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INVESTIGATING THE RELATIONSHIP BETWEEN EMPOWERMENT AND SECONDARY SCIENCE TEACHERS' TECHNOLOGY INTEGRATION KNOWLEDGE

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Education
at the University of Kentucky

By
Jane Elizabeth Walsh
Lexington, Kentucky
Director: Dr. Maria Cahill, Professor of Educational Leadership Studies
Lexington, Kentucky
2023

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ABSTRACT OF DISSERTATION

INVESTIGATING THE RELATIONSHIP BETWEEN EMPOWERMENT AND SECONDARY SCIENCE TEACHERS' TECHNOLOGY INTEGRATION KNOWLEDGE

Empowered teachers believe they can improve their work conditions and positively impact student outcomes. Likewise, teachers with technology integration knowledge can effectively use technology to enhance lessons and improve student learning. This quantitative correlational study investigated teachers' empowerment, teachers' technology integration knowledge, and associations between empowerment and technology integration knowledge. Two hundred fourteen randomly selected high school science teachers from across the United States responded to a survey intended to measure empowerment and technology integration knowledge. The teachers' average responses indicate that teachers generally agree with statements surrounding empowerment (*M* = 3.93, *SD* = 0.54) and technology integration knowledge (*M* = 4.09, *SD* = 0.59).
The Spearman's rank correlation indicates a positive and moderate (r = .41) association between empowerment and technology integration knowledge. This study fills a gap in educational leadership and science education literature by providing insight into leadership practices that may be associated with teachers' effective integration of technology in the classroom.

KEYWORDS: Technology Integration Knowledge, Empowerment, TPACK, Educational Leadership, Science Education, Educational Technology

Jane Elizabeth Walsh

(Name of Student)

12/12/2023

Date

INVESTIGATING THE RELATIONSHIP BETWEEN EMPOWERMENT AND SECONDARY SCIENCE TEACHERS' TECHNOLOGY INTEGRATION KNOWLEDGE

By
Jane Elizabeth Walsh

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Director of Dissertation

Dr. John Nash
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12/12/2023
Date

DEDICATION

This work is dedicated to my children, Adam, Christopher, Grace, Joseph, and Nora, for all your love, support, and patience.

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CHAPTER 1. INTRODUCTION

This chapter provides a background on technology in education, technology integration knowledge, teachers' underutilization of available technologies in the classroom, and teacher empowerment. It also describes the significance of gathering more information on factors related to technology integration in science classrooms and how this study may contribute to current research and literature. This chapter presents the research questions and methods to answer those questions. It also includes a definition of the terms and limitations of the study. Finally, this chapter provides an overview of the organization of the remainder of this dissertation.

Introduction

Today's world consists of increasingly rapid shifts in societal needs and technological advances. Schools help equip students with skills beyond traditional academics to adapt to and prepare for future challenges. The Partnership for 21st Century Skills (2009) developed a framework that describes the skills and competencies necessary for students to succeed in work and life. Information and communication technology (ICT) is at the core of 21st Century skills (Voogt & Roblin, 2010). ICT can help students build and share knowledge (Pascopella, 2008). However, its effectiveness relies on teachers knowing how to use technology to support student learning (Smetana & Bell, 2012). Using technology effectively in the classroom for student learning involves the combination of three knowledge bases: technology, pedagogy, and content (Mishra & Koehler, 2006).

Traditionally, images and videos helped teachers illustrate complex phenomena in science learning. Digital technologies aid inquiry learning by enabling learners to explore these complex concepts through observation, questioning, and problem-solving in interactive virtual simulations. Luckie et al. (2012) demonstrated that inquiry enhances student learning. Technology can serve as a tool for this inquiry (Larson et al., 2010). For example, teachers can offer virtual simulations that contain a model of a system or process (de Jong & van Joolingen, 1998) to provide experiences beyond a traditional classroom (de Jong et al., 2013; Smetana & Bell, 2012). Students can use these simulations for discovery learning as they change the values of input variables and observe the resulting changes in the values of output variables.

Studies show that teachers who use strategies that actively engage the students through scientific investigations are more successful at increasing student conceptual understanding than teachers who use more lecture-based teaching strategies. These studies also demonstrate that inquiry-based science instruction is more practical for students in social learning and K-12 science classrooms (Minner et al., 2010). The conceptual change in physical or virtual settings depends heavily on the type of instruction, either direct or discovery, the type of knowledge to be acquired, and the type of materials used (Pyatt & Sims, 2012).

Integration of technology in science classrooms is dependent upon teachers having the requisite tools and knowledge to design engaging lessons. Before teachers can utilize technology in the classroom, they need to have access to various digital technology tools and have the understanding and comfort to use them. In addition, teachers need to know what science concepts may be better taught using technology and what technologies are available for those topics (Kadıoğlu-Akbulut et al., 2020). Teachers should also be able to transform lessons using technology that is both appropriate and engaging for the students they teach (Andeli & Valanides, 2009). Worldwide, school systems have the hardware, policies, and broadband access to support technology integration into teaching and learning, yet secondary science teachers tend not to use ICT for student-centered activities (Carstens & Pelgrum, 2009).

School leaders can influence teachers’ technology knowledge and their use of technology in schools. Often, teachers did not experience using technology in their learning experience as students or in their teacher training, so they may be uncomfortable using it to present content to their students (Longhurst et al., 2016). Leaders can design professional development to enhance teachers' self-efficacy (Barton & Dexter, 2019), giving them the confidence to incorporate technologies into their lessons. Leaders can tailor this learning to the content area to make it more relevant for teachers' classrooms (Jones & Dexter, 2014). Additionally, they can facilitate teachers’ engagement in professional learning communities which provide peer support for technology knowledge and use (Durff & Carter, 2019).

Statement of the Problem

While there has been an increase in the availability of technology tools in classrooms, their usage has not increased similarly (Ditzler et al., 2016; Mason et al., 2008). Teachers identify several reasons for not using technology even when they know it can help student learning (Kopcha, 2012). Teachers report a lack of training, being uncomfortable with technology tools, and being generally unsure how the tools’ use will fit into their instructional plan as barriers to ICT use for teaching and learning purposes (Durff & Carter, 2019). Additionally, teachers who feel underprepared or inexperienced in using technology often need help with additional classroom management issues (Kopcha, 2012), yet another barrier to ICT use.

Science teachers are missing opportunities to promote student learning by not integrating ICT into teaching and learning. First, students are losing opportunities to build technology skills commonly used for work and everyday life. Additionally, since technology can support science education by enhancing student learning through experiences not available in the traditional classroom, not using ICT can limit students' understanding and learning experiences in science classrooms (Larson & Miller, 2011). Inquiry learning becomes more limited as well. Additional research can inform educational leaders on ways to support increased technology integration in secondary science classrooms.

Dee et al. (2003) connect empowerment to creating conditions that develop teachers' mindsets about their organization. Teacher empowerment is the teacher's belief that they have the knowledge and skills to improve a workplace situation (Bogler & Somech, 2004). When teachers feel empowered, they tend to take charge of their growth and resolve their problems (Short, 1994). Further, they believe that they have the skills and knowledge to act on a situation and make improvements. As discussed previously, leaders can influence the use of technology in schools by providing professional development. Additionally, building a school culture that allows teachers to participate in the decision-making process can positively impact student achievement (Sebastian et al., 2016). Empowered teachers may take on the role of teacher leaders who motivate other teachers (Muijs & Harris, 2003). It may be possible that teachers would encourage other teachers to use technology.

Purpose and Significance of the Study

This study investigates the relationship between empowerment and technology integration knowledge. Short and Rinehart (1992) describe empowerment as having six domains: autonomy, decision-making, professional growth, impact, self-efficacy, and status. Professional growth (Kulaksiz & Karaca, 2023) and self-efficacy (Abbitt, 2011a; Ertmer, 2005) are both associated with increasing technology integration. Beyond these two domains, there is a lack of research on the relationship between empowerment and technology integration knowledge. It is possible that the other domains may be associated with technology integration knowledge as well. A teacher who experiences autonomy in their classroom might feel free to make technological choices and develop technology integration knowledge in the process. Additionally, a teacher empowered in decision making may have more opportunities to decide on technology programs or purchases in their school. There may also be some carryover between technology integration knowledge and a teacher's feeling of status and impact. Therefore, this study explores a possible relationship between empowerment and technology integration knowledge overall as well as within the domains of each.

Overall, this study will add to the field of education by adding to the existing knowledge base in educational leadership and science education. It does so by exploring whether certain domains of empowerment are related to technology integration knowledge in secondary science teachers. Understanding the relationship between empowerment and technology integration knowledge could help school leaders enhance science teachers' effective use of technology in the classroom which could also enhance secondary students' learning.

Research Questions and Study Design

Research Questions

The following research questions guided this study:

1. What is the level of empowerment for secondary science teachers overall and in each domain area: decision-making, professional growth, status, self-efficacy, autonomy, and impact?
2. What is the level of technology integration knowledge for secondary science teachers overall and in each domain area: planning, design, implementation, ethics, and proficiency in technology integration?
3. What is the relationship between empowerment and technology integration knowledge for secondary science teachers?

Assessing the level of empowerment and technology integration knowledge, overall and for each domain, will provide the necessary information to test the following hypothesis:

H_0: There is no relationship between empowerment and technology integration knowledge for secondary science teachers.

H_a: A positive relationship exists between empowerment and technology integration knowledge for secondary science teachers.

This study explores the possibility that a higher level of empowerment correlates with higher technology integration knowledge in secondary science teachers.

Definition of Terms

The following list provides the definitions of the terms to ensure an understanding of these terms as used in this study.

- *Autonomy* - The teacher's perception that they have the freedom to make decisions impacting their work, such as scheduling, curriculum, textbooks, and instructional planning (Short, 1994).
- *Designing* - Editing existing ICT applications or creating new applications to teach the content or to conduct online assessment and evaluation using appropriate technologies (Kabakci Yurdakul et al., 2012).
- *Decision Making* - Teacher's ability to provide input and increase their control over the school environment, such as budgets, scheduling, curriculum, and teacher selection (Short, 1994).
- *Ethics* - The moral principles that govern behavior while using digital resources, including students' access to technological sources, copy-right issues, guiding students toward reliable internet sources, and use in the evaluation of students' achievement (Kabakci Yurdakul et al., 2012).
- *Impact* - Having an effect and influence on school life (Short, 1994).
- *Implementing* - Using technology to motivate students in the teaching-learning process and using technology to evaluate students' success (Kabakci Yurdakul et al., 2012).
- *Planning* - Determining appropriate teaching technologies and approaches based on student characteristics, time, content, objectives, readiness, and teaching environment (Kadıoğlu-Akbulut et al., 2020).
- *Professional Growth* - Teachers' opportunities to learn and develop teaching skills and content knowledge (Short, 1994).

- *Proficiency* - Ability to overcome technological problems with hardware and software and to guide and collaborate with colleagues in science and other disciplines to select technologies and develop associated lessons (Kadıoğlu-Akbulut et al., 2020).
- *Self-Efficacy* - Teachers' perception that they possess the skills and ability to help students learn (Short, 1994).
- *Status* - Teachers' perception that they have respect and support from their colleagues for their knowledge and expertise (Short, 1994).

Overview of Methods

The study utilizes a quantitative approach to explore the possible correlation between empowerment and technology integration knowledge. Specifically, the study explores correlations between empowerment and technology integration knowledge of science teachers in secondary schools across the United States. Market Data Retrieval (MDR) provides a list of randomly selected email addresses for teachers identified as teaching science in secondary schools. Those teachers were sent an electronic survey consisting of two validated instruments for self-reporting empowerment and technology integration knowledge. The data received from this survey were analyzed to identify if there is a statistical relationship between empowerment and technology integration knowledge.

Limitations of the Study

This study has some limitations due to the methodology, sampling, and data collection. First, this correlational study seeks to determine the relationship between empowerment and secondary science teacher technology integration knowledge. This methodology does not determine or suggest causation. Second, the sampling strategy is not entirely random. The email addresses of potential participants were retrieved from MDR's database. While this database is extensive, it does not include the email addresses of every secondary science teacher in the United States. For example, addresses are not available for school systems that do not allow emails from outside their system's network. The data may also be subject to respondent bias. The participants used a Likert-type scale to rank their opinions, and each respondent may rank slightly differently. Additionally, participants are self-reporting on the survey, making verification of responses difficult.

Several factors may influence a teacher’s choice to use technology for student learning. First, devices must be accessible to students. Likewise, teachers should have technology integration knowledge to create engaging, technology-enhanced lessons (Angeli & Valanides, 2009). Having technology integration knowledge does not necessarily lead to an increase in the use of technology for teaching and learning. Cuban (2003) described the push by various entities to increase access to technology in classrooms with the thought that it would improve teaching and learning in classrooms. After studying how technology was being used in classrooms, Cuban found that technologies were primarily being used for word processing and internet searches and not for student-centered learning. Transformation of teaching and learning had not occurred. A more recent report by UNESCO (West, 2023) highlights the results of educators’ sudden switch to using technology during the pandemic. The outcomes indicate challenges in developing engaging lessons and increased inequalities in student learning. Having the technology may be only part of the equation.

It is also important to acknowledge that teachers may possess the knowledge to effectively integrate technology but still not use the technology. Cuban (2003) offers possible explanations for this lack of use. First, school administrators may bring technology into the school as "symbolic political gestures" (p.158) or due to pressure from corporate leaders and parents. Cuban also notes that school leaders often do not consult teachers in the decisions to acquire technology or how teachers will use the technology. Therefore, the available technology may not suit what the teacher feels is pedagogically relevant to their topics, or it may not address student needs. In this case, the teacher may choose not to use the technology even though they have access to it and possess the knowledge to use it.

Summary

This chapter presented the introduction, statement of the problem, the significance of the study, and research questions. The next chapter provides a review of the literature on the current state of technology integration in education, the utilization of technology in science classrooms, empowerment, and teacher technology integration knowledge. The latter sections of the literature review focus on the frameworks that inform this study: Technological Pedagogical Content Knowledge (TPACK) and empowerment. Chapter 3 presents the context, methodology, research design, description of the research sample, and a summary of the data analysis. Next, Chapter 4 presents the results and analysis of the collected data. Finally, Chapter 5 summarizes the study, discusses the findings in relation to the literature, and provides recommendations for further study.

CHAPTER 2. LITERATURE REVIEW

Research shows that technology has a place in the classroom and can enhance student learning (Pascopella, 2008; Shaffer et al., 2015). In response to the information gained from these studies, school leaders have bolstered access to devices and the infrastructure to make technology available to students (Barton & Dexter, 2019; UNESCO, 2023). Teachers have also increased their usage, but not at a rate consistent with the availability of technological tools (Ditzer et al., 2016). School leaders can influence teachers' use of technology. Some factors that have a positive influence on teachers are domains within empowerment (Hutchison & Woodward, 2018; Karaca et al., 2013). Therefore, this study investigates an association between empowerment and technology integration knowledge in secondary science teachers.

This literature review begins with information on the pervasiveness of technology in schools globally and within the United States from the turn of the century until the COVID-19 pandemic. This summary includes reports on device availability and usage in classrooms. Next, the review emphasizes information on organizations supporting technology integration, ways of measuring technology integration knowledge, barriers and facilitators of integration, and the role ICT should play in science instruction. Finally, the last section of the review presents literature regarding the conceptual frameworks that guide this study: TPACK and empowerment.

Review of the Literature

Prevalence of ICTs in Schools

Beginning of the 21st Century

The International Association for the Evaluation of Educational Achievement (IEA) conducted the Second Information Technology in Education Study (SITES) in 2006 (Carstens & Pelgrum, 2009). This survey study of school principals, technology coordinators, and mathematics and science teachers in more than 60 countries looked at pedagogical practices, how teachers and students used ICT and the associated development of 21st Century skills.

Mason et al. (2008) summarized the report's findings on system-level and school-level factors. In general, many of the systems participating in the survey said they had a system-wide policy on ICT use in education, and most school systems reported having computer and internet access for teaching and learning. Teachers reported low ICT usage, with science and math teachers as more frequent users than other content teachers. The teachers' pedagogical approach influenced the teachers' perceived impact of ICT with those using a life-long learning approach seeing more gains in inquiry and collaboration, both 21st Century skills.

Early 21st Century

The SITES study (Carstens & Pelgrum, 2009) indicated that technology available in schools increased between 1998 and 2006. Schools continue to increase the number of digital devices and access to the internet (Barton & Dexter, 2019). In their 2019 report, the EducationSuperHighway, identified that the E-rate program, state funding, and service providers completed the infrastructure needed to help provide internet access to millions of students with 99% of United States schools having high-speed broadband connections. Drawing on 2019 application data from the FCC’s Schools and Libraries Program (“E-rate”), the report also noted that 87% of teachers implemented digital learning several times a week, and 75% of schools have at least one device per student. A

Pearson Student Mobile Device survey (2015) of students in grades 4-12, identified that laptops are the most commonly used mobile device students use for schoolwork at 83%. Further, many students reported tablets change how they learn and make learning more fun, and 54% indicated they would like to use multiple devices more in the classroom than they do now.

Present

The 2023 Global Education Monitoring Report (UNESCO, 2023) summarizes the current status of technology use in schools worldwide. The report highlights information from the Organisation for Economic Co-operation and Development (OECD) 2018 Programme for International Student Assessment (PISA) which found that 65% of 15-year-old students in OECD countries had teachers with the teaching and technological skills to integrate technology. In addition, 54% of those students were in schools with online learning support platforms (the report does note that these numbers are likely higher since the pandemic). However, many teachers reported needing more confidence or preparation to teach using technology.

The report also highlighted information on technology software. In the United States, an average of 67% of education software licenses were unused, and 98% were used rarely. Interestingly, around 15% of 15-year-old students in math and science reportedly used digital devices for more than an hour per week. However, the report also quotes information from the EdTech Genome Project, saying that 85% of around 7,000 pedagogical tools across subject area disciplines needed to fit better or be utilized correctly. Furthermore, most education technology tools did not meet the U.S. Every Student Succeeds Act requirements which include data privacy, interoperability, and research-backed evidence (Instructure, 2023). Only 26% of the educational technology tools researched aligned with the Every Student Succeeds Act (Instructure, 2023; UNESCO, 2023). These numbers illustrate that schools are making software available. However, teachers could use it more frequently and integrate it properly.

Technology for Teaching and Learning

21st Century Skills

Students use technology and ICT almost every day. Learners need to be able to “research, organize, evaluate and communicate information” with technology (Larson & Miller, 2011, p. 122). Additionally, Larson, Miller, and Ribble (2010) highlight the need to identify technology as more than using gadgets but as a tool for inquiry. Technology facilitates 21st Century skill-building by assisting with strategies such as collaboration, creativity, personal responsibility, and adaptability. One of the focal points of the SITES study (Carstens & Pelgrum, 2009) was to look at ICT usage in math and science classrooms worldwide since ICTs can aid in the development of 21st Century skills. The Partnership for 21st Century Skills developed a framework to help teachers integrate specific skills into core academic subjects (Partnership for 21st Century Skills, 2009). This Framework for 21st Century Learning describes the skills, knowledge, and expertise that students must master to succeed in work and life, and it is a blend of content knowledge in core subjects (English, world languages, arts, mathematics, economics, science, geography, history, and government and civics), along with specific skills, expertise, and literacies. The framework provides a format for teachers to aid students in learning skills essential for success in the 21st Century. The associated skills include: (a) learning and innovation skills, (b) information, media, and technology skills, and (c) life and career skills (Kaufman, 2013).

International Society for Technology in Education

The International Society for Technology in Education (ISTE) is another organization focused on integrating technology in teaching and learning. ISTE aims to improve technology use in schools worldwide. ISTE has professional development courses, blogs, and podcasts to help educators and leaders learn and develop skills in technology for the classroom. ISTE created technology learning and teaching standards with separate standards (guidelines) for teachers, students, educational leaders, coaches, and computational thinking competencies. All 50 U.S. states adopted these standards (Lcom Team, 2022) which focus on learning, not devices or tools. Thus, teachers nationwide should be integrating ICTs to enhance student learning, and they should be supported by educational leaders and technology integration coaches.

The Role of ICTs in Secondary Science Classrooms

ICT use for student learning can take on different formats in the classroom. Teachers can use ICTs for record keeping or maintain data on student performance; thereby making their work processes more efficient. However, this type of use does not enhance student learning. On the other hand, Web 2.0 tools do help students gain 21st century knowledge-sharing and knowledge-building skills (Pascopella, 2008) when used in the classroom to interact directly with students. In other words, when teachers use ICTs for demonstration, or students use the technology themselves, the technology can impact student learning outcomes.

Additionally, the term technology comprises those tools commonly known as digital technologies and not the more traditional technologies such as a whiteboard, pen, calculator, or flip charts. Digital technologies can include such things as hardware (computers, tablets, smartphones), software programs (PowerPoint, Word, simulations), visual resources (videos), or data-collecting tools (probes and recording devices). Shaffer et al. (2015) identified three kinds of learning technology. The first is digital workbooks. These help students learn essential skills via routine practice. Another is digital texts; for example, eBooks, virtual museums, and learning games. These furnish students with mediated experiences. Thirdly, digital internships simulate real-world practices. These simulations allow students to learn real-world problem-solving. In science classrooms, students can use virtual simulations to supplement or replace hands-on laboratory activities. However, their effectiveness depends on how they are used (Smetana & Bell, 2012). Specifically, ICT in the classroom should help promote 21st century learning as part of the P 21 framework (Larson & Miller, 2011). Shaffer et al. (2015) argue that digital learning technologies allow teachers to design and align lessons based on their students' needs. Expressly, using ICT can help students' comfort level with technology. This comfort will make them better experienced in using technology for day-to-day purposes. Technology is also a means to research a topic and communicate. These uses of ICT can be effective in any subject matter or content.

The focus of this study is secondary science classrooms. At this level, ICT can take the format of virtual learning simulations. Virtual laboratories accomplish similar objectives as those completed in physical laboratories (de Jong et al., 2013). Teachers can use these simulations in place of traditional lessons in some situations but, they should be primarily used to support traditional lessons and supplement regular teaching. These simulations can be used as standalone tools when physical activities in the classroom are not possible due to remote learning or if the costs and safety are a concern. Teachers can also employ ICTs to create a game setting which can improve student learning and increase student motivation (Bonde et al. 2014).

Technology can provide opportunities to students that they would not otherwise have in the classroom and traditional settings. McCrory (2008) highlights how technology can enhance learning in ways that would not be possible without the technology:

1. Speeding up time via simulations of natural events (e.g., geological animations)
2. Saving time through data collection devices and or recording data that would otherwise be hard to gather (e.g., digital probes)
3. Seeing things that could not otherwise be seen (e.g., digital microscopes)
4. Organizing data that would otherwise be hard to organize (e.g., graphical visualization models)

Instead of replacing traditional lessons, technology should supplement them. Technology can hurt student performance if inappropriate or excessively used (UNESCO, 2023). Thisgaard and Makransky's (2017) research suggests increased student learning when the teachers use technology in conjunction with lessons to support their traditional teaching methods. For example, virtual laboratories cannot wholly replace physical laboratory exercises (de Jong, 2013); they should serve as supplements (Smetana & Bell, 2012). In a physical laboratory, students may have to troubleshoot malfunctioning equipment. When using simulations, they typically work as planned. Outcomes may be programmed into the software consistently, and students see the results with set outcomes. Yet, experiments often go differently than planned in the real world, and scientists need to strategize different methods to investigate a hypothesized outcome. The students need to be able to experience when equipment malfunctions or results do not come out as planned due to outside circumstances. Moreover, students learn how to troubleshoot and learn the value of maintaining consistency and their procedures. These are all functions that technology and virtual learning are incapable of achieving.

Trey and Khan (2008) demonstrate how a computer simulation can help student understanding. LeChatelier's Principle relates to the effects of disturbing a system at equilibrium. It can be a difficult concept for chemistry students to grasp since it involves molecular processes and is consequently unobservable. In their study, Trey and Kahn (2008) used pre- and post-test assessments on two groups of students, and the teacher used the same introductory instruction on the topic for both groups. Then, one group interacted with a dynamic computer-based analogy, and the other used pictures and narrative text. The results show a significant relationship between the type of instruction and the test score. Students using a computer simulation achieved greater understanding than those using traditional pictures and text.

Other studies show similar success with combining technology with traditional teaching methods. When chemistry students complete a virtual lab activity before a similar hands-on exercise, the instructor can focus on theories and concepts rather than technique or instrument operation. Student learning also increases, as shown with significantly fewer students scoring at lower levels of attainment (Climent-Bellido et al., 2003). Limniou et al. (2007) found that students who participate in simulation activities and pre-lab instruction were more comfortable entering the lab. Students also did not need instruction during the lab and scored significantly better on their work. Limniou et al. also found that students without the simulation experiences encountered the need to repeat the activity due to errors in procedure/technique. Another study by Riess and

Mischo (2010) used a computer simulation in teaching systems thinking in biology. With the simulator alone, the researchers saw minor improvement in achievement scores compared to traditional lessons. However, the researchers saw marked improvement when students used the simulator in conjunction with conventional lessons. Additionally, de Jong et al. (2013) noted that students who collect faulty data will have more difficulty developing and describing an accurate model of the phenomenon. The student errors in data collection can result from improper procedures or external contributing factors that prevent accurate data collection. In this event, students would use erroneous data to read and describe the phenomenon they studied. De Jong et al. (2013) describe how using technology can provide data that is not impacted by procedural or external errors which can help allow students draw correct conclusions.

Teachers need to do more than add digital tools to replace traditional methods; they need to use pedagogically relevant tools that align with the instructional goals (Hutchison & Woodward, 2018). Teachers can use virtual activities and simulations along with traditional teaching methods. According to Thisgaard and Makransky (2017), student learning improves when teachers use this combined approach; thus, they recommend that teachers use this technology to support their traditional teaching methods. Interestingly, virtual learning simulations can also help promote entry into a STEM major and obtaining a STEM-related career (Thisgaard & Makransky, 2017). The virtual learning simulations provide a low-cost, accessible way to get insight into possible career paths.

Barriers to Educational Technology Integration

Gaps exist between the amount of technology available for teachers and the teachers' use of that technology (Ditzer et al., 2016). Kopcha (2012) summarized the various reasons for this gap. Firstly, some teachers simply do not have access to functioning technology tools or any technology tools. Those who do, sometimes lack necessary training to connect the tools to actual classroom practice and focus exclusively on technical skills rather than learning. Other teachers may believe in the usefulness of technology; however, they lack pedagogical knowledge. The time required to mediate students' behavior when using the technology deters them from using the tool at all. Other teachers lack confidence in their technology integration ability and revert to traditional teaching methods when there is a setback in relation to the technology. Gray and Lewis (2021) found that approximately 80% of teachers feel they do not have sufficient training to use technology for teaching. About the same amount reported that other priorities limit technology use for instructional purposes. Schools have also faced some challenges with professional development regarding sustainability and scalability (Barton & Dexter, 2019). Short, one-time workshops do not work for teacher training in technology integration (Gunter and Reeves, 2017). However, many schools still need to change their professional growth strategies since most professional development follows a traditional half- or one-day format (Rucker, 2018).

When interviewed, principals indicated valuing the use of technology in education but felt their schools exhibited low integration and low professional development (Machado & Chung, 2015). The principals thought that their schools lacked the necessary money and time for professional development. They also perceived a lack of district support and teachers' negative preconceptions regarding technology as barriers to use for teaching and learning. Durff and Carter (2019) also found an attitudinal barrier in relation to some teachers’ comfortable with technology in the classroom. They also report some teachers failing to use technology either because of the teachers' own belief that they are too old to learn how to use it or because they struggle to keep up with the continually changing tools and software. Additionally, they found that some teachers discount the value of using technology for student learning while other did not receive proper training in their teacher education programs.

Ways to Support Educational Technology Integration

Professional Development

Leaders can provide teachers experience through professional development. Kulaksiz and Karaca (2023) identify professional development as the most influential factor affecting technology integration knowledge, followed by teacher beliefs and attitudes. The primary focus of professional development should not be using technology. The focus should be on the instructional goals and how technology can help achieve those goals (Hutchison & Woodward, 2018). Leaders should design professional development to help teachers connect digital resources to traditional learning but also to support teachers' shift to student-centered approaches (Shaffer et al., 2015). Leaders should provide learning opportunities and create supportive environments (Dexter & Richardson, 2020) but not require specific hardware or software (Durff & Carter, 2019). Professional development can take different forms (Barton & Dexter, 2019): (a) leader-directed in a formal setting, (b) teacher-directed informal professional development, and (c) independent professional learning. Teachers prefer customized training classes to the content area and choice of training sessions (Jones & Dexter, 2014). Professional development should be introduced in small steps rather than all at once (Brinkerhoff, 2006). Ertmer (2005) recommends starting with simple uses of technology first and then allowing teachers a chance to explore by providing opportunities to experience different technologies.

Williams and colleagues (2017) suggest that flexibility is critical when using technology for inquiry learning since teachers often seek alternatives to technology when it does not work. Further, short, focused episodes of inquiry help teachers to gain confidence in using the technology. Gunter and Reeves (2017) found that an online 8-week professional development course with subject-specific content increased teachers' attitudes toward using mobile technologies. Wang et al. (2004) saw that hands-on professional development empowers teachers to integrate mobile technology in their classrooms. These researchers also discovered that teachers were more successful when given goals to achieve while exploring the technology. These goals included instructional goals, procedures students follow to achieve the goal and methods of evaluating student achievement.

In some cases, the leader initiates the professional development setting, but the teachers determine the focus topic for the professional development. Teachers’ likelihood of utilizing technology for teaching and learning increases when professional development is teacher focused (Barton & Dexter, 2019), as informal learning typically is. Teachers prefer these informal scheduled sessions with technology leaders within their own schools (Ertmer, 2005). This format allows one-on-one activities and the teacher to suggest content on which to work. It is also helpful for the technology leader to model activities (Jones & Dexter, 2014). However, informal learning can also happen through email or face-to-face conversations (Jones & Dexter, 2014).

Teachers also value self-directed learning, in which they explore technologies independently (Barton & Dexter, 2019). Self-directed learning can involve using teacher-specific websites, internet searches, and video-sharing sites (Jones & Dexter, 2014). Additionally, Jones and Dexter (2014) found that teachers' technology integration increased when they had access to a school-based resource sharing portal.

Collaboration

Sebring et al. (2006) highlight that cooperation and collaboration between teachers, parents, and the community are essential for student learning. This environment helps to develop teamwork and also makes teachers realize that they are responsible for all students in the school, not only the ones in their classroom. When teachers collaborate, they can help to solve instructional problems. Professional learning communities (PLCs) serve as a means to promote teacher collaboration. PLCs involve teachers meeting to discuss planning, teaching methods, and strategies. They include five dimensions: supportive and shared leadership, shared values and vision, collective learning and application of knowledge, supportive conditions, and shared practice (Bendtsen et al., 2022).

PLCs help develop teacher relationships through group communication (Jones & Dexter, 2014). PLC meetings allow teachers to discuss technology integration specific to their content area. This peer support can help some teachers overcome attitudes against using technology (Durff & Carter, 2019). Ertmer (2005) reported that teachers are more likely to integrate technology after participating in professional communities discussing the strategies, materials, and methods of using technology. The informal learning they experience when working with peers allows them to have conversations about specific technology uses (Jones & Dester, 2014). Hutchison and Woodward (2018) reported that

PLCs also enhance teacher success with technology integration. Teachers benefit from scheduled and consistent meetings with their peers, and this collaborative mentoring also increases self-efficacy, and boosts their optimism about their probable use of technology with students.

Teachers can also find learning communities outside traditional school meetings. Some teachers have reported benefits of involvement in a social media group where they could exchange ideas about using specific devices or potential class activities (Khlaif, 2018). Trust (2017) found that teachers who used an online platform to connect, collaborate and learn with others felt empowered to change their practice. They were more willing to take risks and attempt new teaching resources, including technology and more student-centered methods. Given the variety of modes of professional development, Barton and Dexter (2019) suggest a holistic approach to professional development, including formal and informal development opportunities.

Self-Efficacy

Bandura's theory on self-efficacy (1977) maintains that when people believe in their capabilities, that belief can be a source of motivation for personal accomplishment. In other words, self-efficacy is a person's belief in their ability to succeed in a particular situation. Abbitt (2011a) identified a strong relationship between teachers' technology integration knowledge and self-efficacy. This self-efficacy can grow through experience, professional development, and collaboration.

Experience

Khlaif (2018) found that a teacher's previous experience with ICT was positively related to the teacher's attitude and acceptance of the technology in their practice. Specifically, the teacher’s prior experience with a tool will influence its perceived usefulness. Notably, these experiences do not necessarily need to be hands-on. Teachers can gain self-efficacy in technology integration through vicarious experiences (Wang et al., 2004). A teacher watching another teacher successfully use technology may experience a boost in efficacy in relation to using that same technology in their classroom (Ertmer, 2005). The perceived amount of effort and ease of use can also influence a teacher's confidence in choosing to use technology in a lesson (Holden & Rada, 2011).

Ways of Measuring Technology Use

To gain a better understanding of technology in education, researchers may measure teachers' use of technology. The tools vary in their focus and different aspects of technology integration. Considerations may include the teacher's decision to use technology over traditional methods, the level of learning associated with using the technology, or the teacher's understanding of using technology appropriate to content and learning needs. This section briefly describes tools that researchers can use to measure a teacher's use of technology.

Technology Acceptance Model

The Technology Acceptance Model (TAM) is a theory by Davis (1989) that represents an individual's intention to use technology. Positive perceptions of technology arise from perceived usefulness, perceived ease of use, and an amenable attitude toward using technology. Teachers with positive perceptions of technology are more likely to use ICTs to improve teaching (Joo et al., 2016).

The Technology Integration Matrix

The Technology Integration Matrix (TIM) is another framework to evaluate technology use and learning. It evaluates five learning methods: active, collaborative, constructive, authentic, and goal-directed. Each of these is associated with five levels of technology integration: entry, adoption, adaptation, infusion, and transformation. These create a matrix of 25 cells that can be used to explore the level of technology integration (Harmes et al., 2016).

TPACK

The TPACK framework describes the knowledge that a teacher uses when effectively incorporating technology into their teaching. It is made of the knowledge of understanding and using technology, pedagogical knowledge in knowing how to plan lessons and teach students, and content knowledge. When a teacher has TPACK, he or she has combined knowledge of technology, pedagogy, and content. With TPACK, a teacher has the knowledge to effectively integrate technology into a lesson, teaching students on a particular topic. In other words, the teacher has technology integration knowledge. Graham et al. (2012) describe TPACK as providing an explicit mechanism for discussing tools teachers use in the service of teaching and learning" (p.3) as well as "an analytical lens with which to look at the instructional decisions teachers make." (p. 4). Furthermore, several researchers note that TPACK provides teachers a way to talk about technology integration and the specific knowledge teachers need to be successful (Graham et al., 2012, Mishra & Koehler, 2006, Setiawan et al., 2019).

These three frameworks provide various ways to measure technology integration in classrooms. Each has a slightly different focus. TAM measures a teacher’s intention to use technology in their teaching. On the other hand, TIM considers the teacher is using technology and measures the level of technology integration. Technology should supplement traditional methods in science teaching rather than focus on the technology itself (de Jong, 2013; Smetana & Bell, 2012). TPACK takes a more comprehensive approach where pedagogy and content are taken into consideration. Teachers need to consider how technology can transform the teaching of a particular concept (Angeli & Valanides, 2009). Therefore, TPACK considers more of the concepts related to incorporating technology into science teaching and will serve as the means of rating technology integration for this study.

Types of Instruments used to Measure Teacher Technology Integration Knowledge

Researchers have utilized different instruments to measure a teacher's use or possession of TPACK. Most instruments involve teachers self-reporting through a survey about whether they have the knowledge or how they apply it in practice (Abbitt, 2011b). Two additional methods of evaluating TPACK are through design tasks and teaching observations. The usefulness of these three methods is considered here.

The most prevalent method of measuring TPACK is surveys and questionnaires (Brantley-Dias & Ertmer, 2013). This method helps identify group characteristics and testing variables within a population; however, it relies on self-reporting and the participant's ability to assess their knowledge appropriately. Additionally, surveys evaluating TPACK tend to be long since assessing all the domains in a short questionnaire is difficult. Brevity results in questions that are too broad or vague for a valid assessment of each construct. Brantley-Dias and Ertmer (2013) suggest that questions containing discipline, context-specific, or technology-specific examples are more detailed and may better measure teachers' TPACK.

A second method for measuring TPACK is through design tasks. These tasks include solving design problems, creating lesson plans, or reflecting. Graham et al. (2012) utilized this method with pre-service teachers. The students were given content and specific teaching tasks and needed to describe how they would integrate technology.

Later, the researchers analyzed the teachers' work for the TPACK constructs in terms of technology.

Brantley-Dias and Ertmer (2013) noted the challenges in relation to measuring TPACK via design tasks. However, Jonsson and Svingby (2007) note limitations of scoring rubrics intended to evaluate design tasks: usefulness can be constrained by the quality of the rubric. A lower quality rubric will provide less information. Secondly, it is difficult to increase reliability without lowering validity. Thirdly, rubrics need to be analytical, specific to the topic, and provide examples or training for the rater. The requirement of topic specificity could prove to be challenging in the measurement of technological content knowledge (Brantley-Dias & Ertmer, 2013). A scoring rubric that needs to be topic-specific would not be helpful across broad areas. Rubrics would need to be modified for specific use in different disciplines. For example, the rubric would need to include references to using technology to teach a specific content area. It would be a challenge and time-consuming to develop useful rubric rating criteria for each content area with associated technologies. Technology integration knowledge is an internal construct, meaning that it is developed internally. It can make it difficult for design task methods to measure all the components of TPACK (Brantley-Dias & Ertmer, 2013).

A third type of instrument used to measure TPACK is teacher observation. The researcher would take field notes while observing a teacher during the lesson. The drawback of teacher observation is that it is a small picture of what the teacher does throughout the school year. The researcher would need to complete multiple observations for the same teacher to obtain a comprehensive assessment of the teacher’s TPACK.

Self-assessment surveys may be most effective at measuring teachers’ knowledge of technology integration (Brantley-Dias & Ertmer, 2013). Comparing the three types of measurement, surveys provide some advantages in terms of the magnitude of a teacher’s technology integration knowledge. Surveys allow collection of data from teachers across multiple schools and the identification of the present levels of technology integration knowledge for various teachers. The use of surveys also avoids the problems associated with observations and design tasks.

Conceptual Frameworks

Two frameworks guide this study investigating science teacher technology integration. The first framework, the transformative model of TPACK was developed from Mishra and Koehler's conceptualization of technological pedagogical content knowledge. This framework informs how teachers use the combined knowledge of technology, pedagogy, and content to integrate technology. The second framework, empowerment, describes the different aspects of a teacher's workplace related to their perception that they have the resources and confidence to make decisions and promote change. These two frameworks together will guide this investigation regarding the relationship between teachers' perceptions of empowerment and their knowledge of technology integration in science teaching.

TPACK

The TPACK framework builds upon Shulman’s (1986) pedagogical content knowledge (PCK) framework. PCK describes the intersection of teacher content knowledge (CK) and pedagogical knowledge (PK). Content knowledge includes facts, concepts, principles, and how ideas are formed within a specific discipline or content area of learning. Pedagogical knowledge is the knowledge of teaching strategies, theories on student learning, lesson planning, assessment, and classroom management. Shulman describes PCK "for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations-in a word, the ways of representing and formulating the subject that make it comprehensible to others" (p.9).

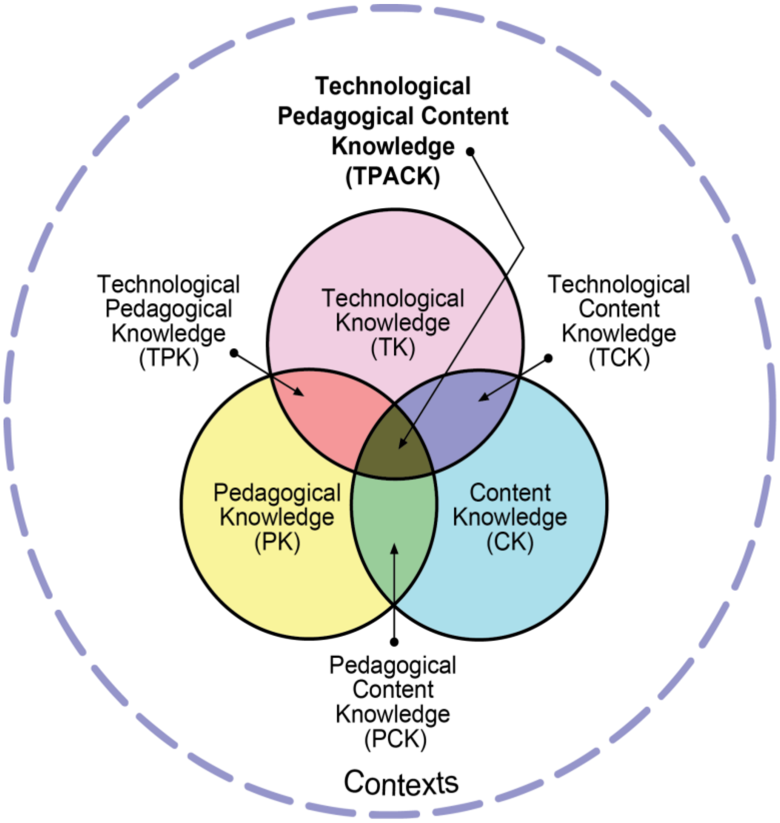
Mishra and Koehler (2006) built upon Shulman's work by adding a technology component to the PCK framework. Thus, introducing the "T" in TPACK. This framework focuses on teachers’ use of technology within lessons. Technological knowledge (TK) is the knowledge about various technologies and the skills required to operate them. When teachers use technological knowledge in conjunction with content knowledge, the result is technological content knowledge (TCK). "Teachers need to know not just the subject matter they teach, but also the manner in which the subject matter can be changed by the application of technology" (p. 1028). Then the intersection of pedagogical and technological knowledge is technological pedagogical knowledge (TPK). Teachers express this knowledge as understanding the various technological tools and teaching strategies that may be changed or utilized by that technology. TPACK is the knowledge that emerges when CK, PK, and TK are interwoven into a lesson. TPACK serves as a framework for describing and examining teachers' use of tools and instructional decisions within the context of teaching.

The TPACK framework allows researchers to look at teachers' technological tools and instructional decisions in using these tools (Mishra & Koehler, 2006). Figure 2.1 illustrates the interacting parts of technological, pedagogical, and content knowledge within a specified context include the following seven knowledges: content knowledge

(CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical knowledge (TPACK).

Figure 2.1

Visualization of the TPACK Framework



Note: Reproduced by permission of the publisher, © 2012 by tpack.org

In 2008, Mishra and Koehler added context to the original TPACK model. They noted that TPACK would look different in varying educational contexts. The interactions of the three components, content, pedagogical and technological knowledge, will take shape differently across different contexts (Mishra & Koehler, 2008). For example, the setting for a science teacher in higher education is not the same as that of a teacher in an elementary classroom. Both may be equally competent in the science content and have a thorough knowledge of various forms of technology and pedagogical methods; however, the interaction of the three forms of knowledge will look quite different. Porras-Hernandez and Salinas-Amescua (2013) subsequently developed a TPACK model that includes three levels of context. The lowest level includes students and classroom conditions, and then moves to a broader level, including school leadership and the community. The third level includes the influences from more national and global levels.

Although the context may not have been a part of the original framework, it is an important aspect that researchers should identify when utilizing TPACK and reporting findings of technology integration (Mishra & Koehler, 2008). This information can inform other researchers and allows for comparison. Although. However, Rosenberg and Koehler (2015) report that many researchers do not include context when describing TPACK in their studies.

Conceptualization of TPACK

There is more than one way of conceptualizing TPACK (Rosenberg & Koehler, 2015; Jin, 2019). The first is an integrative approach. In this approach, the different pieces of knowledge within TPACK are distinct. The integrative model assumes that when the teacher's knowledge develops in even just one of the multiple components, the teacher's TPACK has progressed overall (Kadıoğlu-Akbulut et al., 2020). However, Angeli and Valanides (2009) refute the notion that an increase in one of the components increases overall TPACK.

Valanides' and Angeli's (2008) case study of secondary science teachers professional development for technology integration found that teachers with more significant technology experience did not possess a greater ability to design lessons using computers: these teachers had difficulty using computer representations for inquiry and learner-centered instruction. Rather, the teachers benefited from being explicitly shown how the technology tools could transform content instruction and how to design interactive learning activities. In their later study, Angeli and Valanides (2009), focused on ICT-TPCK, or technology integration knowledge related to the use of information and communication technologies. They worked with preservice teachers to determine how technology mapping and assessment feedback from self, peers, and experts impact a teacher's developing level of TPACK. Technology mapping "is an interaction technique that seeks to identify the dynamic transactions among all constituent knowledge bases of ICT-TPACK" (p. 160). Angeli and Valanides found that the preservice teachers' ICT-TPCK improved significantly through this instruction and further improved with self-reflection and feedback from peers and experts.

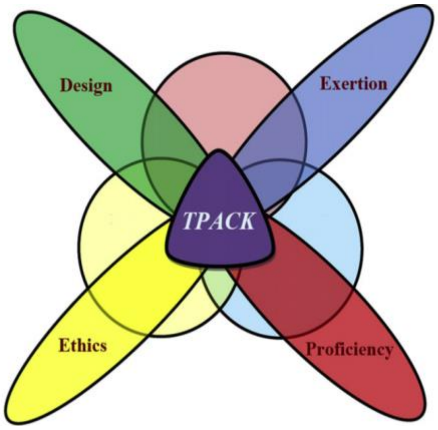
Other researchers (Jin, 2019; Angeli & Valanides, 2009) also contend that TPACK does not develop from the individual parts but is an independent body of knowledge. This viewpoint is known as the transformative perspective and the one used in this study. Angeli and Valanides (2009) describe research using the transformative model as not focusing on measuring any of the three knowledges of technology, pedagogy, or content knowledge. As is the case with studies using the integrative model. Instead, the focus is on the collective knowledge TPACK. The research methodology focuses on collecting data on TPACK and drawing conclusions about technology integration knowledge. Angeli and Valanides describe TPACK as the knowledge that enables a teacher to be competent in integrating technology in the learning process. It combines knowledge about context, students, content, and technology tools to create an understanding of how technology can be used to transform a lesson to more effectively teach learners in situations where topics are difficult for learners to understand or difficult for teachers to present. Situations such as those mentioned previously that are unique to science teaching where constraints on time and space can be overcome.

Kabakci Yurdakul et al. (2012) expanded on the transformative approach and developed the TPACK-deep framework; the first survey based on the transformative model (Kadıoğlu-Akbulut et al., 2020). Unlike many previous studies which focused on individual components, the framework by Kabakci Yurdakul et al. focus directly on the central component, TPACK. See Figure 2.2. The transformative model highlights that teachers’ TPACK is developed, or transformed, through the experiences provided in the design and delivery of content-relevant instruction using technology (Kadıoğlu-Akbulut et al., 2020)

The TPACK-deep instrument developed by Kabakci Yurdakul et al. (2012) follows the assertion of Angeli and Valanides (2009) that TPACK is a unique body of knowledge. Yet, the TPACK-deep instrument breaks the items down into separate factors. This subdivision into distinct factors is similar to that of previous instruments. However, it differs in that these factors do not directly represent competency in areas such as TK or TCK. The TPACK-deep framework’s sub-factors are those competencies that reflect the knowledge acquired through working with technology in student learning, such as designing and implementing. This subdivision method follows the idea that TPACK is a knowledge transformed through these experiences requiring collective knowledge of technology, pedagogy, and content.

Figure 2.2

Visualization of the TPACK - Deep Framework



Note: From “The development, validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale.” By Kabakci Yurdakul, I., Odabasi, H. F., Kilicer, K., Coklar, A. N., Birinci, G., and Kurt, A. A. (2012). *Computers and Education, 58*(3), 964–977. https://doi.org/10.1016/j.compedu.2011.10.012 Reprinted with permission.

The TPACK-deep framework has a four-factor structure: design, exertion, ethics, and proficiency. According to Kadıoğlu-Akbulut et al. (2012), the design factor is the most important of these. The design factor refers to creating and developing lessons and environments that combine technological tools and resources to maximize student learning of the content. The questions within this factor relate to the teaching design process. Table 2.1 provides sample items for this, and the other factors. The domains in this model do not assess a single knowledge in TPACK. The instrument items, for a domain, span across the three knowledges of TPACK. Therefore, an improvement in the designing domain would reflect an overall increase in TPACK. The exertion factor consists of implementing the design plans and assessments through the appropriate use of technologies. The questions within this factor address the active learning process. The ethics factor refers to the legal and ethical behavior associated with technology use and teaching practices; it involves privacy, accuracy, property, and accessibility as related to the ethical use of technology by both teachers and students. The proficiency factor reflects the teacher's leadership ability in promoting and demonstrating effective technology integration. The items in this factor address content problem-solving, technology and the teaching process, and guiding others in these processes.

Table 2.1

Sample Items from TPACK-Deep Scale

Factor	Sample Item
Design	I can plan the teaching and learning process according to the available technological resources. I can develop appropriate assessment tools by using technology. I can organize the educational environment in an appropriate way to use the technology.
Exertion	I can implement effective classroom management in the teaching and learning process in which technology is used. I can guide students in the process of designing technology-based products (presentations, games, films, and etc.). I can use innovative technologies (Facebook, blogs, twitter, podcasting, etc.) to support the teaching and learning process.
Ethics	I can follow the teaching profession's codes of ethics in online educational environments (WebCT, Moodle, etc.) I can provide guidance to students by leading them to valid and reliable digital sources.
Proficiency	I can troubleshoot problems that could be encountered with online educational environments (WebCT, Moodle, etc.) I can cooperate with other disciplines regarding the use of technology to solve problems encountered in the process of presenting content.

What TPACK Explains in the Context of this Study

In this study, the TPACK framework will help guide the understanding of how teachers use the constructs of the various bodies of knowledge to create technology-enhanced lessons. The TPACK-deep framework developed by Kadıoğlu-Akbulut et al. (2012) will provide the foundation for understanding teacher use of technology. The focal point of this framework is the combined knowledges of content, pedagogy, and technology with teacher abilities in using those knowledges in the areas of design, exertion, ethics, and proficiency. The TPACK instrument developed by Kadıoğlu-Akbulu et al. (2020) will be a means to assess the level of technology integration knowledge that teachers possess. This study compares science teachers' technology integration knowledge with their level of empowerment. A relationship between the two may give leaders insight into leadership efforts that could improve learning in their schools.

Empowerment

Empowered teachers assume responsibility for their professional conditions, utilizing their knowledge and skills to make necessary improvements and finetune their expertise (Bogler & Somech, 2004; Short, 1994).

Short (1994) identified six aspects that are key to teacher empowerment:(a) *decision making* as characterized by increased control over the work environment through decisions on scheduling, curriculum, and budgets, (b) *impact* and the ability to impact school life, (c) teacher *status* as teachers' perception that they have the respect and support of their colleagues, (d) *autonomy* providing freedom to make certain decisions, (e) *professional growth* opportunities enabling teachers to learn, develop skills, and grow professionally, (f) teacher *self-efficacy* or perceived knowledge and skills to promote students' learning and desired outcomes.

However, school leaders play a vital role in creating a school climate conducive to teacher empowerment. Using data from the North Carolina Teacher Working Conditions Survey, Burkhouser (2017) determined that school principals greatly influence teachers' perceptions of their work environment. The particular principal matters in the teacher's perception of their work environment in the areas of teacher time, physical environment, teacher empowerment, and professional development. The researcher also concluded that favorable conditions in one of these areas may translate to other areas. Overall, empowerment is a source of debate for educational reform (Marks & Louis, 1997).

Decision Making

Short (1994) describes aspects that can make the teaching profession challenging. Traditionally, teachers are not involved in decisions that affect their work, and due to the nature of teaching in a classroom, most work separately from their colleagues most of the day. Leaders can empower teachers by increasing their ability to make decisions that impact the teacher's workplace (Short, 1994). Murphy et al. (2006) analyzed the concept of learning-centered leadership and identified leadership as a shared process, not a character trait of an individual. It involves interactions and helps the organization reach its goals. Team leadership is essential to their Learning-centered Leadership framework in three capacities: The school has leadership roles in the form of teacher mentors or teacher coaches. Teachers also take on additional leadership responsibilities. Additionally, communities of practice involve both formal and informal leadership. These second two aspects coincide with the ideas behind empowerment by placing the teacher in a leadership function. The leader positions teachers to make decisions that involve themselves and others in the school. The professional learning communities also allow the teacher to have a role in professional development and curriculum decisions. Finally, leaders within this framework also develop a shared vision. This vision arises with input from the various stakeholders. A shared vision promotes collaboration and communication amongst faculty.

Leithwood (2017) comments on the Ontario Leadership Framework (OLF) recommended practices for school-level leaders. Shared leadership is one of the assumptions of this framework. Intentionally sharing leadership with various people within the school creates more opportunities for collective learning and teacher development. These practices reflect the ability of a teacher to participate in decision-making for the school.

Professional Growth

The leader's role is to prompt and guide faculty in professional growth and continued learning (Sebring et al., 2006). Professional development opportunities enable teachers to learn, develop skills, and grow professionally (Short, 1994). In the Learning-Centered Leadership framework, Murphy et al. (2006) analyzed the concept of learning-centered leadership and identified leadership as a shared process, not a character trait of an individual. It involves interactions and helps the organization reach its goals. Teacher development in this framework is instructional-focused. Student achievement indicates school success, and leadership is a core component. Leaders work with teachers to strengthen instructional skills. In this framework, the leader creates learning opportunities for students and teachers. They readily assist teachers in learning instructional skills and gaining new knowledge. Leaders ensure necessary resources and provide professional development opportunities by providing various learning experiences and ensuring that these experiences link to the district or school goals; actively designing and working with teachers on instructional issues; supporting teachers' implementation and providing feedback for improvement and modeling lifelong learning and growth with a focus on the outcome of student success.

Status

Status represents the teacher's perception that they have the respect and support of their colleagues. Teachers like acknowledgment and reciprocity; leaders must show interest in teachers' work (Bendtsen et al., 2022). Teachers also like support and respect from colleagues. Karaca et al. (2013) convey that colleagues provide support by modeling ways to use technology and solve problems. Additionally, teachers can provide support by sharing instructional media and materials. Karaca et al. (2013) also found that principal support explained 59% of the variance in colleague support. Although principal support did not directly influence technology integration, it indirectly mediated technology competencies, teachers' attitudes and beliefs, and colleague support.

Self-efficacy

Self-efficacy, in the context of teacher empowerment, means that the teacher perceives they have the knowledge and skills to promote learning effectively and achieve desired student outcomes (Short, 1994). It reflects the teacher's beliefs surrounding how their influence and ability to perform (Kelley & Finnigan, 2003). Teacher self-efficacy is strongly linked to student achievement (Walker & Slear, 2011). Self-efficacy can include a teacher's perception of their capability of integrating technology. Zeng et al. (2022) studied the relationship between self-efficacy and TPACK and found them closely related. Self-efficacy is related to expectancy since it relates to the teacher's perception that they can influence student outcomes. Kelley and Finnigan (2003) show that there is also a link between teacher expectancy and student achievement.

Walker and Slear (2011) not only found that student achievement increased with teacher self-efficacy but also found a positive relationship between principal behavior and teacher self-efficacy. Different behaviors were significant for varying years of teacher experience. Modeling instructional expectations had most significantly associated with beginning teacher self-efficacy. On the other hand, teacher self-efficacy for those teachers with 4-7 years of experience was more associated with communication and modeling instructional expectations. Slightly more experienced teachers’ self-efficacy is associated with the principal's concern for getting to know the teacher and concern for their welfare. Finally, inspiring group purpose or working as a team toward shared goals was the more significant principal behavior associated with self-efficacy for teachers with over 15 years of experience.

Autonomy

Autonomy represents the freedom to make certain decisions (Short, 1994). Autonomy occurs in various stages of life. Erickson's stages of development include autonomy as a child's second stage of development. It describes when a child gains the capacity for self-governance and self-direction (Graves & Larkin, 2006). Gutmann's theories carry these ideas into education, with parents wanting some control over their children's education (Corngold, 2010).

For teachers, autonomy represents their belief that they can have some control in their classroom (Pearson & Hall, 1993; Short, 1994). "Teachers desire the most participation and decisions clearly within the classroom" (Conley, 1991, p. 257). Teachers take chances and can build confidence. Autonomy can also represent participating in decisions outside the classroom such as curriculum, materials, instructional planning, and sequencing (Pearson & Hall, 1993). Studies show that morale and production increase when workers are provided autonomy and allowed to achieve influence and intrinsic rewards (Bolman & Deal, 2017, p. 140). Lee and Nie (2014) studied four factors in empowerment: teachers' sense of meaning, competence, autonomy, and impact. The researchers found teachers' sense of autonomy to be most important in promoting teachers' organizational commitment.

Impact

The last empowerment domain Short (1994) described is impact, relating to the ability to impact school life. Dee et al. (2003) summarize empowerment as focusing on the teacher's perception of meaning or the value of the work, the teacher's belief that they can skillfully perform their work, and having self-determination. The concept of impact is the teacher's perception of their ability to influence outcomes at work. Empowerment theory in education includes impact and ability to impact school life (Short, 1994)—individuals who design a shared vision impact the organization's future direction. Additionally, by creating shared goals, the teacher helps decide how the school will achieve that vision.

Dee et al. (2003) found that a teacher's sense of impact positively affected organizational commitment. A study by Lee and Nie (2014) also supports the association between impact and organizational commitment. Bolman and Deal (2017, p. 140) also describe teacher autonomy as providing a teacher's sense of influence.

Research Measuring Empowerment

The Short and Rinehart (1992) School Participant Empowerment Scale (SPES) is an often-used instrument to measure teacher empowerment (Hidiroglu & Tanriogen, 2020). This instrument produces quantitative data and lends itself to use in correlational studies. It is a 38-item questionnaire using a 5-point Likert scale. Short and Rinehart used secondary teachers in the development of their subscales: *decision making, professional growth, self-efficacy, status, autonomy,* and *impact.* Several researchers have used the SPES scale in many studies that explore the relationship between various concepts and teachers' perceptions of empowerment.

Bogler and Somech (2004) studied outcomes related to the behavior of teachers, including organizational commitment, and used the SPES (Short & Rinehart, 1992) to measure the six aspects of empowerment. Bogler and Somech found that self-efficacy and status predicted the outcomes of organizational commitment. These researchers also used Bandura's (1971) theory on self-efficacy to explain why higher reported self-efficacy results in more organizational behaviors.

Bogler and Nir (2012) found a positive relationship between organizational support and empowerment. These researchers used the SPES scale and the Survey Perceived Organizational Support developed by Eisenberger et al. (1986). In another study, Sharif et al. (2011) utilized SPES and the Organizational Commitment Questionnaire (Mowday, 1979) to determine the relationship between empowerment and organizational commitment. In this study, Sharif et al. found a correlation between these variables. The mean was highest for the correlation between self-efficacy, autonomy, and professional growth. More recently, Ghaemi and Sabokrouh (2014) used the SPES to determine the relationship between empowerment and teacher job satisfaction. This correlational study used SPES and the Teacher Job Satisfaction Questionnaire developed by Lester (1987).

Summary

This chapter reviewed the literature on technology used in education and empowerment. Technology can enhance student achievement. And most educators agree that technology has a place in education. The physical infrastructure has increased to promote technology use in schools. However, the use of technology has yet to follow. Research studies have considered the barriers in addition to the factors that encourage technology integration. Teacher technology integration knowledge concerns the intersection of technology, pedagogy, and content knowledge. School leaders can empower teachers in various aspects of their work: decision making, professional growth, status, self-efficacy, autonomy, and impact. This study explores the relationship between teacher integration knowledge and empowerment. Surveys can measure a teacher's perceptions of both facets of their work. Chapter 3 presents the research methods used to investigate this relationship.

CHAPTER 3. RESEARCH METHODS

Problem Addressed

Studies have shown that ICT technology-enhanced lessons can develop 21st Century skills (Larson & Miller, 2011). At the same time, teachers report not using technology for teaching and learning (Mason et al., 2008). In seeking a solution, researchers found that teachers report that professional communities, collaboration, and content-specific professional development increase self-efficacy toward using technology (Ertmer, 2005; Jones & Dexter, 2014). All of these concepts are components of empowerment. This study explored the relationship between secondary science teacher empowerment and teacher use of technology in the classroom.

Research Questions

This study investigated the possibility of a relationship between empowerment and teacher technology integration knowledge for secondary science teachers. The following questions guided this study:

1. What is the level of empowerment for secondary science teachers, overall and in each domain area: decision-making, professional growth, status, self-efficacy, autonomy, and impact?
2. What is the level of technology integration knowledge for secondary science teachers, overall and in each domain area: planning, design, implementation, ethics, and proficiency in technology integration?
3. What is the relationship between empowerment and technology integration knowledge for secondary science teachers?

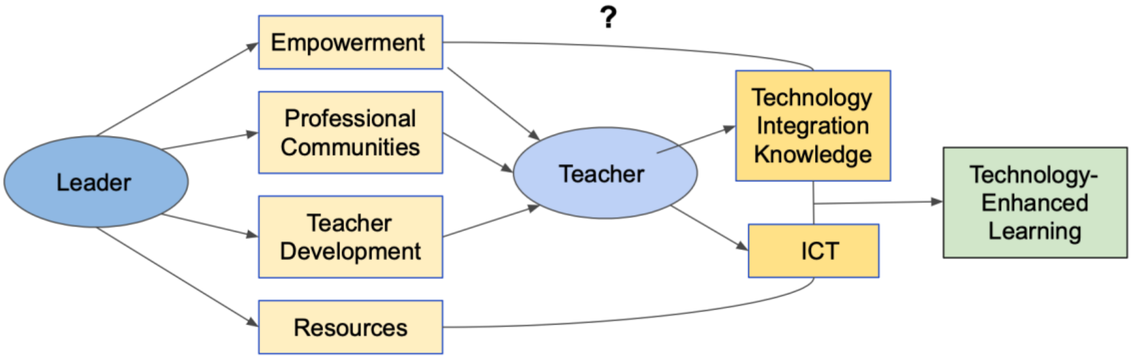
Assessing the level of empowerment and technology integration knowledge, overall and for each domain, provided the necessary information to test the following hypothesis:

H_0: There is no relationship between empowerment and technology integration knowledge for secondary science teachers.

H_a: A positive relationship exists between empowerment and technology integration knowledge for secondary science teachers.

Figure 3.1

Interrelated Concepts of this Study



This study explored the possibility that a higher level of empowerment is correlated with a higher level of secondary science teacher technology integration knowledge. Figure 3.1 illustrates the different concepts within this study. The leader brings many things to the table, including, but not limited to, empowerment, supporting professional communities, promoting teacher development, and providing resources. Specific to this study are ICT resources. Empowerment, professional communities, and teacher development help teachers grow and improve. Studies have shown that professional communities improve technology integration knowledge (Baran et al., 2016; Higgins & Spitulnik, 2008). Teachers utilize their technology integration knowledge along with ICT to create technology-enhanced lessons. The study explored whether there is a relationship between empowerment and technology integration knowledge.

Organization of Chapter

This chapter summarizes and describes the research methods for this study. First, the chapter discusses the research design along with the rationale and support for this design. Next, the chapter describes the research setting, sample population, and sampling procedures, including protecting participant rights. This chapter includes the instrument, data collection, and analysis procedures. Following this section is a description of the researcher's role in the study. Finally, the chapter ends with a timeline of the study events.

Study Design

This study sought to determine whether there is any relationship between teacher empowerment and technology integration knowledge. The study did not seek to determine whether empowerment leads to a certain level of technology integration knowledge, so a determination of causation was not a goal. Therefore, the research design was correlational.

Correlational research, or associational research, investigates possible relationships between two variables (Fraenkel et al., 2019). Correlational studies can determine if there is a positive or negative association between two variables. The two variables in this study were technology integration knowledge and empowerment. Correlational studies follow some basic steps (Fraenkel et al., 2019). The first step is to determine the problem, followed by selecting the sample. The minimum recommended sample size is at least 30. The instruments utilized should provide quantitative data. Next, the researcher collects information on the subjects regarding two (or more) variables, and then the data are analyzed and interpreted. The researcher calculates a correlation coefficient. This number is a decimal between zero and a positive or negative one. A positive number represents a positive relationship, and a negative one represents a negative relationship. Numbers close to zero indicate no relationship. Numbers between -.5 and .5 make it challenging to make a prediction. A correlation less than - 0.65 or higher than 0.65 allows for some predictive capability. Values over 0.85 indicate a close relationship between the variables. However, Fraenkel et al. (2019) note that high correlations are rare.

There are a few possible threats to validity in correlational research. One threat includes the possibility of other factors explaining a relationship (Fraenkel et al., 2019). Researchers can use control variables to help reduce alternative explanations. However, control variables can cloud results, and leaving them out can improve interpretation (Becker et al., 2016). Therefore, this study did not control for the type of school where the teacher works. Due to the inherent design of the study, it was necessary to sample teachers from different schools to access participants who experience different levels of empowerment. This sampling also helped control for the possibility of other explanations. Teachers sampled across the United States were teaching in varied educational settings, reducing the chances of an alternative factor explaining the relationship.

Another concern in this type of study is location threat, where subjects may be in different environments when they take the survey (Fraenkel et al., 2019). The subjects received the survey by email and completed it in their chosen location. Therefore, this threat was difficult to control. The typical threats to instrumentation are instrument decay, data collector characteristics, and bias (Fraenkel et al., 2019). These diminish in concern due to the instrument's one-time, online survey structure as they are absent. However, the order of the questions within the survey may influence participant responses (Pew Research Center, 2021). For this study, respondent fatigue was a concern due to the length of the survey. Therefore, more extended questions were asked at the beginning of the survey. Additionally, to help with survey fatigue, the survey questions were separated into smaller sections using page breaks organized according to the domains within the instrument. Doing so did not reduce the number of items; however, the participant may have been more relaxed when seeing all the items within a domain at once and having a slight break when moving to the next page.

Research Context

The context of this study was science education in United States secondary schools. This section briefly describes the educational system where the target population of science teachers works. The education system in the United States consists of several levels of education (*Structure of U.S. education,* 2008). These levels include early childhood, primary, middle, secondary, and tertiary. Middle school corresponds to the International Standard Classification of Education (ISCED) level on lower secondary school (NCES, n.d.). The use of the term secondary education in this study corresponds to the ISCED upper secondary level. Many schools in the U.S. high schools include 9th to 12th grade. This study focuses on teachers of students in these grades. Core courses in the curriculum include English, mathematics, science, social studies, and a foreign language. Other courses include fine arts, physical education, career technical education, and various electives. Following secondary school, students attend post-secondary school or enter the workforce (*Education Indicators: An International Perspective / Indicator 3*, n.d.).

Secondary education and primary and middle school are publicly funded and governed by a district within the state. An alternative to traditional public schools is charter schools. These schools are also publicly funded. However, they are under the control of an organization with a legislative contract. Approximately 3.4 million of the 49.5 million students in the United States attend charter schools (National Center for Education Statistics, 2022). However, some parents refrain from enrolling their children in publicly funded schools. 4.7 million students attend private schools (National Center for Education Statistics, 2022). The National Center for Educational Statistics defines private schools as Catholic, other religious, and those not religiously affiliated. Since parents are responsible for the cost of tuition, the student population consists of those who can afford the tuition or obtain a scholarship. An alternative to public or private school is homeschooling. In this case, parents choose to educate their children themselves. This study relied on gathering data on teachers' reported empowerment. Therefore, this study only included education in the school setting. Teachers in some types of schools may inherently perceive more or less empowerment. However, the type of school and the empowerment level is beyond the scope of this study. As stated previously, this study attempted to achieve a sampling of participants with varying empowerment levels. Thus, the research context included all types of secondary schools in the United States.

Research Sample and Data Sources

Sample

The target population in this study was secondary science teachers working in the United States. More specifically, secondary teachers certified to teach science and primarily teaching this subject. It is critical to survey teachers from various schools. Considering the opposite condition may highlight the importance of this requirement. Should all teachers be in the same school and exposed to the same leadership with similar levels of empowerment, it would not be possible to determine different technology integration knowledge levels with varying levels of empowerment. Therefore, the study included teachers from across the United States. It is more practical to collect data on a sample of the population (Agresti & Finlay, 2009). Therefore, a subset of the population was surveyed to acquire a manageable amount of data.

How Participants Were Selected

Over 285,000 high school teachers are working in the United States (Zippia.com, 2022). This study sampled a portion of this larger population. Market Data Retrieval (MDR), a mailing list company, provided a list of email addresses for secondary science teachers in the United States. The list MDR provided came from their database of teachers from schools across the United States in all types of communities (urban, rural, and suburban). Additionally, the MDR-supplied email list consisted of teachers from all types of schools (public, charter, and private). This study used the following criteria for MDR to select teachers from their database: (a) Max. Records in each Building: 1 (no more than one teacher per school will be selected), (b) Institution type: Senior High schools within Public Schools, State Schools, County Schools, Bureau of Indian Affairs, Private Schools, and Catholic Schools, (c) Geography: United States; (d) Personnel:

Science Teacher, Physical Science Teacher, General Science Teacher, Chemistry Teacher, Life Science Teacher, Environmental Science Teacher, Biology Teacher, Physics Teacher, Human Anatomy/Physiology Teacher, Earth/Space Science Teacher, and Astronomy Teacher. Utilizing the MDR service avoided possible email solicitation restrictions and avoided contacting only teachers in a college-town setting whom research survey requests may overly bombard. A mailing list service also provided a more varied source of respondents than teachers in a specific locale.

Sample-size.net supplies an online calculator for sample size in correlational studies (Kohn & Senyak, 2021). The correlation coefficients from previous research can help determine an expected correlation coefficient. Currently, no studies consider the relationship between empowerment and teacher technology integration knowledge. Therefore, studies using domains within empowerment helped to determine the expected correlation coefficient. Previous studies that looked at associations between technology integration knowledge and the areas of development, self-efficacy, and support found correlation coefficients between 0.307 and 0.607 (Baran et al., 2019; Dong et al., 2020; Zeng et al., 2022). Since a smaller expected correlation coefficient requires a larger sample size, this study used the smallest value in the calculation. The minimum sample size is 85 participants when using $\alpha = 0.05$ and $\beta = 0.20$ and an expected correlation coefficient of 0.3. The survey reached 5,000 teachers in anticipation of receiving sufficient responses to meet this minimum number of participants.

Sampling Bias and Limitations

MDR has an extensive database; however, its use may not provide a random sample. Their database fails to include the email addresses of all secondary science teachers in the United States. Some school districts do not allow teachers to receive emails from outside their network of schools. Therefore, MDR excludes contact information for teachers in those school systems. In doing so, some entire schools are excluded from the potential sample, which could result in sampling bias. This possible bias results in a sample that cannot be considered random and potentially does not represent the population. The uncertainty of the representativeness of the sample limits the generalizability of the results.

Protection of Participant Rights

The setup of this survey involved measures to protect the rights of the participants. This study utilized Qualtrics to deliver the survey instrument. Participants who received the survey voluntarily choose to complete the survey. Qualtrics provides a feature entitled "Anonymize Responses." to prevent the collection of email responses for participants, and that feature was enabled for this study. Therefore, teacher responses are not associated with any particular teacher or email address. Teachers wishing to enter the drawing for an Amazon gift card were directed to a separate survey to ensure that the email address provided for entry in the drawing was completely separate from the survey response. Finally, email addresses obtained from MDR were stored in a file on a password-protected encrypted hard drive.

Instruments and Procedures

Description of Instruments

Data for this study were collected using a survey. This survey combined two previously used and validated data collection instruments and demographic questions to inform sample characteristics. Surveys are the most common method of measuring technology integration knowledge (Brantley-Dias & Ertmer, 2013), therefore they are an appropriate method of collecting data for this study. The first portion of the survey contained the technology integration knowledge items. The questions were longer and more detailed than the remaining questions. In addition, responses might have been influenced if the participant was aware of questions about empowerment. Demographic questions were the last questions that participants completed. These questions were easy to answer quickly and least likely to cause respondent fatigue.

ICT-TPACK-Science Scale

The first portion of the survey consisted of the ICT-TPACK-Science scale developed by Kadıoğlu-Akbulut et al. (2020). Researchers developed this TPACK scale using the transformative approach to assess science teachers' technology integration knowledge. The ICT-TPACK-Science scale builds on the TPACK-deep framework that Kabakci Yurdakul et al., (2012) developed. Kadıoğlu-Akbulut et al. modified the original survey to format questions specific to science education and technologies, and they also placed more emphasis on the Design factor by adding items and separating it into two factors: planning and design. Furthermore, the modified survey relabeled the Exertion factor as Implementation.

The scale consists of 38 Likert-type questions for teachers to self-assess their technology integration knowledge. The survey organizes the questions by the factors they intend to measure: planning, design, exertion, ethics, and proficiency. The factors and associated survey questions can be summarized as follows:

- Planning - the teacher's ability to locate and analyze appropriate teaching technologies that consider student characteristics, time, and content.
- Design - teacher's ability to use appropriate science education technologies to design lessons by creating videos, animations, simulations, and assessments.
- Exertion - teacher's ability to implement ICT- integrated science instruction.

- Ethics - teacher's ability to act ethically when accessing technology and maintaining confidentiality and intellectual property rights.
- Proficiency - teacher's ability to solve hardware or software problems and collaborate with science education colleagues using technologies.

The participants responded on a five-point Likert-type scale where 1 = strongly disagree, 2 = disagree, 3 = neither disagree nor agree, 4 = agree, and 5 = strongly agree. Kadıoğlu-Akbulut et al. (2020) published the survey questions and confirmed the validity of the final instrument: $\chi 2 = 1030.27$ ($df = 652$, $p < .05$); NNFI = .99; CFI = .99; and RMSEA = .042; Cronbach's alpha for this scale ranged from 0.83-0.90.

School Participant Empowerment Scale

The second portion of the survey consisted of the School Participant Empowerment Scale (SPES), developed by Short and Rinehart (1992). The survey is a 38-item questionnaire using a 5-point Likert-type scale designed to measure teacher empowerment. The SPES consists of six subscales: (a) Decision Making, (b) Professional Growth, (c) Status, (d) Self-Efficacy, (e) Autonomy, and (f) Impact. Comparable to the ICT-TPACK-Science scale, the participants respond on a five-point Likert-type scale where 1 = strongly disagree, 2 = disagree, 3 = neither disagree nor agree, 4 = agree, and 5 = strongly agree. Short and Rinehart (1992) determined that the internal consistency for reliability for the total scale was .94 and ranged from .81 to .89 for the six-factor scales.

Demographic Questions

The third portion of the survey included demographic questions. These questions were the shortest and least subject to participant fatigue. Therefore, they were listed last. The demographic questions served two purposes. First, they ensured that the participant was part of the intended target population: secondary teachers certified to teach science and primarily teaching in that subject area. The analysis disregarded responses from respondents outside the intended criteria. Secondly, these questions provided more information on the characteristics of respondents in this study. Providing this information may make results more helpful for other researchers. A copy of the data collection instrument is in Appendix B.

Data Collection Procedures

The data collection instrument was in the form of an online survey. The survey was built using Qualtrics and consisted of a cover letter (Appendix A), the combined two survey instruments to measure teacher technology integration knowledge (TPACK-deep scale) and empowerment (SPES), a short demographic section (Appendix B), and a thank you statement. The survey used the "Anonymize responses," so Qualtrics did not link participant responses to their email address.

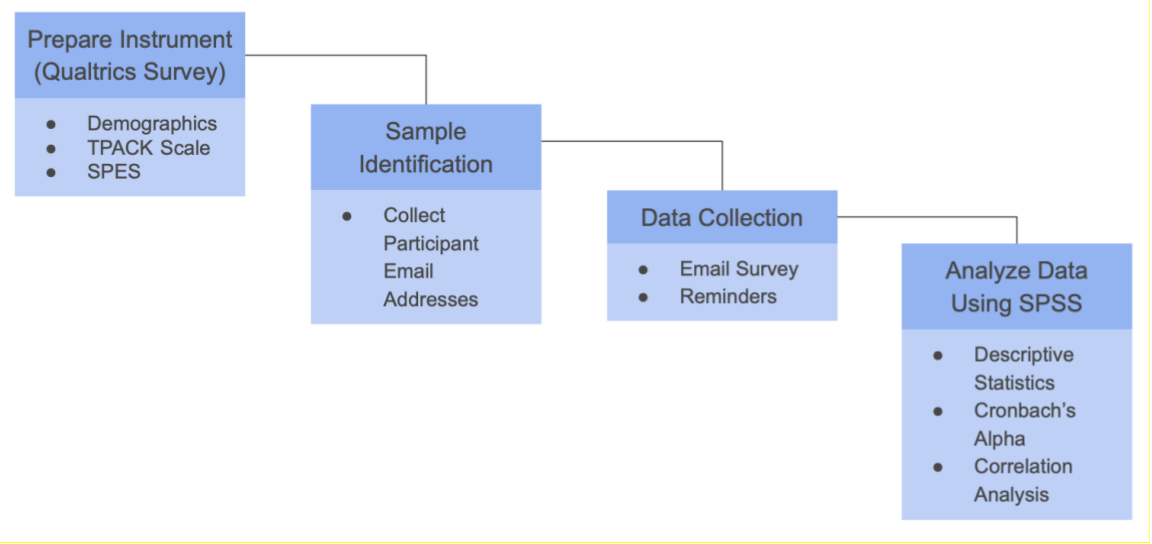
The next step involved acquiring the email addresses of 5,000 secondary science teachers from the MDR database and sending the email invitation through Qualtrics requesting participation in the study. The email request included the link to the survey in Qualtrics with instructions regarding how to complete the survey. Participants had fifteen days to complete the survey, with three reminders sent after the initial email invitation. The original survey invitation went out on a Wednesday, with reminders sent the following Monday and Friday, with the final reminder on Wednesday, fourteen days after the first invitation. As an incentive for participants to complete the survey, they had the opportunity to enter a drawing to receive an Amazon e-gift card worth $10.00, which they could use for needs in their classroom. Entrants had approximately a 1 in 50 chance of winning. To ensure the anonymity of survey responses, participants who chose to enter the drawing were directed to a separate survey to enter contact information. Qualtrics held participant responses in a database until they were ready for analysis. Once retrieved from Qualtrics, the data were stored on a password-protected, encrypted hard drive.

Data Analysis

The survey data were imported into SPSS, the statistical software used to conduct subsequent analyses.

Figure 3.2

Data Collection and Analysis



First, an examination of the data evaluated them to ensure sufficient questions were answered and that respondents were part of the target population. The first question in the survey asked the participant if they were a secondary science teacher. This question confirmed that responses came from teachers who are part of the intended population. For inclusion in the study, participants needed to answer at least 75 percent of the questions within each domain. The dataset excluded responses from participants who answered less than 75 percent of the questions in any domain. For the participants who completed at least 75% of the questions for a domain, multiple imputations in SPSS accounted for any missing data.

Next, measuring the internal consistency helped determine the reliability of the scale. Cronbach's alpha is a common test to measure reliability in Likert scales (Lund Research, Ltd. n.d.). The SPSS reliability command calculated Cronbach's alpha for the empowerment scale and each technology integration knowledge subscale. The closer the value of alpha is to 1, the higher the probability that the items are measuring the same concept. A value over 0.8 represents a good level of internal consistency (George & Mallery, 2011).

Next, the analysis compiled the raw data for mean scores for each participant. Likert-type questions are in themselves ordinal measures. However, when there are multiple respondents, one can use the sum or mean of two or more ordinal variables to create an approximately continuous variable (Sullivan & Artino, 2013). In this study, both scales had a different number of questions. Therefore, summed scores were not useful in this case. Consequently, the analysis utilized a mean score for each participant. For the empowerment questions, the scores for each participant were summed and divided by the number of questions in that section that the participant answered. This process provided the mean empowerment score for each participant. The same process gave each participant a mean overall technology integration knowledge score. Next, the same process produced each participant's mean score for each empowerment and technology integration knowledge subscale. For example, for the technology integration knowledge planning subscale, the scores were summed for all questions (#1-8) and divided by the number of questions answered in that section. Once completed, each participant had a mean overall empowerment score, a mean overall technology integration knowledge score, and a mean score on each technology integration knowledge subscale.

After tabulating the participants' scores for empowerment and technology integration knowledge, SPSS software statistical analysis provided descriptive statistics. This process gave a side-by-side comparison of the number of participants, minimum, maximum, mean, and standard deviation for the variables on overall empowerment, overall technology integration knowledge, and the technology integration knowledge subscales of planning, designing, implementation, ethics, and proficiency.

Before running any calculations, a histogram confirmed the normal distribution of the data. Finally, SPSS calculated the correlation coefficient between overall empowerment and technology integration knowledge competencies. A correlation test evaluated the association between variables. This study anticipated a relationship between teacher empowerment and technology integration knowledge. This research is exploratory, so the null hypothesis is that there is no correlation between the variables in the population. Likewise, there was a similar null hypothesis for the association between the overall empowerment and each technology integration knowledge subscale. Correlations are statistically significant when the "Sig. (2-tailed)" < 0.05.

Role of the Researcher

The researcher had several roles in this study, including planning, implementing, evaluating, and presenting. The researcher's first responsibility was identifying a problem and evaluating published literature that provides relevant background information to understand the problem thoroughly. Based on information learned in the literature, the researcher planned the research to investigate and learn more about the matter. The researcher determines the best method to collect data. The researcher was responsible for appropriate methods of data analysis and drawing conclusions. Finally, the researcher was responsible for disseminating the findings so that others in the field may gain from the knowledge learned from this study.

This study follows a post-positive philosophy. As such, it utilizes quantitative methods to gather and analyze the data. The study assumed someone could measure teacher technology integration knowledge and empowerment levels. The ICT-TPACK-Science and SPES scales provided numerical data. While there may have been researcher bias in selecting instruments and chosen methods of statistical analyses, it tended to lend itself to a more objective means of investigation. It was also assumed that the ICT-TPACK-Science and SPES scales sufficiently capture the teachers' knowledge of technology integration and empowerment, respectively. These measurements provided practical knowledge and enabled the identification of the relationship between the two concepts. When sufficient data is collected, the study's results can be replicated and generalized to the larger population of secondary science teachers in the United States. However, the scope of this study may need to provide more data to allow generalizability.

Summary

This chapter described the methods used in this correlational study to determine the relationship between empowerment and technology integration knowledge of secondary science teachers. It described the research design, context, population, and sampling procedure. This chapter also discussed the instrument for collecting data and subsequent methods of analyzing the data. Chapter 4 presents the results and statistical analysis of the data.

CHAPTER 4. RESULTS

Information communication technologies (ICT) help students gain 21st Century skills (Pascopella, 2008). In addition, using technology with traditional lessons can increase student learning (Thisgaard & Makransky, 2017). Schools have increased the number of devices and software for use in schools. Yet, teachers still need to similarly increase their use of technology (UNESCO, 2023). While the literature indicates that some of the domains within empowerment can increase teachers' use of technology, it is unknown whether overall empowerment and technology integration knowledge is associated.

Research Questions

The following research questions guided this study:

1. What is the level of empowerment for secondary science teachers, overall and in each domain area: decision-making, professional growth, status, self-efficacy, autonomy, and impact?
2. What is the level of technology integration knowledge for secondary science teachers, overall and in each domain area: planning, designing, implementing, ethics, and proficiency in technology integration?
3. What is the relationship between empowerment and technology integration knowledge for secondary science teachers?

This study tested the following research hypothesis:

H_0: There is no relationship between empowerment and technology integration knowledge for secondary science teachers.

H_a: A positive relationship exists between empowerment and technology integration knowledge for secondary science teachers.

Summary

This correlational study aimed to determine the relationship between teacher empowerment and teacher technology integration knowledge for science teachers in the United States. Quantitative data were collected using two existing survey instruments: the School Participant Empowerment Survey (Short & Rinehart, 1992) and the ICT-TPACK Science Scale (Kadıoğlu-Akbulut et al., 2020). Each scale uses a Likert-type format for participants to self-report their agreement on the statements related to the various domains within empowerment and technology integration knowledge. Five thousand randomly selected teachers from this population received the survey instrument by email. This chapter provides details about the participants and the response rate, results of data analyses, and findings of the study.

Response Rate

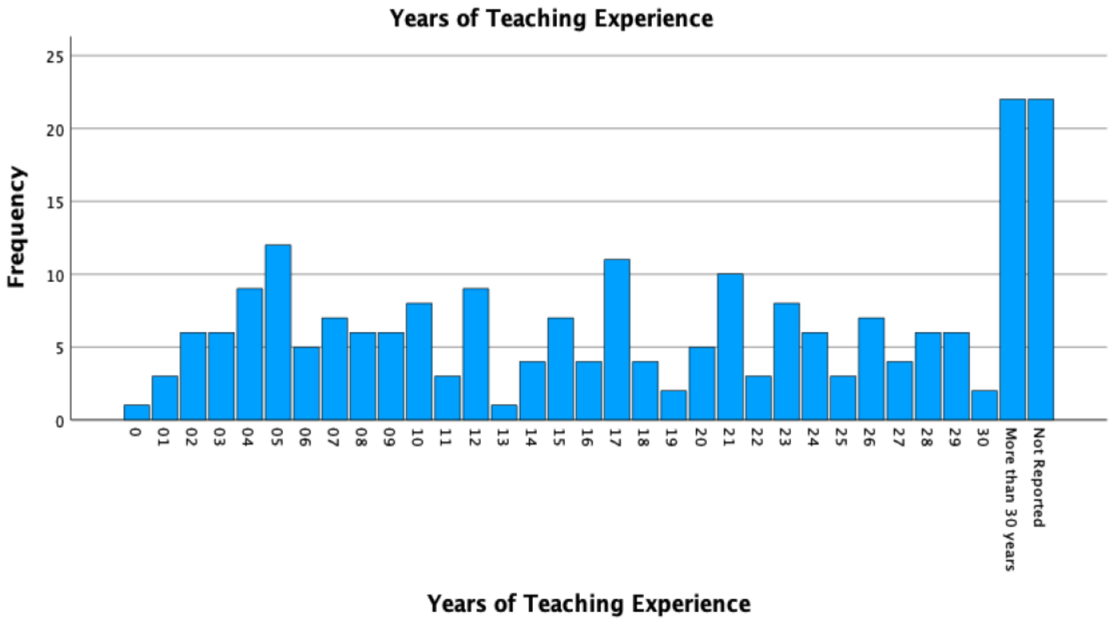
A survey invitation sent by email through Qualtrics reached 5,000 secondary science teachers in the United States. Three hundred sixty-eight of those teachers opened and started the survey. The first survey question functioned as a screening question to ensure that only the intended population completed the survey. Seven respondents screened out as part of this process. However, responses to the demographic questions at the end of the survey indicated that an additional four respondents did not meet the selection criteria. One respondent reported only teaching mathematics, and three others reported only teaching in grades 6-8 which is generally not considered high school. One teacher did not complete any demographic data. However, since most respondents met the selection criteria, this response remained part of the data. The analysis only included responses with at least 75% completion of the items in each domain. This process ensured that participants completed sufficient questions within the survey to provide usable information. After removing the incomplete responses, 214 participants’ responses remained for data analysis. These 214 participants constitute the sample of the larger population in this study.

Participant Demographics

The survey collected a small amount of demographic information from the participants. Many respondents answered some demographic questions, but not all. Since the demographic information was not directly a part of this study, the failure to respond did not remove the participant from the study. However, demographic information may help to understand the participants better. Figure 4.1 illustrates the frequency of responses on teaching experience. Appendix D contains detailed frequency tables.

Figure 4.1

Participant Teaching Experience



The sample population had varying years of experience as seen in Figure 4.1. Unfortunately, 22 teachers did not respond to this question making it difficult to know the actual distribution of years of experience. Additionally, the "More than 30 years" response option has the most considerable response rate. However, it may be misleading since it can include many different years. Table D.1 in Appendix D breaks down the experience levels in 5-year increments. Details on the frequencies of the remaining demographic questions are in Appendix D. In general, the majority (65.0%) of participants identified themselves as female and 93.5% reported only teaching natural or physical science. Of the teachers responding, 96.7% hold a certification to teach science. All participants reported teaching in grades 9-12, with 95.8% teaching only at that level. Finally, 89.7% of participants reported working in public schools.

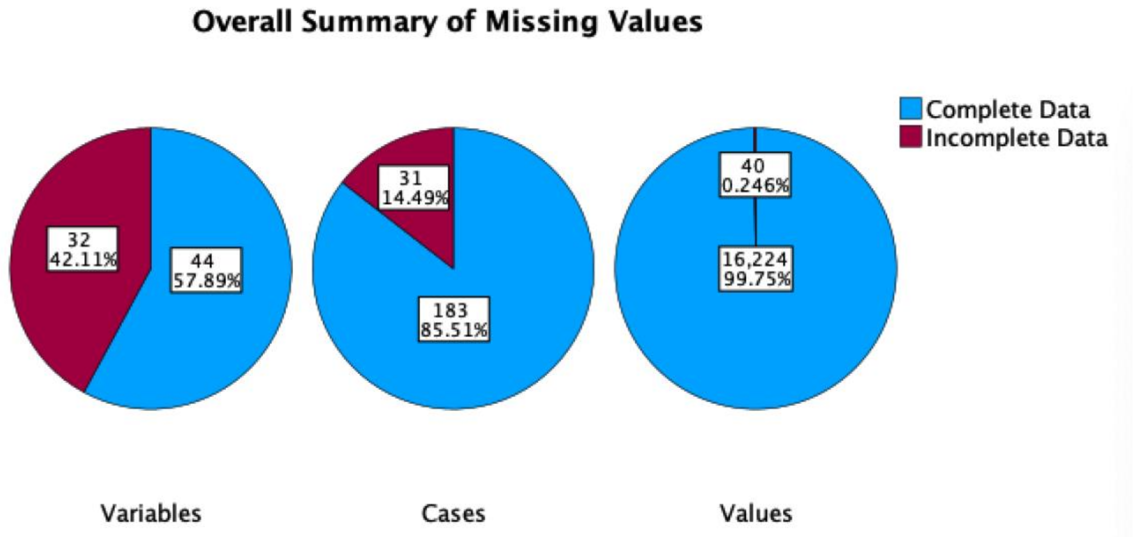
Missing Data

Summary of Missing Data

Most participants completed the survey in its entirety for the technology integration knowledge and the empowerment questions. Of the 214 participants, 183 (85.5%) completed all scale item questions. For those who answered only some of the questions, three or fewer questions were left unanswered on their survey. In addition to most participants answering the questions, no more than three people skipped the same question. The missing data for the ICT-TPACK and SPES scales are presented graphically in Figure 4.2. For the variables, 57.89% of the items, or questions, were answered by all the participants. The majority of participants (85.51%) of participants responded to all scale items in the survey. The Values portion of the figure represents all of the possible responses from the 214 participants on the 76 scale item questions. Only 0.246% of all values, or data points, were incomplete.

Figure 4.2

Summary of Missing Variables



Note: This image reflects missing value for the empowerment and technology integration scale items. It does not include the demographic questions.

Patterns in Missing Data

A Missing Value Analysis (MVA) determines the dataset's extent of missing data and any patterns. The recommended percentage of missing values is 5 percent or less (Njeri-Otieno, 2022). After running the MVA, the percent missing analysis shows that each item had 1.4% missing entries at most. So, the missing values are not excessive in this study. Using the MVA to examine patterns, there does not appear to be bias in the missing data, one variable that the participants routinely did not answer, nor a series of questions left unanswered, as illustrated in Figure 4.3 and Figure 4.4.

Figure 4.3

Missing Value Patterns

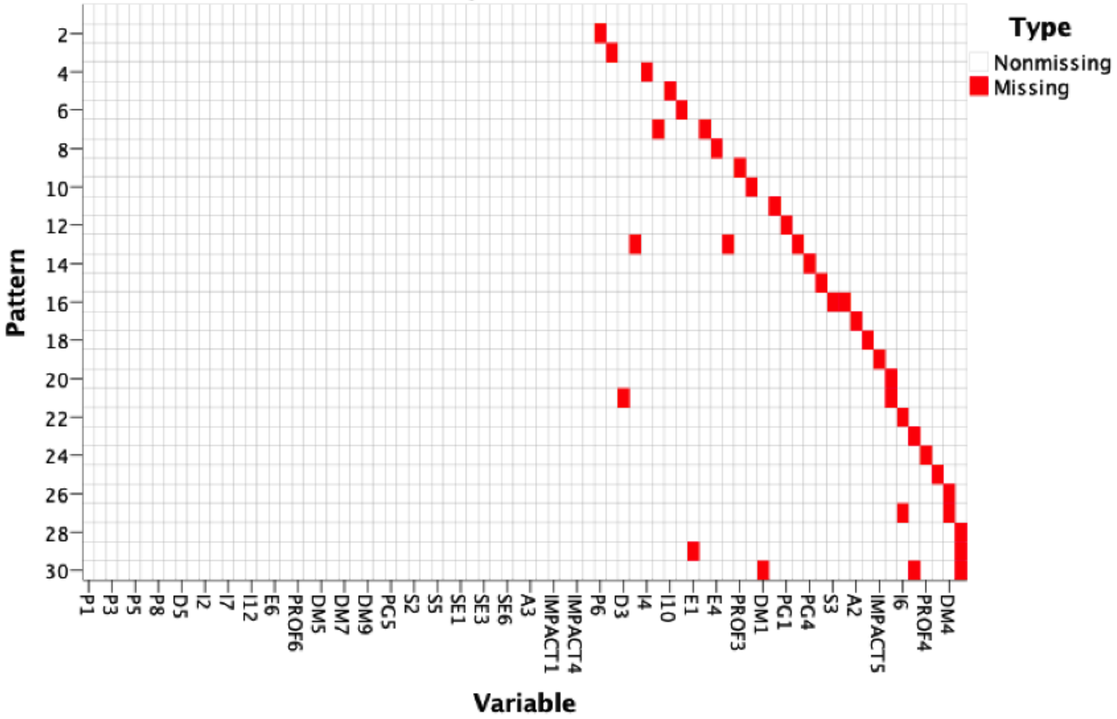
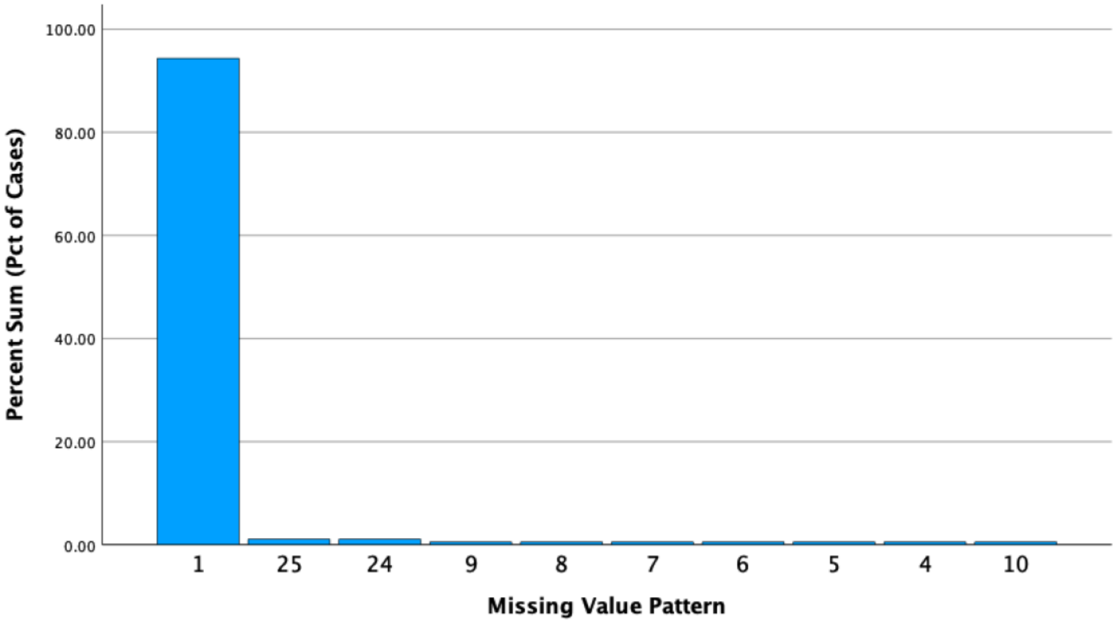


Figure 4.4

Missing Value Pattern Frequency



The 10 most frequently occurring patterns are shown in the chart.

Little’s Missing Completely at Random (MCAR) test (Little, 1988) can identify whether the data are missing completely at random (IBM, 2021). The null hypothesis of Little’s MCAR test is that the data are missing completely at random. After running this test, the significance value was 0.000, less than the alpha value of 0.05. The null hypothesis of MCAR is rejected, indicating that the data are not missing completely at random. Analyzing data with values not missing completely at random, can lead to biased results (van der Heijden et al., 2006). Listwise deletion, or removing a participant’s responses from the study, is the most common method for handling missing data (Kang, 2013). However, removing participants from the sample can remove meaningful data and reduce power (Van Ginkel, et al, 2020). If the assumptions of MCAR are not met, as in this study, listwise deletion can also lead to bias (Kang, 2013). Imputation is a method to handle these missing values and reduce bias (Cummings, 2013). Multiple imputation, in particular, can provide an unbiased estimate of the associations based on the existing data (Pedersen et al., 2017).

Imputation

Imputation is a way to work with missing data instead of reducing the sample size (van der Heijden et al., 2006). Multiple imputation is a method that creates several datasets with missing values replaced with possible values. These datasets are then pooled into one dataset that estimates the likely values of the missing data. This approach is considered more accurate than methods that involve single imputation (IBM, 2021). This study used five imputations consisting of many iterations. Further statistical analysis used the pooled data from these five cases. Tables in Appendix E contain the means for each scale item within the empowerment and technology integration knowledge scales.

Findings

Internal Consistency

Cronbach's Alpha measures the internal consistency between items in a scale, expressed as a number between 0 and 1. Internal consistency represents the extent that items in a test measure the same concept or construct. A value greater than 0.7 is generally acceptable (Tavakol & Dennick, 2011). All items in the two scales are positively worded, so there is no need to reverse any variables when calculating Cronbach’s Alpha. Since the survey consisted of two scales with subscales, Cronbach's Alpha was determined for each subscale.

Two hundred fourteen participants completed the survey. The technology integration knowledge portion of the survey consists of five subscales. The *planning* subscale consists of 8 items (α = .90), the *designing* subscale consists of 6 items (α = .82), the *implementing* subscale consists of 12 items (α = .91), the *ethics* subscale consists of 6 items (α = .89), and the *proficiency* subscale consists of 6 items (α = .92). The empowerment portion of the survey consists of six subscales. The *decision making* subscale consists of 10 items (α = .88), the *professional growth* subscale consists of 6 items (α = .89), the *status* subscale consists of 6 items (α = .83), the *self-efficacy* subscale consists of 6 items (α = .89), *autonomy* subscale consists of 4 items (α = .74), and *impact* subscale consists of 6 items (α = .85).

Descriptive Results

This study assesses the self-reported technology integration knowledge and empowerment levels from 214 secondary science teachers in the United States. These combined scales consisted of 76 variables. Numerical Likert responses provide a way to analyze the results with a mean rating. The mean for each question represents the participants' mean agreement with the statement for that item. Multiple imputation provided a dataset without missing values in calculating these means. Appendix E contains tables detailing the means for each item. These means show how the sample population of teachers agreed with statements in individual items. However, the mean for the item does not illustrate the participants' overall perception of each subgroup or domain within each scale.

The mean rating of all scores within a domain for a participant will illustrate the participants' overall perception of that domain, within the larger scale. The ratings within a domain are then computed into a new variable representing the mean responses for that domain. Table 4.1 contains the descriptive statistics for this study. The overall technology integration knowledge scores had a minimum rating of 1.0 and a maximum of 5.0, with a mean rating of 4.06. The standard deviation of scores was 0.59. This value is the average deviation of technology integration knowledge scores from the mean. The mean is somewhat closer to the higher end of the range. Empowerment had a minimum of 1.0 and a maximum of 5.0, with a mean of 3.96 and a standard deviation of 0.54. The imputed means varied slightly from the means of the original dataset. However, after rounding, they are equivalent.

This study proposes that an increase in technology integration knowledge may be associated with an increase in empowerment level. The scatter plot in Figure 4.5, illustrates the mean empowerment rating as the independent (predictor) variable and mean technology integration knowledge as the dependent (outcome) variable. This graph of the two variables shows a positive and moderate linear association between empowerment (independent variable) and technology integration knowledge ratings (dependent variable). The data generally follow the regression line and look linearly related. The relationship is positive, meaning that as empowerment rating increases technology integration knowledge rating also increases.

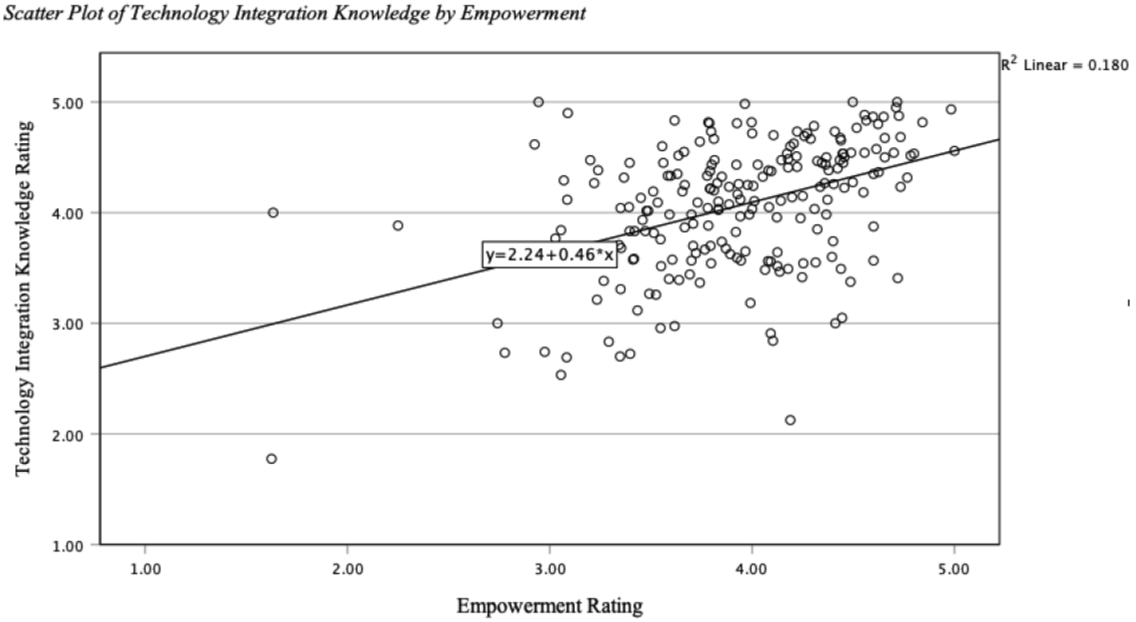
Table 4.1

Descriptives for Each Domain

Domain	N	Minimum	Maximum	*M*	*SD*	Imputed Mean
			ICT-TPACK Science Scale			
Planning	214	1.00	5.00	4.36	0.67	4.36
Designing	214	1.00	5.00	3.22	0.93	3.22
Implementing	214	1.67	5.00	4.32	0.65	4.32
Ethics	214	1.00	5.00	4.67	0.55	4.67
Proficiency	214	1.00	5.00	3.75	0.98	3.75
Overall Scale	214	1.78	5.00	4.06	0.59	4.06
			School Participant Empowerment Scale			
Decision Making	214	1.00	5.00	2.82	0.88	2.82
Professional Growth	214	1.00	5.00	4.19	0.80	4.19
Status	214	2.33	5.00	4.57	0.51	4.57
Self-Efficacy	214	1.67	5.00	4.50	0.60	4.50
Autonomy	214	1.00	5.00	3.29	0.96	3.29
Impact	214	1.50	5.00	4.23	0.70	4.23
Overall Scale	214	1.63	5.00	3.93	0.54	3.93

Figure 4.5

Scatter Plot of Technology Integration Knowledge by Empowerment



Note: Graph uses the original data set, not the imputed data.

Correlation

Pearson's r correlation is a common way to determine the correlation between two variables. However, outliers can greatly impact Pearson's r correlations (Wilcox, 2016). Outliers, as with Pearson's correlation coefficient, do not impact a Spearman's Rank (r_s). Furthermore, Spearman's is often used for ranked items such as Likert scale items. Therefore, Spearman's rank correlation was used in this study. Spearman's rank correlation measures the strength and direction of a relationship between two variables. It ranges between 1.0 and -1.0. The closer the value is to positive or negative 1.0, the stronger the correlation. Conversely, the closer the value is to zero, the weaker the correlation. A correlation of zero means there is no relationship between the variables. It tests the Null hypothesis that H_0: $\rho = 0$ and the Alternative hypothesis that H_0: $\rho \neq 0$. This was a two-tailed test with $\alpha = 0.05$ and $df = 212$.

Table 4.2 shows the relevant r_s values for the overall empowerment and technology integration knowledge ratings. An interpretation of these values can vary. However, a value between .4 and .49 is generally considered a moderate relationship, .3 to .39 is weak to moderate, and below .3 is weak to none (Akoglu, 2018). This study showed a moderate relationship between overall technology integration knowledge and empowerment, r_s (212) = .41, $p < .001$. The effect size for empowerment ($r^2 = .17$) indicates that the level of empowerment that the teacher perceives accounted for a portion (17%) of the variability in technology integration knowledge. The Null hypothesis is rejected; a relationship exists between the variables.

Table 4.2

Spearman's-Rank Correlations

Variable		Technology Integration Knowledge					
		Planning	Designing	Implementing	Ethics	Proficiency	Over-all
Empowerment	Decision Making	.29**	.27**	.32**	.13	.40**	.37**
	Professional Growth	.24**	.16*	.26**	.28**	.26**	.29**
	Status	.36**	.10	.38**	.30**	.27**	.33**
	Self- Efficacy	.37**	.22**	.41**	.35**	.31**	.40**
	Autonomy	.14*	.11	.22**	.06	.25**	.19**
	Impact	.35**	.19**	.44**	.27**	.34**	.39**
	Overall	.36**	.21**	.43**	.28**	.40**	.41**

Note: **Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

Assumptions of Linear Regression

Regression analysis relies on several assumptions: a linear relationship, normality, no multicollinearity, no auto-correlation, and homoscedasticity. The scatterplot in Figure 4.5 indicates there is a linear relationship. Histograms in Figures 4.6 and 4.7 show the distribution of overall empowerment and technology integration knowledge ratings. The data are approximately normally distributed. However, there are outliers noted in both. Linear regression is sensitive to outliers. Winsorizing these outliers ensured that the minimum standardized residuals did not exceed -3.29 and the maximum did not exceed 3.29.

Figure 4.6

Histogram of Technology Integration Knowledge Ratings

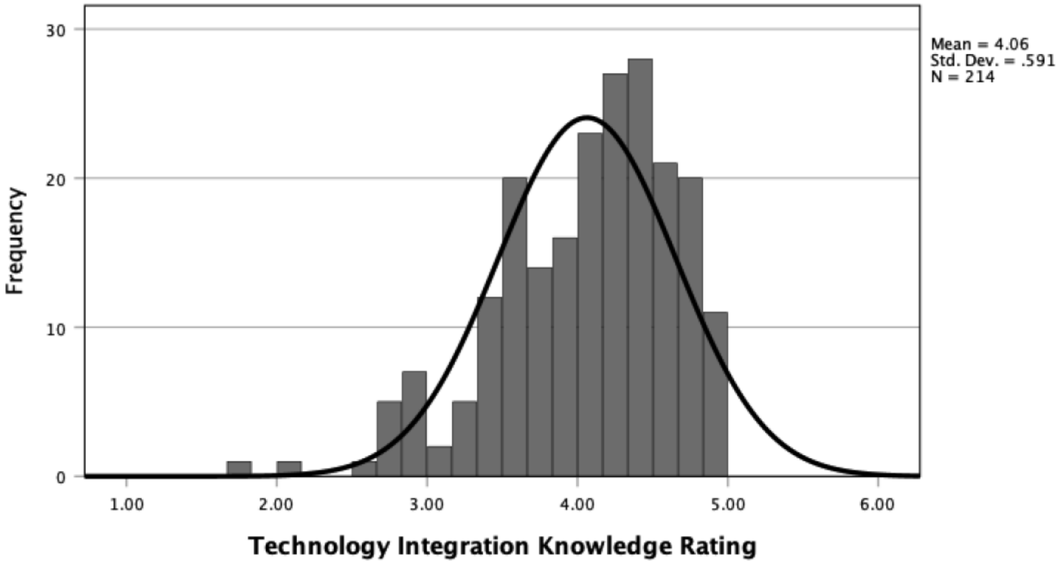
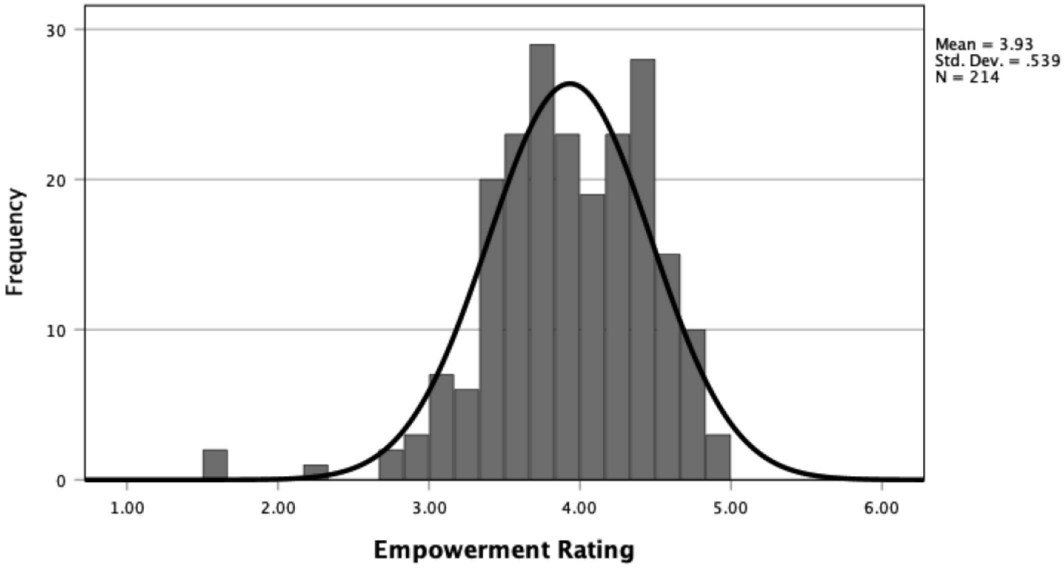


Figure 4.7

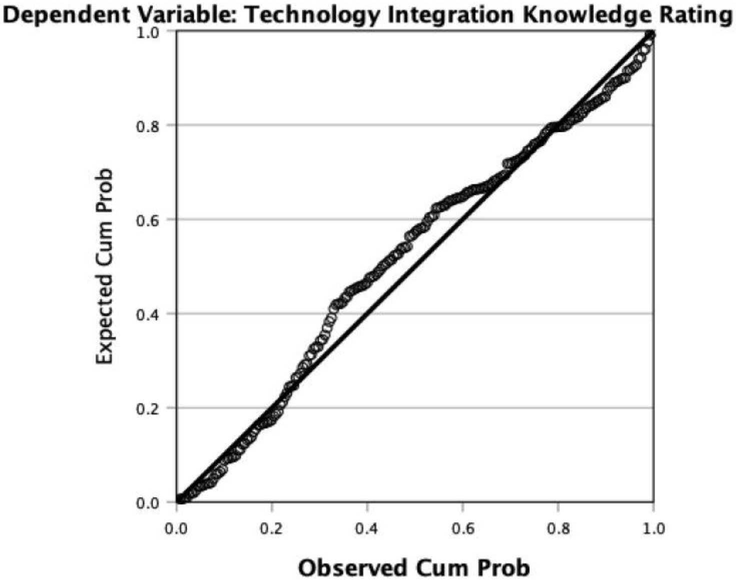
Histogram of Empowerment Ratings



The Predicted Probability (P-P) plot in Figure 4.8 also shows that the residuals are normally distributed.

Figure 4.8

Normal P-P Plot of Regression Standardized Residual



The next assumption for regression analysis in no multicollinearity. Multicollinearity is the correlation between predictor variables. This type of correlation can cause trouble in regression analysis when there are multiple predictor values. If the predictor variables are highly correlated, it can be difficult to determine the effect of each variable on the outcome variable (Bhandari, 2023). The Variance Inflation Factor (VIF) is an indicator that detects multicollinearity. Table 4.3 contains the VIF values for the domains in the empowerment scale. A VIF value of 1.0 reflects no correlation and greater than 5.0 indicates a high correlation (Bhandari, 2023). All values are less than five, so there is no multicollinearity, and this assumption is met.

Table 4.3

Coefficients

		Collinearity Statistics	
Model		Tolerance	VIF
1	Decision Making	.672	1.488
	Professional Growth	.622	1.609
	Status	.540	1.853
	Self-Efficacy	.428	2.338
	Autonomy	.769	1.300
	Impact	.392	2.551

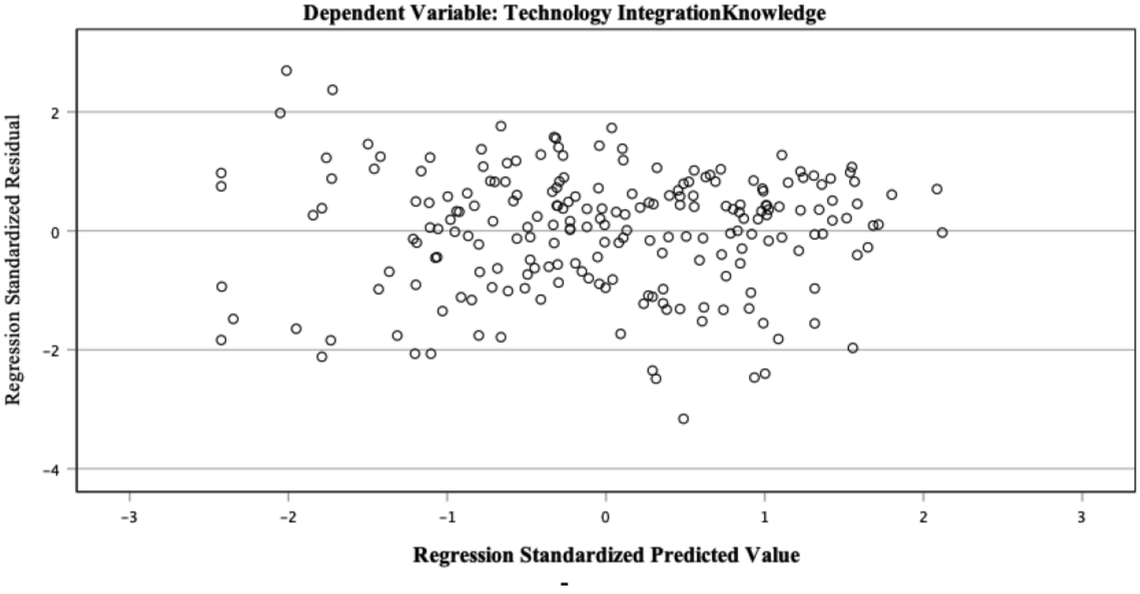
[a.] Dependent Variable: Technology Integration Knowledge Rating

Linear regression also relies on the assumption that there is no auto-correlation. This type of correlation is a concern with time series variables (Taylor, 2023). This study did not collect data on the same variables at different time intervals. Therefore, auto-correlation in not a concern for this study and this assumption is also met.

Additionally, a check for homoscedasticity (similar variance in the variables) yields the scatterplot of the residuals in Figure 4.9. The points on the graph are fairly equally distributed around zero on both the X and Y axes. This assumption is also met.

Figure 4.9

Scatterplot of the Standardized Residuals

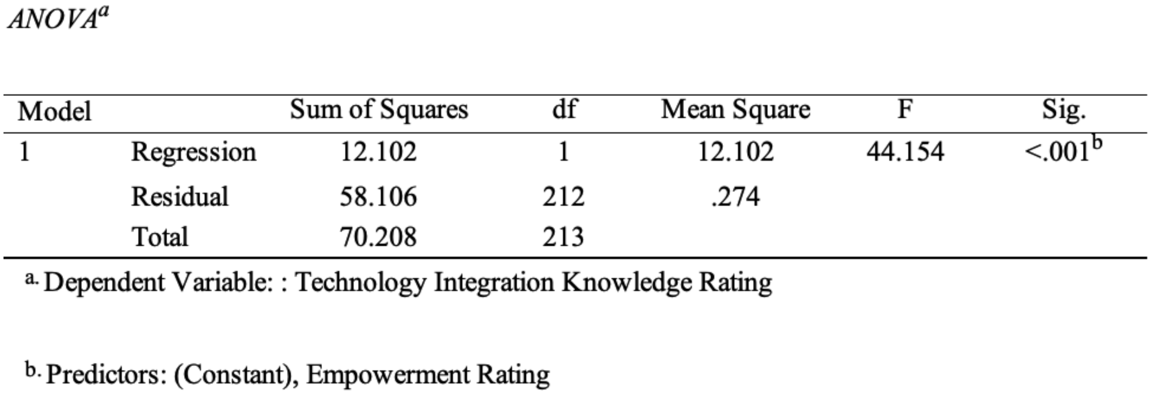


Regression Analysis

A linear regression was conducted to examine how well empowerment could predict technology integration knowledge. The scatter plot in Figure 4.5 (in the descriptive results) shows a positive relationship between empowerment and technology integration knowledge. The F value in the ANOVA table (Table 4.4) is statistically significant (< .001). This finding indicates that empowerment is a better predictor of technology integration knowledge than simply using the technology integration knowledge rating mean. A statistically significant relationship exists between the predictor (empowerment rating) and the outcome variable (technology integration knowledge).

Table 4.4

ANOVA Table



ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.102	1	12.102	44.154	<.001[b]
	Residual	58.106	212	.274		
	Total	70.208	213			

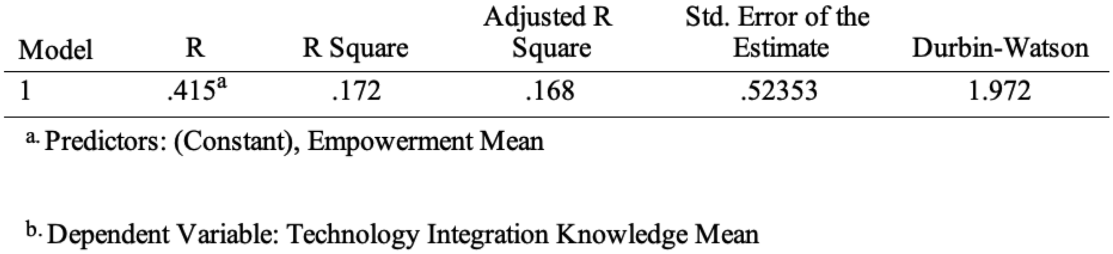
[a] Dependent Variable: : Technology Integration Knowledge Rating

[b] Predictors: (Constant), Empowerment Rating

R square is the coefficient of determination based on multiple predictor values. The R square (.172) in the model summary table (Table 4.5) indicates that the level of empowerment predicted 17.2% of the variance in technology integration knowledge.

Table 4.5

Regression Model Summary



Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.415[a]	.172	.168	.52353	1.972

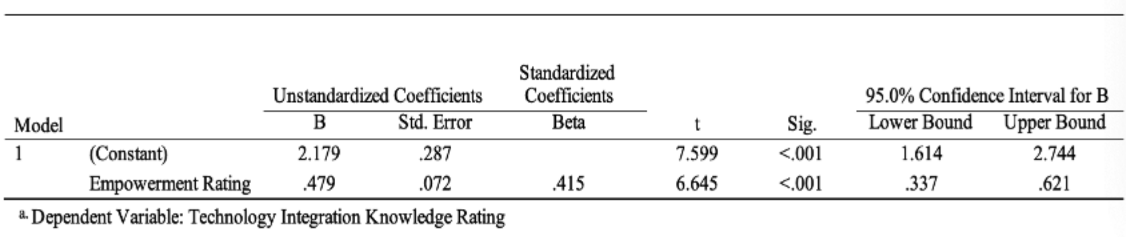
[a] Predictors: (Constant), Empowerment Mean

[b] Dependent Variable: Technology Integration Knowledge Mean

The coefficients of the regression model are found in Table 4.6. The findings indicate that for every one unit increase in empowerment rating, there is a 0.479 unit increase in technology integration knowledge rating. The correlation between empowerment and technology integration knowledge is significant $r(212) = .41$, $p < .001$. The regression equation for predicting the technology integration knowledge is $\hat{y} = 2.18 + 0.48x$. We can be 95% confident that the true slope of the relationship between empowerment and technology integration knowledge is between. .337 and .621. The r^2 for this equation is .172 meaning that 17.2% of the variance in technology integration knowledge is predictable from the level of empowerment.

Table 4.6

Regression Model Coefficients



		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
Model		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	2.179	.287		7.599	<.001	1.614	2.744
	Empowerment Rating	.479	.072	.415	6.645	<.001	.337	.621

a. Dependent Variable: Technology Integration Knowledge Rating

Summary

This chapter presented the data collected and the results of the statistical analyses. The demographic items provided a small amount of information about the characteristics of the sample population. And the Likert-scale survey responses provided quantitative data to run statistical analysis. The correlational analysis indicates a moderate relationship between empowerment and technology integration knowledge for secondary science teachers. The strength of the relationship varies between the individual domains within the empowerment and technology integration knowledge ratings. However, all are positive, and even if the relationship is weak, a relationship does exist. These findings support rejecting the null hypothesis. Chapter 5 summarizes the study's findings, discussions, limitations, and recommendations for further study.

CHAPTER 5. DISCUSSION AND CONCLUSIONS

This chapter summarizes the study and its results and implications. First, this chapter provides an overview of the problem, the purpose statement, the research questions, the research design and methodology, and the results. Next, the chapter includes a discussion of major findings as related to the literature on empowerment and teacher technology integration knowledge. The discussion of the results includes the study's contribution to educational leadership and the limitations and generalizability of the results. Finally, the chapter provides recommendations for practice and future research.

Summary of the Study

Problem Overview

Information communication technologies (ICT) help students acquire 21st Century skills (Pascopella, 2008). In addition, using technology with traditional lessons can increase student learning (Thisgaard & Makransky, 2017). Schools have increased the number of devices and software available for use in schools. Yet, teachers still need to similarly increase their use of technology (UNESCO, 2023). While the literature indicates that some of the domains within empowerment can increase teachers' use of technology, it is unknown whether overall empowerment and technology integration knowledge are associated.

Purpose Statement

This quantitative, correlational study aimed to explore the relationship between empowerment and technology integration knowledge of secondary science teachers. This study also sought to investigate a relationship between the domains within empowerment and the domains within technology integration knowledge. The empowerment domains include *decision making*, *professional growth*, *status*, *self-efficacy*, *autonomy*, and *impact*. Likewise, the domains within technology integration knowledge include *planning*, *designing*, *ethics*, *implementing*, and *proficiency*.

Research Design

To extend the literature, this study used a correlational approach to investigate the relationship between empowerment and teacher technology integration knowledge. The study considered teacher perceptions of empowerment within the domains of *decision making, professional growth, self-efficacy, status, autonomy,* and *impact.* The factors considered within technology integration knowledge were *planning, designing, ethics, self-efficacy,* and *proficiency*. Investigating the relationship between these variables may help provide information and assist in understanding how empowering leadership may influence teachers' use of technology.

Research Questions

The following research questions guided this study:

1. What is the level of empowerment for secondary science teachers overall and in each domain area: decision-making, professional growth, status, self-efficacy, autonomy, and impact?
2. What is the level of technology integration knowledge for secondary science teachers overall and in each domain area: planning, design, implementation, ethics, and proficiency in technology integration?
3. What is the relationship between empowerment and technology integration knowledge for secondary science teachers?

Methodology

To conduct this correlational study, a survey instrument built from two previously used survey instruments collected the data. The first instrument was the ICT-TPACK-Science scale developed by Kadıoğlu-Akbulut et al. (2020) to measure the teachers' technology integration knowledge. The second instrument was Short and Rinehart's School Participant Empowerment Scale (1992) to rate the teachers' perceived empowerment. Both instruments consist of 5-point Likert-type scale questions.

A sample of the 285,000 United States high school science teachers comprised 5,000 randomly selected teachers from the Market Data Retrieval (MDR) database. These teachers received an email inviting them to take the survey through Qualtrics anonymously. The teachers had two weeks to complete the survey. Data cleaning removed responses from teachers who did not finish at least 75% of each domain within both samples or did not represent the intended sample population. Multiple imputations filled in the missing data values. A quantitative analysis of the data using SPSS software yielded descriptive statistics and Cronbach's alpha. Using empowerment as the predictor variable, SPSS determined Spearman's rank correlation coefficient giving the values needed to determine the relationship between empowerment and teacher technology integration knowledge.

Major Findings

Roughly 4% of the 5,000 invited teachers, or 214 teachers, participated in the research study. The mean empowerment rating was 3.93, along with the following domain means*: decision making,* 2.82*; professional growth*, 4.19; *status*, 4.57; *self-efficacy*, 4.50; *autonomy*, 3.29; and *impact*, 4.23. The mean technology integration knowledge rating was 4.06, with the following domain means: *planning*, 4.36; *designing*, 3.22; *implementing*, 4.32; *ethics*, 4.67; and *proficiency*, 3.75. The mean ratings of overall empowerment and overall technology integration knowledge correspond with the "Agree" on the Likert scale of 1-5. The Spearman's-rank correlation found that the correlation coefficient between overall empowerment and overall teacher technology integration knowledge was .41. This information and the scatterplot represent a moderate positive relationship between these two variables. The correlation coefficient between the domains of each scale ranges from .06 (weak) to .44 (moderate to strong). The weakest relationship is between *autonomy* and *ethics*. The strongest is between *impact* and *implementation*. Across the board, *autonomy* has the weakest association with all the domains within technology integration knowledge.

Discussion

Participant Demographics

The statistical analyses in this study did not include participant demographic information—the demographic survey items aid in confirming that the respondents are part of the intended population. Additionally, the data help determine whether the sample reflects the larger population. The Digest of Education Statistics 2022 report contains demographic statistics for the school year 2020–2021 (National Center for Education Statistics (NCES, 2022). Regarding gender, 64% of participants in this study are female, and the NECS report shows 54.3% of secondary high school teachers are female. Public school teachers made up 89.7 percent of the participants which aligns with the national average.

Participants in this study had slightly different years of teaching experience than the national average. The participating teachers comprised a higher percentage of teachers on the lower and upper ends of the experience range. This study had 13.6% of participants having less than three years of experience compared to the 6.5% national average. Participants with over 20 years of experience comprised 35% of the sample compared to the 27.7% national average. These higher numbers mean less representation of teachers in the middle years of experience.

The experience level of the teachers may have played a role in participant responses regarding technology use. Khlaif (2018) reports that a teacher's experience with ICT and prior experience with a tool can impact a teacher's decision to use technology. Having twice the national average of beginning teachers in this study may have affected the mean responses. Younger teachers may have needed more time to develop experiences with tools for teaching.

Secondary Science Teachers’ Empowerment Level

This study used a 5-point, Likert-type survey for teachers to rate their agreement with statements regarding their perception of empowerment. The responses ranged from "strongly disagree" to "strongly agree." The sample, as a whole, agreed with the statements in the empowerment scale (*M* = 3.93, *SD* = 0.54). This overall empowerment rating suggests that the sample population of teachers perceives they are empowered within their schools.

There is some variability in the mean ratings at the domain level. The lowest-rated items are in the *decision making* domain (*M* = 2.82, *SD* = 0.88), this corresponds to a mean response between "disagree" and "neither disagree nor agree" with their decision-making characteristics. The mean *autonomy* ratings (*M* = 3.29, *SD* = 0.96) are slightly higher but still comparatively low. *Impact* (*M* = 4.23, *SD* = 0.70), and *professional growth* (*M* = 4.19, *SD* = 0.80) were rated much higher. *Status* (*M* = 4.57, *SD* = 0.51) and *self-efficacy* (*M* = 4.50, *SD* = 0.60) were rated highest, starting to approach the "strongly agree" mean rating. The sample as a whole agreed with the statements reflecting empowerment (*M* = 3.93, *SD* = 0.54).

School principals greatly influence teacher perception of their work environment (Burkhouser, 2017), so much so that empowerment is a subject of much research surrounding educational reform (Marks & Lewis, 1997). According to this section's responses, teachers feel empowered in *professional growth*, *status*, *self-efficacy,* and *impact*. The mean in these domains is 4.19 or greater, suggesting that the teachers feel empowered.

On the other hand, teachers are perceiving less empowerment in the areas of *decision making* and *autonomy*. According to the empowerment frame, these areas allow teachers to make decisions at the school level or in their classrooms (Short, 1992). One item, in particular, stands out with a low rating: the mean response (*M* = 1.87) indicates that teachers disagreed with the statement: "I can determine my own schedule." Teachers also rated another item relatively low. The statement associated with this item was "I have control over daily schedules." (*M* = 2.29). Having the ability to make decisions in the classroom is essential to teachers (Conley, 1991). Most teachers surveyed, appear not to be empowered to control their schedules. A teacher's sense of autonomy can promote organizational commitment (Lee & Nie, 2014).

Secondary Science Teachers' Technology Integration Level

The sample, as a whole, had a mean rating that suggests agreement with the statements surrounding technology integration knowledge (*M* = 4.06, *SD* = 0.59). This overall technology integration knowledge rating reflects that the sample population of teachers perceives they are generally comfortable with educational technologies. As with the empowerment scale questions, there is some variability in mean ratings at the domain level.

The lowest-rated items in this scale were in the *designing* (*M* = 3.22, *SD* = 0.93) and, to some degree, the *proficiency* domains (*M* = 3.75, *SD* = 0.98). They both were leaning towards a general agreement with the statements. Mean *planning* (*M* = 4.36, *SD* = 0.67) and *implementing* (*M* = 4.32, *SD* = 0.65) ratings are roughly the same, with a higher agreement with the statements in those two domains. On average, teachers had the highest agreement with statements in the *ethics* domain (*M* = 4.67, *SD* = 0.55). These means indicate that, on average, the teachers strongly agreed with the statements in the *ethics* domain.

These findings indicate that the teachers feel relatively confident about their abilities in the areas of *planning*, *implementing*, and *ethics*. They feel their abilities are lower in the *designing* and *proficiency* areas. The items in the *designing* domain address the three knowledges in TPACK. Technology knowledge in knowing how to create or update technology. Teachers show pedagogy and content knowledge in selecting science and technology that aligns with student characteristics. Much of the literature discusses research on using existing materials like simulations but not necessarily designing or changing them. Teachers need relevant tools that align with the instructional goals (Hutchison & Woodward, 2018). Not all technology fits every classroom perfectly. So being able to design and modify tools is essential.

The other area teachers rated slightly lower was *proficiency*. The items in the *proficiency* domain also address the three knowledges in TPACK. Knowing how to troubleshoot in the science teaching process and guiding and collaborating with colleagues in technology use for teaching. Working with slow or faulty technology is a barrier to use in the classroom (Kopcha, 2012). Teachers are likely to use different teaching strategies when technology does not work (Williams et al., 2017). School technology leaders and peer collaboration can help teachers overcome attitudes against technology (Ertmer, 2005). Jones and Dexter (2014) highlight that leaders can help to promote collaboration through professional learning communities. These communities provide an informal learning environment where teachers knowledgeable in technology can model its use to their colleagues (Jones & Dexter, 2014). Barton and Dexter (2019) not that informal learning and guidance from their colleges in their content area, help teachers more with technology integration than professional development run by school leaders.

Relationship between Empowerment and Technology Integration Knowledge

The correlation analysis found positive relationships between most domains of empowerment and technology integration knowledge, although the strength of these relationships varied. The weakest correlations were found between autonomy and the technology integration domains. This finding implies there may be little association between these variables. The strongest relationship was between *impact* and the *implementing* domain (r = .44). Possibly, teachers who are confident in their abilities to use technologies also feel stronger that they are making an impact.

The mean professional growth rating was comparatively higher, although its correlation with technology integration knowledge was weaker than anticipated based on some prior studies. Further research is needed to understand the relationship between specific forms of professional development and technology integration capacity. Their type of professional development may be unrelated to technology use or not designed effectively. Teachers improve their use of technology in smaller settings and when the development links to their content (Jones & Dexter, 2014). The *designing* domain had a lower overall mean as well as a lower strength correlation, so empowerment does not have much association with this level. The items in the *designing* domain assess the teachers' knowledge surrounding creating or updating existing technology. Current literature focuses on helping teachers design student-centered lessons (Shaffer et al., 2015) and helping teachers become more confident with using technology (Williams et al., 2017). While this is valuable, and it does not address components of the *designing* domain (creating and updating). Durff and Carter (2019) also discuss overcoming attitudinal barriers where teachers do not see the value of using technology. Teachers with the knowledge to create or update the technology may find it more useful.

Contribution to the Field

The findings in this study contribute to the field by filling a gap in the literature. Studies report on the significance of technology use in science classrooms and its ability to improve student understanding and achievement. Likewise, studies have focused on how to improve teacher technology integration knowledge. However, research into the association between empowerment and teacher technology integration knowledge had yet to be done. The information gained from this study may benefit school leaders in supplying another view on factors concerning technology integration.

Finally, most previous research on technology use in schools was published or in process before the pandemic. Many teachers used technology to help students learn remotely during that time. This experience likely impacted teachers' technology integration knowledge. The findings of this study may assist those researching technology integration knowledge.

Limitations

This study has several limitations due to methodology, data collection, and sampling. The first limitation is the inability to determine causation. This study determined a relationship between empowerment and teacher technology integration knowledge. However, it was a correlational study that did not determine or suggest causation. It is unknown if working to increase empowerment will result in increased technology integration knowledge. Therefore, even though there is an association between empowerment and technology integration knowledge, one cannot say that higher levels of empowerment cause teachers' technology integration knowledge to increase.

Another limitation is the possibility that the data may be subject to respondent bias. Despite having a sufficient sample size to meet the requirements for the correlation and regression analyses, the response rate to the survey was low. The study received 214 completed responses from the 5,000 teachers contacted via email invitation. This raises concerns about non-response bias. This type of bias results when some members of the population are systematically omitted from the sample, at which point the sample can no longer be considered random (Berg, 2005). Teachers who did not respond to the survey may have had characteristics that differ from those who did respond. Resulting in the sample population not being completely representative of the larger population.

The survey format itself may have led to bias in participant responses. Previous questions may have influenced teachers' responses to later questions. Additionally, the Likert-type survey in this study relied on teachers to self-report their perceptions on empowerment and their technology integration knowledge. When participants use a Likert-type scale, each respondent may rate their opinions slightly differently. For example, if participants slightly agree with a statement, one may mark “neither disagree nor agree,” whereas another may mark “agree.” In addition, it is impossible to verify participants’ responses on an anonymous survey.

Social desirability bias may have been another type of respondent bias in this study. With this type of bias, respondents’ answers may reflect their concern with how they present themselves. They may underreport, or answer more negatively, to socially undesirable topics and over-report, or respond more positively to, socially desirable topics (Krumpal, 2013). In terms of this study, Teachers may have overreported empowerment. Also, teachers may have wanted to appear more knowledgeable in technology integration instead of reporting the were incapable or unknowledgeable. Further, the teacher may wish to appear positive or respond favorably to align with the study’s goals.

Additionally, the sampling strategy was not entirely random. While MDR's database is extensive, it does not include the email addresses of every secondary science teacher in the United States. For example, addresses are not available for school systems that do not allow emails from outside their system's network. Additionally, teachers could choose whether or not to respond. The response rate was low, and those teachers willing to participate may have had similar characteristics.

In addition to data possibly being impacted by the previously named types of bias, the analyses may be impacted by missing data. Multiple imputation helped estimate the missing values. It should be remembered that imputation is an estimation of what the participant may have responded to, but it is unknown what their actual response may have been. Furthermore, the data on the level of empowerment enabled comparison between subscales and the overall scale. However, there is difficulty in comparing the means in this study to the means obtained in other studies. The populations between studies are different. Therefore, it is not possible to say that the mean empowerment level is high or low compared to that of another study. Likewise, is the case for data on technology integration knowledge. This difficulty impacts the generalizability of the findings on the empowerment level and the technology integration knowledge for the sample in this study.

Additionally, the survey instrument could use some improvements. A review of the responses regarding years of experience revealed a potential problem with the wording of the fixed response options available in the survey. The question asked, “Including this year, how many years have you been teaching?” Less than 1 year was an option, but if the teacher was currently teaching, the lower end of the available options should have been “1”. Only one participant selected “Less than 1 year” as a response. Further, one teacher was confused about the order of the responses. Making the order more apparent at the beginning may prevent confusion. Also, rewording for clarity in the ICT-TPACK-Science scale would be helpful. Another teacher reported a general concern about too much technical jargon and a vague *planning* question: “I can select the ones that are compatible with each other by evaluating the instructional principles, methods, and technologies appropriate to the characteristics of the science subjects.” The word “ones” is referring to the technologies listed in the previous question.

Generalizability

The generalizability of the results is limited because of sampling concerns and a low response rate. As mentioned in the limitations section, the low response rate of 4% may be an indicator of non-response bias. This type of bias may prevent the sample from being considered a random sample. This limitation reduces the generalizability of the data collected in this study. It is possible that the teachers who chose to complete the survey were not entirely representative of the population of secondary science teachers. Attempting to generalize the findings from the sample's responses to a larger population could lead to incorrect conclusions.

Little demographic information was collected from the teachers. From the information that was collected, the ratios of the types of school where the teachers worked were comparable to the national average. However, there was an underrepresentation of males and teachers in their middle years of teaching, which may further limit the generalizability of the findings. More information on the school could provide a more detailed picture of the teachers and the schools where they work. For these reasons, it may be difficult to generalize the findings of this study. Additionally, all schools vary slightly, and leaders must consider the school atmosphere before generalizing the study's findings.

Implications

Recommendations for Practice

This study surveyed teachers and compiled data to determine the mean ratings of teachers in the areas of empowerment and technology integration knowledge. The means suggest that these teachers feel empowered (*M* = 3.93) and have a reasonable level of integrating technology knowledge (*M* = 4.06). Nonetheless, there is room for improvement. The empowerment area rated lowest was *decision making* (*M* = 2.82). While a causal relationship has not been established, leaders may have more impact by focusing on this lower-rated area of empowerment, since it provides the greatest opportunity for improvement. According to Short (1992), the *decision making* domain involves making decisions that impact the teachers' workplace at the school level. Sebring et al. (2006) suggest allowing faculty to contribute to a shared vision as a way for teachers to influence school policy. Leithwood (2017) and Murphy et al. (2006) present shared leadership as conditions where leaders purposefully share leadership roles and provide decision-making opportunities. This leadership can take the form of mentoring and involvement in professional communities. Leaders may be unable to allow teachers to create their schedules; nonetheless, there may be ways to help teachers feel more involved in the decision. Since additional duties, such as committee participation, can increase decision-making involvement (Murphy et al., 2006), a leader could enlist a committee to help determine schedules. This route may be an alternative that gives teachers a voice in scheduling decisions.

The mean ratings indicate that the teachers in this sample had higher ratings in the *implementing* domain (*M*=4.32) than in the *designing* domain (*M*=3.22). The ICT-TPACK-Science scale distinguishes between knowledge of using existing technologies in the *implementing* domain and that of designing and creating new technologies and part of the *designing* domain. Teachers may feel more competent implementing available tools than creating original tech tools and content. This aligns with the distinction between technological pedagogical knowledge (knowing how to use tech tools for teaching) and technology content knowledge (repurposing tech for content), which could involve a need for a higher level of technology knowledge.

Leaders should target professional development to support the designing and *proficiency* domains. The lower ratings for *designing* domain (*M* = 3.22) within technology integration knowledge suggest teachers may need more development of their knowledge in Technological Content Knowledge (TCK). TCK focuses on understanding how technology can change and enhance the representation of concepts within a content area. However, TPACK is a collective knowledge and focusing on just part (such as TCK) might not necessarily lead to higher technology integration knowledge (TPACK). Therefore, professional development would also need to involve practice in using teaching strategies along with TCK. Leaders could offer professional development opportunities that provide content-specific practice in designing or adapting digital simulations, animations, or other technologies that align with the science concepts they teach since this type of professional development is most effective in supporting the increased use of technology (Jones & Dexter, 2014).

Proficiency is another area that leaders could consider improving through professional development. However, this area may benefit more from informal professional development such as collaborating with peers, since teachers are learning from each other. This type of learning aligns with building self-efficacy through experience and collaboration (Abbitt, 2011a). *Proficiency* ratings, may increase when teachers work together in groups, such as professional learning communities or interdisciplinary groups (Durff & Carter, 2019; Ertmer, 2005; Kadıoğlu-Akbulut et al., 2020). Two statements in the ICT-TPACK-science scale involve interdisciplinary work "Participate in the process of developing technology-supported interdisciplinary teaching by collaborating with colleagues in different fields (mathematics, information technologies, etc." and "Make interdisciplinary collaboration in using advanced level technologies to enrich the teaching process of science." Some science topics involve math calculations, especially in chemistry and physics. Still others involve social or political associations such as environmental science. If science teachers collaborated with teachers in these other content areas, they would likely rate their agreement with questions differently.

This study reveals a relationship between empowerment and technology integration knowledge. While the study does not establish causation, it does show that more empowered teachers also have higher technology integration knowledge. The association between empowerment and technology integration is moderate (r = .41), yet a relationship does exist. This information may provide preliminary support for leaders to explore empowerment-focused strategies that research has shown also improve technology integration knowledge. Professional learning communities are a means of improving both empowerment and technology integration knowledge. Murphy et al. (2006) describe the communities as a means of informal leadership, allowing teachers to play a role in professional development and curriculum decisions. These collaborative meetings provide a place for teachers to build relationships, share ideas on technology and improve technology integration (Hutchison & Woodward, 2018).

Professional development is vital in helping teachers use technology in the classroom (Kulaksiz & Karaca, 2023). Based on the findings of this study, the *designing* and *proficiency* domains had the lowest mean ratings. A professional development session might bolster these competencies. This session could align with multiple factors within the empowerment and TPACK framework. The following is a suggested professional development session that aligns with the domains of empowerment and TPACK. Leaders could consider surveying science teachers to identify an education technology they would like to use in their classroom that does not quite suit their needs. Conducting this survey will allow decision making by the teachers to aid in deciding the topic of professional development. After finding a suitable technology, locate a science teacher with experience designing or updating the technology tool identified from the survey willing to lead a science teacher professional development session. Allowing a teacher to lead the session will demonstrate their proficiency and enable other teachers to learn from the experience of updating a technology tool. A small group session focused on science teaching keeps the session content-specific and relevant. The experienced teacher can demonstrate the process; the other teachers can learn by watching, followed by group practice. This process provides a safe space for teachers to practice and build self-efficacy through the design process. The group can then collaborate on teaching strategies for incorporating this technology into a specific lesson. Finally, regular PLC meetings might promote continued collaboration, open discussion, and sharing of ideas on working with integrating technology.

Recommendations for Further Study

Future studies could expand upon the information gained in this study. First, this correlational study does not tell us if increasing empowerment (or its domains) will cause an increase in technology integration knowledge. Knowing whether empowerment or its individual domains cause an increase in technology integration may benefit school leaders wishing to improve technology-enhanced learning in their schools. To assess causality, another study should use an experimental design. A pretest– posttest design would help to determine a causal relationship. Using a pretest, the researcher could assess technology integration knowledge before altering leader empowering behavior. Then, use a posttest to determine if increasing empowerment increases teacher technology integration knowledge.

Second, the demographics information collected in this study indicated that the sample did not reflect the full secondary science teacher population. The sample included more female teachers than the national average and fewer teachers with middle years of teaching experience. A future study could utilize probability sampling to ensure that the sample reflects the gender and experience levels of the general population. This study looked broadly at secondary science teachers nationwide and did not focus on any particular demographic population. Researchers could further study the relationship between empowerment and technology integration knowledge in specific populations based on gender, type of school, or experience level.

Third, a qualitative study may gain better information about the reasoning behind some of the mean values found in this study and ways to make improvements. The *designing* domain had a particularly low mean. Research into improving this domain of technology integration knowledge could help school leaders know how to help teachers increase their knowledge in designing or editing existing ICT. A qualitative study could also probe deeper to identify why a stronger association exists between some variables and not others. For example, the empowerment domain of *professional growth* has a low association with all domains of technology integration knowledge in this study. However, research shows that professional growth is vital in developing technology integration knowledge (Kulaksiz & Karaca, 2023). Professional growth can occur at different levels or focus on various aspects of teaching. A qualitative study with interviews could help gain information on the teachers’ experience with professional growth. This type of study could help better understand this low association between this domain of empowerment and technology integration knowledge.

Finally, improvements should be made to the survey instrument to overcome the concerns noted in the limitations section. Wording in the demographics section should not include zero years of teaching experience since teachers should answer “1” if they are in their first year of teaching. Wording of questions in the TPACK scale should be revised to make them easier to read with more common, everyday language. Also, in order to avoid vagueness, as reported by a participant, questions should be able to be read as stand-alone questions and not follow off information provided in the previous question. Finally, technology is always changing. The survey questions should be updated to include current technologies; artificial intelligence (AI), for example.

Concluding Statement

In general, teachers feel empowered and have reasonable technology integration knowledge. The mean ratings indicate that teachers were agreeable with statements regarding both concepts. The areas that could use improvement are empowering teachers in decision making and autonomy. Leaders should also consider helping teachers increase their technical knowledge in designing and modifying technology to suit their needs. They should also create situations for teachers to share their knowledge.

A key finding of this study is that a relationship exists between empowerment and technology integration knowledge. Self-efficacy and professional growth are factors within empowerment that were previously considered as ways of increasing technology integration knowledge. However, using overall empowerment as a predictor for technology integration knowledge had yet to be considered. This study found that overall empowerment explains 17.2% of the variance in technology integration knowledge.

School leaders should consider what that means in the context of their own schools. Professional learning communities can help teachers share ideas and learn about technology integration while at the same time building opportunities to be involved in decision-making. These collaborative communities may foster empowerment and technology integration knowledge and enhance the relationship between the two.

APPENDICES

APPENDIX A. SURVEY INVITAYIONS

Survey Invitation Cover Letter

Dear Secondary Science Teacher:

Researchers at the University of Kentucky invite you to participate in a survey about technology integration knowledge of secondary science teachers and teacher empowerment. You are part of a random sample of secondary science teachers chosen to complete a questionnaire about your experiences as a teacher. A goal is to help inform science education, and I am writing to ask for your help with this study.

Although you may not get personal benefit from taking part in this research study, your responses may help us understand more about situations surrounding teachers' use of technology. Some volunteers experience satisfaction from knowing they have contributed to research that may possibly benefit others in the future.

Upon completion of the survey, the first 500 participants who opt-in to the study may choose to be entered to win a $10 Amazon gift card which you may use towards classroom or personal needs. You have an approximate 1 in 50 chance of winning.

If you do not want to be in the study, there are no other choices except not to take part in the study.

The survey will take about 15 minutes to complete.

There are no known risks to participating in this study.

Your response to the survey is anonymous which means no names, IP addresses, email addresses, or any other identifiable information will be collected with the survey responses. We will not know which responses are yours if you choose to participate.

We hope to receive completed surveys from about 384 people, so your answers are important to us. Of course, you have a choice about whether or not to complete the survey, but if you do participate, you are free to skip any questions or discontinue at any time. You will not be penalized in any way for not participating, skipping or discontinuing the survey. If you are one of the first 500 participants, you will still be eligible to enter the gift card drawing.

Please be aware, while we make every effort to safeguard your data once received from the online survey company, given the nature of online surveys, as with anything involving the Internet, we can never guarantee the confidentiality of the data while still on the survey company's servers, or while en route to either them or us. It is also possible the raw data collected for research purposes will be used for marketing or reporting purposes by the survey/data gathering company after the research is concluded, depending on the company's Terms of Service and Privacy policies. Survey responses will be stored and may be used for up to two years by the researcher in future studies. The researcher collects no identifying information, so no risks are associated with further use.

If you have questions about the study, please feel free to ask; my contact information is given below.

Thank you in advance for your assistance with this important project. To ensure your responses/opinions will be included, please submit your completed survey by May 17, 2023.

Sincerely,

Jane Walsh

Educational Leadership Studies, University of Kentucky

PHONE: 704-756-4453

E-MAIL: jewa230@uky.edu

Faculty advisor: Dr. Maria Cahill; Email: Maria.Cahill@uky.edu

If you have complaints, suggestions, or questions about your rights as a research volunteer, contact the staff in the University of Kentucky Office of Research Integrity at 859-257-9428 or toll-free at 1-866-400-9428.

Survey Invitation First Reminder

Dear Secondary Science Teacher:

Earlier this week I sent an email to you asking for your participation in the technology integration knowledge and empowerment survey. If you have already completed this survey, thank you. If you still need to, I hope that providing you with a link to the survey website makes it easy for you to respond.

To complete the survey, click on this link:

Survey Link

Your participation in this survey can provide valuable information for this study. As before, your response is voluntary, and I appreciate your consideration.

In case you need it, a copy of my first invitation is at the bottom of this email.

Sincerely,

Jane Walsh

Educational Leadership Studies, University of Kentucky

PHONE: 704-756-4453

E-MAIL: jewa230@uky.edu

Faculty advisor: Dr. Maria Cahill; Email: Maria.Cahill@uky.edu

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Survey Invitation Second Reminder

Dear Secondary Science Teacher:

Recently I sent you an email asking you to complete a survey about science teachers' technology integration knowledge and empowerment. Thank you if you have already completed the survey. I sincerely appreciate your help.

If you still need to answer the questionnaire, I encourage you to take some time to complete it. The survey should only take about fifteen minutes to complete. You may also choose to be entered into the drawing for a $10 Amazon gift card. Click on the link below to be taken to the survey:

Survey Link

I am very interested in collecting your responses and the information that they contribute to this research project.

In case you need it, a copy of my first invitation is at the bottom of this email.

Sincerely,

Jane Walsh

Educational Leadership Studies, University of Kentucky

PHONE: 704-756-4453

E-MAIL: jewa230@uky.edu

Faculty advisor: Dr. Maria Cahill; Email: Maria.Cahill@uky.edu

If you have complaints, suggestions, or questions about your rights as a research volunteer, contact the staff in the University of Kentucky Office of Research Integrity at 859-257-9428 or toll-free at 1-866-400-9428.

Survey Invitation Third Reminder

Dear Secondary Science Teacher:.

A couple of weeks ago, I contacted you asking for your help with the survey on science teachers' technology integration knowledge and empowerment. **Today is the last day the survey will be available and the last day to enter the gift card drawing.** I am writing again because your experience can provide valuable information, and I depend on science teachers like you to complete this survey.

To fill out the questionnaire, click on the link below:

Survey Link

Again, the survey window closes today. So please consider participating. As before, all responses are voluntary. If you need it, a copy of my first invitation is at the bottom of this email.

Thank you for considering my request.

Sincerely,

Jane Walsh

Educational Leadership Studies, University of Kentucky

PHONE: 704-756-4453

E-MAIL: jewa230@uky.edu

Faculty advisor: Dr. Maria Cahill; Email: Maria.Cahill@uky.edu

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APPENDIX B. SURVEY INSTRUMENT

Survey Instrument for Collecting Data on Relationship between TPACK and Empowerment

Initial screening question:

“Are you a secondary teacher certified to teach science and primarily teaching in that subject area?” Yes or no.

A “Yes” response continued the survey and a “No” response terminated the survey.

Survey Questions:

Respondents did not see the subscale headings. They are included here to identify questions for each subscale for analysis purposes. There was a page break after each subscale and subscales with eight or more questions were split across two pages.

Participants chose from the following responses on questions 1-76:

1=strongly disagree, 2=disagree, 3 = neither disagree nor agree, 4 = agree, and 5 = strongly agree

ICT-TPACK-Science Scale

Planning Subscale

Please rate your level of agreement with each of the following statements.

1. I can determine appropriate instructional technologies and pedagogical approaches by evaluating student characteristics, duration, content, and attainment in the science teaching process.
2. I can determine appropriate instructional technologies and pedagogical approaches by taking into consideration student readiness, learning environment, content and technological infrastructure before the science teaching process.

3. I can plan the science teaching process in accordance with the existing technological possibilities (hardware and software).
4. In order to increase the quality of teaching science, I can analyze the needs of instructional technologies.

Please rate your level of agreement with each of the following statements.

I can ...

5. Use time effectively in the science teaching process where information technologies (educational software, virtual laboratory, etc.) are used.
6. Select the ones that are compatible with each other by evaluating the instructional principles, methods, and technologies appropriate to the characteristics of the science subjects.
7. Arrange the environment in which the science teaching process will be carried out in accordance with the use of technology.
8. Use technology to design a material I need for an effective science teaching process that is in accordance with student characteristics, duration, content, and attainment.

Designing Subscale

Please rate your level of agreement with each of the following statements.

In the process of science teaching, I can ...

9. Create/update an instructional video using technologies such as Movie maker, EdPuzzle etc. in accordance with the student characteristics, duration, content, and attainment.

10. Create/update visual materials using technologies such as MindMeister, Piktochart, Thinglink, Pixton etc. in accordance with the student characteristics, duration, content, and attainment.
11. Create/update an animation using technologies such as Powtoon, Animoto etc. in accordance with the student characteristics, duration, content, and attainment.
12. Create/update a simulation using technologies such as Algodoo, PhET, SAS, etc. in accordance with the student characteristics, duration, content, and attainment.
13. Create/update an instructional material using augmented reality technologies such as Blippar, Zappar, etc. in accordance with the student characteristics, duration, content, and attainment.
14. Create/update online assessment evaluation activities using technologies such as Socrative, Kahoot etc. in accordance with the student characteristics, duration, content, and attainment.

Implementing Subscale

Please rate your level of agreement with each of the following statements.

I can ...

15. Implement classroom management when using various technological devices (interactive board, tablet etc.) in the process of science teaching.
16. Implement classroom management when using digital teaching materials (simulation, animation, etc.) in the science teaching process.

17. Apply the instructional principles and methods appropriate to the subject content in the science teaching process with the help of technology.
18. Apply instructional approaches and methods appropriate to individual differences in science teaching with the help of technology.
19. Carry out assessment and evaluation studies on the subjects of science by using appropriate technologies.
20. Use technology to assess performance (homework, projects, etc.) in science subjects.
21. Benefit from technology supported communication environments (blog, forum, chat, e-mail, etc.) in the process of teaching science.
22. Use learning management systems (Canvas, Moodle, Edmodo, etc.) in the science teaching process.

Please rate your level of agreement with each of the following statements.

23. In the process of science teaching, I can guide students in the process of designing technology-based products (presentation, games, films, etc.) or activities (homework, projects, etc.).
24. I can use technology to update my knowledge of science.
25. I can follow recent technologies used in the science teaching process.
26. I can use technology to keep an update of knowledge on the science teaching process.

Ethics Subscale

Please rate your level of agreement with each of the following statements.

27. I can behave ethically in access to technology in educational environments for science.
28. I can follow the ethical rules in acquiring and using private information (audio recording, video recording, document etc.) which will be used in teaching science via technology.
29. I can adhere to the rights of intellectual property (royalties, licenses, etc.) when using technology at every stage of the science teaching process.
30. In technology-based science teaching environments (Canvas, Google Classroom, Edmodo, Moodle etc.), I can adhere to the ethics of the teaching profession at every stage of the process.
31. I can behave ethically regarding appropriate use of technology in the science teaching process.
32. In the process of science teaching, I can guide students to valid and reliable technological resources and guide them to reach the right information.

Proficiency Subscale

Please rate your level of agreement with each of the following statements.

I can ...

33. Troubleshoot the problems (hardware, software, etc.) that could be encountered when using technology in any phase of the science teaching process.
34. Produce alternative solutions by taking advantage of appropriate technologies for the problems encountered in science subjects

(misconception, micro-macro notation, three-dimensional representation, connection with daily life etc.).

35. Lead to the widespread use of technological innovations specific to the subject area in the science teaching process.
36. Guide my colleagues in using technology to solve the problems encountered in the science teaching process.
37. Participate in the process of developing technology-supported interdisciplinary teaching by collaborating with colleagues in different fields (mathematics, information technologies, etc.).
38. Make interdisciplinary collaboration in using advanced level technologies to enrich the teaching process of science.

School Participant Empowerment Scale

Decision Making Subscale

Please rate your level of agreement with each of the following statements.

39. I am given the responsibility to monitor programs.
40. I make decisions about the implementation of new programs in the school.
41. I make decisions about the selection of other teachers for my school.
42. I am involved in school budget decisions.
43. I am given the opportunity to teach other teachers.
44. I can determine my own schedule.
45. Principals, other teachers, and school personnel solicit my advice.
46. I can plan my own schedule.
47. My advice is solicited by others.

48. I have an opportunity to teach other teachers about innovative ideas.

Professional Growth Subscale

Please rate your level of agreement with each of the following statements.

49. I function in a professional environment.
50. I am treated as a professional.
51. I have the opportunity for professional growth.
52. I work at a school where kids come first.
53. I am given the opportunity for continued learning.
54. I am given the opportunity to collaborate with other teachers in my school.

Status Subscale

Please rate your level of agreement with each of the following statements.

55. I believe that I have earned respect.
56. I believe that I am very effective.
57. I have the respect of my colleagues.
58. I have the support and respect of my colleagues.
59. I have a strong knowledge base in the areas in which I teach.
60. I believe that I am good at what I do.

Self-efficacy Subscale

Please rate your level of agreement with each of the following statements.

61. I believe that I am helping kids become independent learners.
62. I believe that I am empowering students.
63. I feel that I am involved in an important program for children.
64. I see students learn.

65. I believe that I have the opportunity to grow by working daily with students.

66. I perceive that I am making a difference.

Autonomy Subscale

Please rate your level of agreement with each of the following statements.

67. I have control over daily schedules.

68. I am able to teach as I chose.

69. I have the freedom to make decisions on that is taught.

70. I make decisions about curriculum.

Impact Subscale

Please rate your level of agreement with each of the following statements.

71. I believe that I have the ability to get things done.

72. I participate in staff development.

73. I believe that I am having an impact.

74. I am a decision maker.

75. I perceive that I have the opportunity to influence others.

76. I perceive that I have an impact on other teachers and students.

Demographic Questions

77. Including this year, how many years have you been teaching?

(drop down menu with choices spanning Less than 1 year to more than 30 years)

78. Indicate the primary subject area(s) in which you currently teach.

- English and Language Arts
- Mathematics

- Computer Science
- Natural or Physical Science
- Social Studies
- Fine Arts
- Other [open entry]

79. Do you hold a certification to teach this subject?

    - Yes, currently licensed in all primary subject area(s) in which I currently teach
    - Yes, currently licensed in one, but not all, primary subject area(s) in which I currently teach. List the subject area(s) with certification. [open entry]
    - Yes, provisional license
    - No, do not hold a certification in any primary subject area(s) in which I currently teach

80. What grade level(s) do you predominantly teach?

    - Pre-K
    - K-5
    - 6-8
    - 9-12
    - Higher Education

81. How would you describe your gender?

    - Male
    - Female

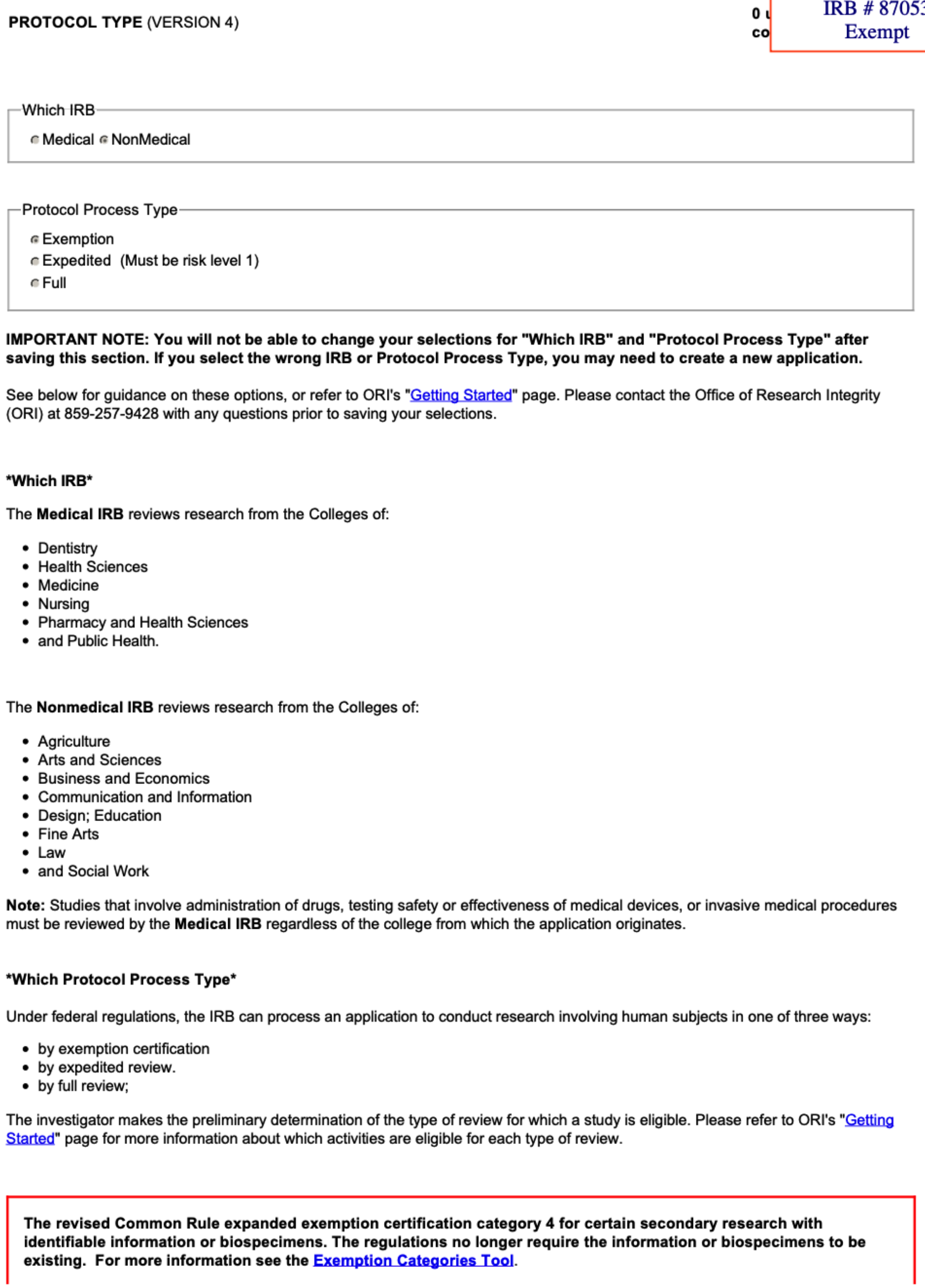
- Other[open entry]
- Prefer not to answer

82. Identify the type of school where you teach.

- Public
- Charter
- Catholic
- Other religious
- Private, not religiously affiliated

APPENDIX C. IRB APPROVAL

IRB Approval
5/2/2023
IRB # 87053
Exempt



PROTOCOL TYPE (VERSION 4)

0 u
co

Which IRB

○ Medical ● NonMedical

Protocol Process Type

● Exemption
○ Expedited (Must be risk level 1)
○ Full

IMPORTANT NOTE: You will not be able to change your selections for "Which IRB" and "Protocol Process Type" after saving this section. If you select the wrong IRB or Protocol Process Type, you may need to create a new application.

See below for guidance on these options, or refer to ORI's "Getting Started" page. Please contact the Office of Research Integrity (ORI) at 859-257-9428 with any questions prior to saving your selections.

Which IRB

The **Medical IRB** reviews research from the Colleges of:

- Dentistry
- Health Sciences
- Medicine
- Nursing
- Pharmacy and Health Sciences
- and Public Health.

The **Nonmedical IRB** reviews research from the Colleges of:

- Agriculture
- Arts and Sciences
- Business and Economics
- Communication and Information
- Design; Education
- Fine Arts
- Law
- and Social Work

Note: Studies that involve administration of drugs, testing safety or effectiveness of medical devices, or invasive medical procedures must be reviewed by the **Medical IRB** regardless of the college from which the application originates.

Which Protocol Process Type

Under federal regulations, the IRB can process an application to conduct research involving human subjects in one of three ways:

- by exemption certification
- by expedited review.
- by full review;

The investigator makes the preliminary determination of the type of review for which a study is eligible. Please refer to ORI's "Getting Started" page for more information about which activities are eligible for each type of review.

The revised Common Rule expanded exemption certification category 4 for certain secondary research with identifiable information or biospecimens. The regulations no longer require the information or biospecimens to be existing. For more information see the Exemption Categories Tool.

Section 1 Page 1 of 2

APPENDIX D. PARTICIPANT DEMOGRAPHICS

Appendix D contains additional tables from Chapter 4 Results. It provides more detailed information on frequencies from the demographic items. Collecting this information was not necessary for the study. However, the information it provides may help to understand the composition of the sample.

Table D. 1

Teaching Experience

Years of Teaching	N	Percent
Less than 1 Year -5	36	16.8
6-10	32	14.9
11-15	23	10.8
16-20	26	12.1
21-25	30	14.0
26-30	25	11.7
More than 30 years	20	9.3
No Response	22	10.3
Total	214	100

Note: Participant years of teaching experience is grouped in 5-year increments to make the table more readable. Figure 4.1 shows all responses.

Table D. 2

Primary Subject Area Taught

Subject Area	N	Percent
Natural or Physical Science	200	93.5
Natural or Physical Science, Mathematics	2	0.9
Natural or Physical Science, Computer Science	1	0.5
Natural or Physical Science, Computer Science, Mathematics, Other	1	0.5
Natural or Physical Science, Other	6	2.8
Other	3	1.4
No Response	1	0.5
Total	214	100

Note: All participants that listed “other”, named a science subject except one. However, that participant also taught a science subject.

Table D. 3

Participant Holds a Certification to Teach in Their Primary Subject

Holds Certification in Primary Subject	N	Percent
Yes, currently licensed in all primary subject area(s) in which I currently teach.	189	88.3
Yes, currently licensed in one, but not all, primary subject area(s) in which I currently teach. *	16	7.5
Yes, provisional license	2	0.9
No, do not hold a certification in any primary subject area in which I currently teach.	4	1.9
No Response	3	1.4
Total	214	100

Note: All participants that answered that they were licensed in one, but not all, of their teaching subjects indicated that they were certified to teach a science subject.

Table D. 4

Grade Level Predominantly Taught

Grade Level	N	Percent
6-8, 9-12	5	2.3
9-12	205	95.8
9-12, Higher Education	3	1.4
No Response	1	0.5
Total	214	100

Table D.5

Gender Identification

Reported Gender	N	Percent
Female	139	65.0
Male	69	32.2
Prefer Not to Answer	6	2.8
Total	214	100

Table D.6

School Type in Which Participant Teaches

School Type	N	Percent
Public	192	89.7
Charter	7	2.8
Catholic	10	4.7
Other Religious	1	0.5
Private, Not Religiously Affiliated	3	1.4
No Response	1	0.5
Total	214	100

APPENDIX E. FREQUENCY TABLES

Tables E.1 – E.11 are frequency tables for all questions within each domain. Each table represents a single domain and frequencies of all the responses for each question.

Table E.1

Mean Responses for Planning Questions of Technology Integration Knowledge

Planning Question	Mean
I can determine appropriate instructional technologies and pedagogical approaches by evaluating student characteristics, duration, content, and attainment in the science teaching process.	4.47
I can determine appropriate instructional technologies and pedagogical approaches by taking into consideration student readiness, learning environment, content and technological infrastructure before the science teaching process.	4.50
I can plan the science teaching process in accordance with the existing technological possibilities (hardware and software).	4.49
In order to increase the quality of teaching science, I can analyze the needs of instructional technologies.	4.26
I can use time effectively in the science teaching process where information technologies (educational software, virtual laboratory, etc.) are used.	4.30
I can select the ones that are compatible with each other by evaluating the instructional principles, methods, and technologies appropriate to the characteristics of the science subjects.	4.20
I can arrange the environment in which the science teaching process will be carried out in accordance with the use of technology.	4.34
I can use technology to design a material I need for an effective science teaching process that is in accordance with student characteristics, duration, content, and attainment.	4.33
Planning Domain	4.36

Note: Means represent pooled data following imputation.

Table E.2

Mean Responses for Designing Questions of Technology Integration Knowledge

Designing Question	Mean
I can create/update an instructional video using technologies such as Movie maker, EdPuzzle etc. in accordance with the student characteristics, duration, content, and attainment	3.96
I can create/update visual materials using technologies such as MindMeister, Piktochart, Thinglink, Pixton etc. in accordance with the student characteristics, duration, content, and attainment.	2.75
I can create/update an animation using technologies such as Powtoon, Animoto etc. in accordance with the student characteristics, duration, content, and attainment.	2.60
I can create/update a simulation using technologies such as Algodoo, PhET, SAS, etc. in accordance with the student characteristics, duration, content, and attainment.	3.50
I can create/update an instructional material using augmented reality technologies such as Blippar, Zappar, etc. in accordance with the student characteristics, duration, content, and attainment.	2.26
I can create/update online assessment evaluation activities using technologies such as Socrative, Kahoot etc. in accordance with the student characteristics, duration, content, and attainment.	4.24
Designing Domain	3.22

Note: Means represent pooled data following imputation.

Table E.3

Mean Responses for Implementing Questions of Technology Integration Knowledge

Implementing Question	Mean
I can implement classroom management when using various technological devices (interactive board, tablet etc.) in the process of science teaching.	4.27
I can implement classroom management when using digital teaching materials (simulation, animation, etc.) in the science teaching process.	4.36
I can apply the instructional principles and methods appropriate to the subject content in the science teaching process with the help of technology.	4.50
I can apply instructional approaches and methods appropriate to individual differences in science teaching with the help of technology.	4.37
I can carry out assessment and evaluation studies on the subjects of science by using appropriate technologies.	4.43
I can use technology to assess performance (homework, projects, etc.) in science subjects.	4.47
I can benefit from technology supported communication environments (blog, forum, chat, e-mail, etc.) in the process of teaching science.	4.33
I can use learning management systems (Canvas, Moodle, Edmodo, etc.) in the science teaching process.	4.18
In the process of science teaching, I can guide students in the process of designing technology-based products (presentation, games, films, etc.) or activities (homework, projects, etc.).	3.95
I can use technology to update my knowledge of science.	4.50
I can follow recent technologies used in the science teaching process.	4.20
I can use technology to keep an update of knowledge on the science teaching process.	4.28
Implementing Domain	4.32

Note: Means represent pooled data following imputation.

Table E.4

Mean Responses for Ethics Questions of Technology Integration Knowledge

Ethics Question	Mean
I can behave ethically in access to technology in educational environments for science.	4.71
I can follow the ethical rules in acquiring and using private information (audio recording, video recording, document etc.) which will be used in teaching science via technology.	4.69
I can adhere to the rights of intellectual property (royalties, licenses, etc.) when using technology at every stage of the science teaching process.	4.53
In technology-based science teaching environments (Canvas, Google Classroom, Edmodo, Moodle etc.), I can adhere to the ethics of the teaching profession at every stage of the process.	4.71
I can behave ethically regarding appropriate use of technology in the science teaching process.	4.79
In the process of science teaching, I can guide students to valid and reliable technological resources and guide them to reach the right information.	4.60
Ethics Domain	4.67

Note: Means represent pooled data following imputation.

Table E.5

Mean Responses for Proficiency Questions of Technology Integration Knowledge

Proficiency Question	Mean
I can troubleshoot the problems (hardware, software, etc.) that could be encountered when using technology in any phase of the science teaching process.	3.84
I can produce alternative solutions by taking advantage of appropriate technologies for the problems encountered in science subjects (misconception, micro-macro notation, three-dimensional representation, connection with daily life etc.).	3.94
I can lead to the widespread use of technological innovations specific to the subject area in the science teaching process.	3.71
I can guide my colleagues in using technology to solve the problems encountered in the science teaching process.	3.81
I can participate in the process of developing technology-supported interdisciplinary teaching by collaborating with colleagues in different fields (mathematics, information technologies, etc.).	3.58
I can make interdisciplinary collaboration in using advanced level technologies to enrich the teaching process of science.	3.59
Proficiency Domain	3.75

Note: Means represent pooled data following imputation.

Table E.6

Mean Responses for Decision Making Questions of Technology Integration Knowledge

Decision Making Question	Mean
I am given the responsibility to monitor programs.	3.33
I make decisions about the implementation of new programs in the school.	2.82
I make decisions about the selection of other teachers for my school.	2.30
I am involved in school budget decisions.	2.03
I am given the opportunity to teach other teachers.	3.29
I can determine my own schedule.	1.87
Principals, other teachers, and school personnel solicit my advice.	3.36
I can plan my own schedule.	2.12
My advice is solicited by others. I have an opportunity to teach other teachers about innovative ideas.	3.67
I have an opportunity to teach other teachers about innovative ideas.	3.35
Decision Making Domain	2.82

Note: Means represent pooled data following imputation.

Table E.7

Mean Responses for Professional Growth Questions of Technology Integration Knowledge

Professional Growth Question	Mean
I function in a professional environment.	4.45
I am treated as a professional.	4.12
I have the opportunity for professional growth.	4.17
I work at a school where kids come first.	4.18
I am given the opportunity for continued learning.	4.07
I am given the opportunity to collaborate with other teachers in my school.	4.15
Professional Growth Domain	4.19

Note: Means represent pooled data following imputation.

Table E.8

Mean Responses for Status Questions of Technology Integration Knowledge

Status Question	Mean
I believe that I have earned respect.	4.41
I believe that I am very effective.	4.53
I have the respect of my colleagues.	4.52
I have the support and respect of my colleagues.	4.46
I have a strong knowledge base in the areas in which I teach.	4.82
I believe that I am good at what I do.	4.71
Status Domain	4.57

Note: Means represent pooled data following imputation.

Table E.9

Mean Responses for Self-Efficacy Questions of Technology Integration Knowledge

Self-Efficacy Question	Mean
I believe that I am helping kids become independent learners.	4.44
I believe that I am empowering students.	4.46
I feel that I am involved in an important program for children.	4.50
I see students learn.	4.61
I believe that I have the opportunity to grow by working daily with students.	4.58
I perceive that I am making a difference.	4.39
Self-Efficacy Domain	4.50

Note: Means represent pooled data following imputation.

Table E.10

Mean Responses for Autonomy Questions of Technology Integration Knowledge

Autonomy Question	Mean
I have control over daily schedules.	2.29
I am able to teach as I chose.	3.73
I have the freedom to make decisions on that is taught.	3.59
I make decisions about curriculum	3.57
Autonomy Domain	3.29

Table E.11

Mean Responses for Impact Questions of Technology Integration Knowledge

Impact Question	Mean
I believe that I have the ability to get things done.	4.57
I participate in staff development.	4.31
I believe that I am having an impact.	4.30
I am a decision maker.	3.91
I perceive that I have the opportunity to influence others.	4.10
I perceive that I have an impact on other teachers and students.	4.19
Impact Domain	4.23

Note: Means represent pooled data following imputation.

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Professional Positions

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Professional Publications

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