5 years
    c. 5+ years

Thank you. You will be contacted with more information regarding the research study.

Appendix B: Interview Protocol

Introduction Script

I want to thank you for your willingness to participate in the interview aspect of my study. This proposed study will explore high school teachers' perceptions of the challenges in integrating technology into math instruction. Our discussion will take about 35 minutes, and I will be recording it so I can go back and make a transcript.

Before we begin, I wanted to remind you about the informed consent form you signed online. Your responses are confidential. You will be given a code so your answers will not be connected to your name, and all the information I collect will be kept on a password-protected computer and back-up drive. The only people who will access your information and your identity are my committee members and me. I do have questions to guide our discussion, but please feel free to share, as I want to know how you are integrating technology into math instruction and your perception of the challenges you encounter. You do not have to answer any questions you do not want to, and you are free to conclude the interview anytime. Do you have any questions before we begin?

Interview Questions

1. How do you ensure that you have a deep understanding of the content you teach? (Content Knowledge (CK))
2. Can you share an example of a lesson demonstrating the pedagogical strategies used to engage students? (Pedagogical Knowledge (PK))

3. Explain how you modify your teaching methods to meet the diverse needs of your students while considering the specific content you are teaching. (Pedagogical Content Knowledge (PCK))
4. What are your experiences with different technology tools or platforms you have used? (Technological knowledge (TK))
5. Share your experience with integrating technology into your math lessons. (Technological content knowledge (TCK))
6. Have you encountered challenges aligning your pedagogical approach with the technology tools available? Can you share an example? (Technological pedagogical knowledge (TPK))
7. Considering technology, pedagogy, and content knowledge, what challenges have you encountered when integrating technology in math instruction? (Technological pedagogical content knowledge (TPCK))
8. What do you perceive as the main benefits of incorporating technology into math teaching?
9. How do you envision the advancement of integration of technology in math instruction?

The following probes will be used if needed for all the semistructured interview questions above to get detailed responses to the questions:

Probe 1: can you tell me more about that?

Probe 2: can you give me an example of that?

Probe 3: what did you mean when you said ...?

Concluding Script

Now that we have concluded the interview, I would like to take this opportunity to address any questions or concerns. I will email you a transcript within the next week. Please review it and email back any corrections within five business days. Thank you for participating and have a great rest of your day!

Appendix C: Invitation to Participate

Dear High School Math Teacher:

There is a new study about challenges in integrating technology in math instruction that could help high school teachers and leaders better understand integrating technology in math instruction. For this study, you are invited to describe your experiences with integrating technology in math instruction.

About the study:
· One 30–60-minute Zoom interview that will be recorded
· You would receive a $20 gift card as a thank-you
· To protect your privacy, the published study will not share any names or details that identify you

Volunteers must meet these requirements:
· High School Math teacher
· Teaches Math in Tennessee
· Has used technology to teach Math

This interview is part of the doctoral study for Jennifer McClellan, a doctoral student at Walden University. Interviews will take place during January.
Please reach out to jennifer.mcclellan@waldenu.edu to let the researcher know of your interest. You are welcome to forward it to others who might be interested.