THE RELATIONSHIP BETWEEN SECONDARY TEACHERS'

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE AND

TECHNOLOGY INTEGRATION FACTORS

by

Randal Cody Raper

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2018

THE RELATIONSHIP BETWEEN SECONDARY TEACHERS'

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE AND

TECHNOLOGY INTEGRATION FACTORS

by Randal Cody Raper

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University, Lynchburg, VA

2018

APPROVED BY:

Cristie McClendon, Ph.D., Committee Chair

Reginald Kimball, Ed.D., Committee Member

Mike Hayes, Ed.D., Committee Member

ABSTRACT

Research in educational technology has led to the discovery of factors for successful technology integration into the classroom—technology access and support, professional development, attitudes toward technology, technology use by students, and technology use by teachers. Additionally, using the Technological Pedagogical Content Knowledge (TPACK) theoretical framework, a teacher's understanding of the knowledge required to effectively implement technology can be measured. This study attempted to examine the relationship between teachers' TPACK score and the key indicators of technology integration using the TPACK survey and the Survey of Technology Integration and Related Factors (STIR). Using a nonexperimental, correlational design, participants were selected from a population of secondary teachers at two school systems in East Tennessee who use the learning management system (LMS) Blackboard. The total sample size was 129 participants. Data were analyzed using a canonical correlation to examine relationships. Results of the survey indicated that a statistically significant relationship exists between a teacher's TPACK score and the five factors of technology integration, with general technology usage by the teacher, teacher attitudes toward technology, and professional development having the largest effects. Further research should be conducted on differing populations, populations that do not use Blackboard LMS, and other integration variables. Furthermore, studies that include teaching experience as a covariate or longitudinal studies regarding TPACK and technology integration factors should be researched.

Keywords: technology, integration factors, TPACK, STIR, learning management system, Blackboard

Table of Contents

List of Tables

List of Figures

List of Abbreviations

Content Knowledge (CK)

Information Computer Technologies (ICT)

Learning Management System (LMS)

Pedagogical Content Knowledge (PCK)

Pedagogical Knowledge (PK)

Substitution Augmentation Modification Redefinition (SAMR)

Survey of Technology Integration and Related Factors (STIR)

Technological Content Knowledge (TCK)

Technological Knowledge (TK)

Technological Pedagogical Knowledge (TPK)

Technology Pedagogical Content Knowledge (TPACK)

CHAPTER ONE: INTRODUCTION

Overview

This study centered on the technological pedagogical content knowledge (TPACK) framework (Schmidt et al., 2009), which measures educators' knowledge of effectively teaching with technology. This study sought to determine if there is a relationship between TPACK and the actual usage of technology among secondary teachers in Southeast Tennessee. This chapter overviews the literature related to TPACK, the specific problem this study attempts to solve, the purpose of the study, the significance of the results, and the research questions that guided the whole process. Finally, this chapter concludes with operational definitions that will be important to understanding this paper.

Background

Schools have been allotted billions of dollars of taxpayer money over the last decade to spend on technology for classrooms (Miranda & Russell, 2012); however, the ineffective utilization of technology continues to be a problem plaguing education (Kopcha, 2012). Technology can impact student learning outcomes, and technology provides many opportunities for instruction and learning to exceed that which takes place in the traditional classroom (Munzur, 2013). Sadly, even if technology is utilized by teachers, it is almost always done in ways that support traditional forms of teaching (e.g., PowerPoint) as opposed to new methodologies for instruction that push learners to achieve more and learn more (Kurt, 2013).

The problems with educational technology utilization in the classroom are well established. Two decades ago, a U.S. Congress Office of Technology Assessment (1995) report indicated that teachers were often not utilizing technology resources available to them. Later, Graham and Semic (2006) noted widespread effective technology use was not present in most schools. Furthermore, robust utilization of technological resources was rare. School districts are

spending money on technologies that teachers are not utilizing. More recently, Kopcha (2012) noted that schools continue to underutilize technology resources in the classroom despite their prevalence.

In an early study involving transformative educational technologies, Venezky (2004) noted that information and computer technologies (ICT) can allow learners access to an ever-growing bank of information that allows students to achieve new levels of learning. The opportunities have continued to grow, and now Web 2.0 technologies (e.g., wikis, social networks, collaborative documents, interactive presentations) are available and accessible to teachers; however, they are often not utilized even though students frequently describe this type of learning as their preferred method of instruction (Rhoades, Friedel, & Irani, 2008). When teachers move away from technology that simply supports traditional methods of teaching and move to technology that supports new methods of learning and discovery, students' understanding of content, emotional engagement, and cognitive engagement can be enhanced (Krajcik & Varelas, 2007).

Kurt and Muhammed (2012) identified key barriers to teacher implementation of technology: lack of availability or access to working equipment, a lack of training and technological understanding of new technologies, and beliefs and attitudes of the teacher about technology use. The barriers to technology use are significant predictors of whether a teacher will choose to utilize technology in the future (Kopcha, 2012). Furthermore, when teachers utilize technology in the classroom, they often feel empowered to use it in the future. This can begin a pattern of using technology in instruction and can lead to deeper learning for students (Kopcha, 2010).

The theory on which this study is based is the technological pedagogical content knowledge (TPACK) framework. The model attempts to describe the type of knowledge

required by educators to effectively implement technology in learning environments. TPACK is based on the concept that effective teaching of technology is a combination of a teacher's technological knowledge, pedagogical knowledge, and content knowledge (Schmidt et al., 2009). The original theory TPACK is based on is the pedagogical content knowledge construct, which describes how pedagogical knowledge and content knowledge work together to enable effective instruction (Shulman, 1986). Mishra and Koehler (2006) added the technology component to this construct to form TPACK. In its current form, TPACK represents three primary types of knowledge—technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK)—while considering the relationships of these variables. This interrelation forms a teacher's technological pedagogical knowledge (TPK), technological content knowledge (TCK), and pedagogical content knowledge (PCK). The intersection of the three primary types of knowledge and relational knowledge of the framework represents a teacher's TPACK (Schmidt et al., 2009). The knowledge components of TPACK are detailed in Figure 1.
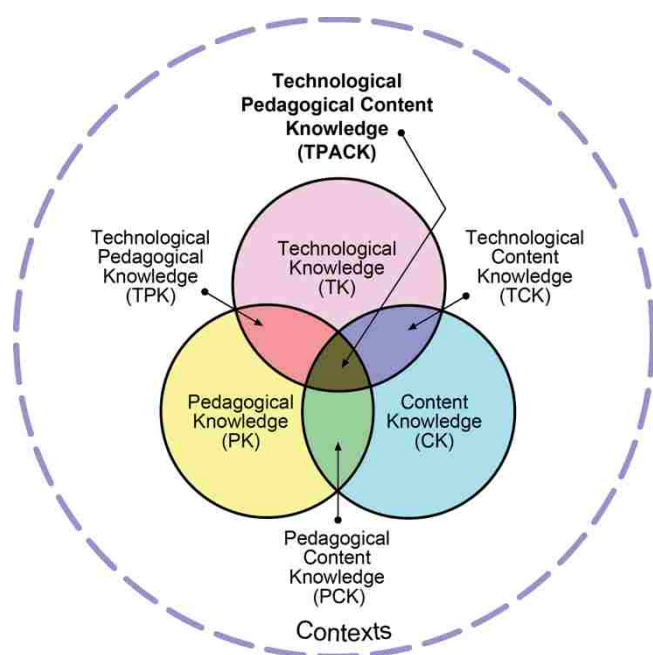
Figure 1. TPACK framework (Koehler, 2012). Reproduced with permission from http://www.tpack.org

Archambault and Crippen (2009) developed the TPACK survey to provide a metric for assessing a teacher's TPACK knowledge. The survey asks participants questions centered on the domains of TPACK that are responded to on a Likert scale (e.g., having teachers rate their ability to use technology aids to represent specific content online). Adding the scores together for each domain provides a subscore for each different component of TPACK. Higher TPACK survey scores represent having greater knowledge of how to teach with technology (Archambault & Crippen, 2009).

In summary, research has indicated that technology can offer avenues to learning that were not previously available to students and teachers. Although schools are spending money on technology for the classroom, much of the technology is not being utilized in meaningful ways that impact student learning. Factors of technology integration such as professional development and a teacher's attitudes about the integration of technology have emerged in the literature as predictors for its use. Finally, the TPACK framework has emerged as a prominent theory in educational technology that describes the knowledge that is necessary for teachers to successfully implement technology into the classroom.

Problem Statement

Technology is used in schools with widely varying degrees of implementation and often only for personal tasks such as email (Ruggiero & Mong, 2015). The TPACK framework measures the knowledge teachers have regarding implementing technology in instruction; however, it is unclear if there is a relationship between the knowledge of utilizing a technology and the implementation of technology in the classroom. After conducting a study of factors that predict preservice teachers' use of Web 2.0 technology, Sadaf, Newby, and Ertmer (2012) recommended further research be conducted that focuses on the factors that influence the implementation of technology for inservice populations who have experience teaching. Sadaf et

al. (2012) believed that similar studies on inservice populations would help researchers understand the relationship between the ways inservice and preservice teachers integrate technology into their classroom instruction. Therefore, the problem is that there is no evidence of if or to what extent a relationship exists between secondary teachers' self-reported TPACK and their level of technology integration in classroom instruction.

Purpose Statement

The purpose of this quantitative, correlational study was to examine the relationship between secondary teachers' self-reported TPACK and level of technology integration. Theory drives practice. TPACK scores are indicative of the knowledge a teacher has of effectively implementing technology in the classroom (Schmidt et al., 2009). If a teacher has a high TPACK score, there should be practical applications of this knowledge in the classroom. A canonical correlation was used to examine the strength of the relationship between each variable. Participants included secondary teachers in Eastern Tennessee who utilize the technology tool Blackboard learning management system (LMS). Teachers were administered two surveys: the Survey of Technology Integration and Related Factors (STIR), which assesses current technology usage (Pittman & Gaines, 2015), and the TPACK survey (Archambault & Crippen, 2009). The STIR assessed the following predictor variables: technology access and support, professional development activities, teacher attitudes toward technology, and general technology usage. The TPACK survey assessed the criterion variables of the TPACK framework (PK, TK, CK, TCK, PCK, TCK, and TPACK). The following definitions were used for the variables:

1. *Teacher attitudes toward technology* (predictor) are the beliefs held by the teacher about technology in relation to integration and effectiveness (Pittman and Gaines, 2015).

2. *Technological Pedagogical Content Knowledge (TPACK)* (outcome) is the knowledge required of teachers to effectively implement technology and is comprised of TK, PK,

CK, and the interaction of each knowledge with each other knowledge (Schmidt et al., 2009).

3. *Technology access and support* (predictor) refers to the technology—both hardware and software—that is available to a teacher and support that is made available to the teacher (Pittman & Gaines, 2015).

4. *Technology professional development* (predictor) is the training teachers receive from their district to further their knowledge or usage of technology (Pittman & Gaines, 2015).

5. *Technology use* (predictor) refers to the ways in which an individual uses technology in his or her daily life (Pittman & Gaines, 2015).

Significance of the Study

Several studies contribute to the body of knowledge surrounding technology integration factors. In research specifically related to the use of LMSs, Comas-Quinn (2011) conducted a hybrid qualitative and quantitative study to understand the attitudes and viewpoints of those educators who taught in foreign language blended-learning courses and utilized course-management systems regarding their efficacy as valid teaching tools. The researchers found that instructors valued tools that enabled peer collaboration and support over ones that had pedagogical functions. Additionally, the researchers noted that technological complications were abundant. However, this research was a retrospective look at experiences of teachers who were compelled to use the technology as opposed to this study which specifically considers the predictors of integrating a specific piece of technology (Comas-Quinn, 2011).

Oliver, Kellogg, Townsend, and Brady (2010) developed a study that considered the needs of teachers when creating online lessons. In this study, teachers helped reveal what was needed for teachers to be successful in technology environments. However, this was a qualitative study that was open ended and not specifically focused on known technology

integration factors and only discovered some integration factors through qualitative questioning. Wang, Hsu, Campbell, Coster, and Longhurst (2014) studied technology in schools by using a mixed methods approach that included surveys, focus groups, and observations of teachers and students in classrooms. The study focused on technology availability, its use at school, and its use at home. The results indicated that while the majority of students and teachers used an array of technology at home, use at school was often limited to simple tasks such as Internet search engines and word processors. The study by Wang et al. (2014) is distinct from this one because the focus was on the differences between digital natives and digital immigrants and not specifically on the implementation of technology.

The quality of a teacher's skills is a critical factor impacting student achievement (Magidin de Kramer, Masters, O'Dwyer, Dash, & Russell, 2012). Furthermore, research has shown that teachers often require a "push" from the school system to adopt new technological skills (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). This study provided specific effects of key integration factors based on TPACK theory by showing the correlation between knowledge of teaching with technology and practical application. The results of this study could empower administrators with the information required to determine if a teacher has the knowledge necessary to effectively use technology in lessons. Administrators can then tailor individual development plans for teachers on specific factors that are known to improve a person's TPACK.

<center>**Research Question**</center>

The research question for this study was:

RQ1: Is there a relationship between the technological pedagogical content knowledge of secondary teachers in East Tennessee and their technology integration?

Definitions

The terms and concepts that are necessary for a thorough understanding of this research study are defined below:

1. *Learning management systems (LMSs)* are platforms that allow for the delivery of instructional content such as class material and resources or the assessment of classroom material through avenues such as quizzes (Murphy, Rodriguez-Manzanares, & Barbour, 2011).

2. *Substitution Augmentation Modification Redefinition (SAMR)* is a technology model that represents the different methods for integrating technology into the classroom (Green, 2014).

3. *Teacher attitudes toward technology* are the beliefs held by the teacher about technology in relation to integration and effectiveness (Pittman & Gaines, 2015).

4. *Technological pedagogical content knowledge (TPACK)* is the knowledge required of teachers to effectively implement technology and is comprised of technological knowledge, pedagogical knowledge, content knowledge, and the interaction of each knowledge with each other knowledge (Schmidt et al., 2009).

5. *Technology access and support* refers to the technology—both hardware and software— itself and support that is made available to the teacher (Pittman & Gaines, 2015).

6. *Technology professional development* is the training teachers receive from the district to further their knowledge or usage of technology (Pittman & Gaines, 2015).

7. *Technology use* refers to the ways in which an individual uses technology in his or her daily life (Pittman & Gaines, 2015).

8. *Web 2.0 technologies* are online tools that allow for creation, collaboration, or interaction with others online (Sadaf et al., 2012).

CHAPTER TWO: LITERATURE REVIEW

Overview

This chapter explores the theoretical framework TPACK in detail by describing its development and maturation over time. Then, there is a summary of key TPACK research yielded from a thorough review of the literature. Next, research pertaining to the seven factors of technology implementation that are critical to the STIR (Pittman & Gaines, 2015) are explored. Finally, the chapter concludes with a summation of the key impacts of noted research impactful to the study.

Introduction

Technology is abundant in schools (Kopcha, 2012); therefore, understanding how to improve the utilization of technological resources in the classroom is a topic frequently studied in research today (Kim, Kim, Lee, Spector, & DeMeester, 2013; Miranda & Russell, 2012; Wang et al., 2014). One of the primary frameworks that helps researchers make sense of technology data is the TPACK model (Koehler & Mishra, 2009). This model is primarily designed around three central components: PK, CK, and TK. Looking at the intersection of these ideas gives researchers a way to begin to understand the abilities of teachers to effectively use technology. TPACK is a widely used construct that has made significant impacts on classroom technology research (Koehler, Shin, & Mishra, 2011). TPACK scores are indicative of the knowledge a teacher has of effectively implementing technology in the classroom (Schmidt et al., 2009). If a teacher has a high TPACK score, there should be practical applications of this knowledge in the classroom. Given that theory drives practice, the purpose of this quantitative, correlational study was to examine the relationship between secondary teachers' self-reported TPACK and level of technology integration.

To understand the body of knowledge surrounding this study, the author conducted a literature review that included the theoretical framework TPACK as well as factors that relate to technology and its integration. The library databases utilized in this study include ERIC, Education Research Complete, ProQuest, and Academic Search Complete. Some of the keywords and phrases included in the search were TPACK, technology integration, school and technology, classrooms and technology, student technology, teacher technology, and factors of technology integration in classrooms. Most articles included in the literature review are recent, peer-reviewed studies; however, historical studies older than five years are included in this literature review when deemed pertinent for an overall contextual understanding of the literature surrounding this study.

In addition to providing a comprehensive review of the theoretical framework, the literature review revealed several factors that are related to higher technology usage by teachers. These factors include: professional development, attitudes of the teacher about technology use, and general computer use by both students and teachers. While each factor can play a critical role in a teacher's choice to use technology, the attitudes a teacher holds about a particular technology's value is often the biggest factor that will inhibit or encourage its usage (Howard, 2013; Inan & Lowther, 2010; Teo, 2011). Finally, this chapter concludes with an overview of the SAMR model (Green, 2014) as well as methods for continuing to sustain technology usage long term. The SAMR model helps teachers understand the different ways to interact with technologies to achieve different goals (Green, 2014), and sustainability is strongly linked with professional development, which is a key factor in changing attitudes of teachers who use technology (Gerard, Varma, Corliss, & Linn, 2011).

Theoretical Framework: TPACK

Overview

TPACK is the knowledge required of teachers to effectively implement technology and is comprised of TK, PK, CK, and the interaction of each knowledge with each other knowledge (Schmidt et al., 2009). At its foundation, the TPACK (Koehler & Mishra, 2009) theory is the framework for understanding the relationship of a teacher's TK, PK, and CK. The three types of knowledge are believed to be what is required for teachers to effectively integrate technology into the curriculum (Koehler & Mishra, 2009). The interrelation among the three primary components of TK, PK, and CK forms TPK, TCK, and PCK. The intersection of the three primary types of knowledge and relational knowledge of the framework represents a teacher's TPACK. The framework's goal is to help researchers both think about and measure (as surveys are developed on the model) the knowledge teachers must have to utilize ICT in lessons (Schmidt et al., 2009). Because this study sought to understand the correlation between theory and practice (e.g., teachers' TPACK scores and their technology usage), the TPACK model served as the framework for the entire study.

Historical Development of TPACK

Shulman (1986) noted that there are two primary forms of knowledge that research suggests educators need to have to effectively teach: CK and PK. However, Shulman (1986) advocated that teachers also need to have PCK—the knowledge of how to effectively teach in a specific area of content. This form of knowledge shows PK and CK work together to form discipline-specific teaching strategies.

Koehler, Mishra, Hershey, and Peruski (2004), accepting the value of Shulman's (1986) research, expanded on his idea and began looking at what is necessary for effective technology instruction. In their research, Koehler et al. (2004) proposed the idea that an effective model for

technology instruction is comprised of three interconnected pieces that form the body of knowledge necessary for teachers to effectively instruct with technology resources: CK, PK, and TK. This model depicted the connections between CK and PK, CK and TK, and PK and TK.

Although the 2004 model laid out the foundation of what TPACK would become, it did not allow for the full interconnectedness of the all of its components (Koehler et al., 2004). Koehler and Mishra (2005) continued to develop the idea and released a new model that demonstrated how each of the three core types of knowledge (content, pedagogical, and technical) relate to one another using a Venn diagram. This model was known as the TPCK model. The authors saw this model as a natural development of Shulman's (1986) idea of PCK creating TCK, TPK, and technological pedagogical content knowledge (Koehler & Mishra, 2005).

Koehler and Mishra (2008) continued to refine the model and released the current framework figure as it is known today (see Figures 1 and 2) and formally changed the name of the model to TPACK (Koehler & Mishra, 2009). The final model allows researchers to not just consider the three primary components in isolation but the intersection of each of the components as well. This model is expected to be able to serve as a framework that dynamically transcends multiple contexts of teaching and learning (Koehler & Mishra, 2009).

Notable Research on TPACK

Koh, Chai, Benjamin, and Hong (2015) advocated that TPACK is not a hard path toward knowledge; rather, it is a flowing discovery and learning process based in reflection of one's own practice. The authors developed a model (see Figure 2) that allows teachers to understand the fluid process of TPACK and utilize technology for the demanding needs of 21st-century learners. The model is centered around questions that help drive the different stages that are involved in

the process. This model encompasses all aspects of the primary domains and subdomains of the

TPACK model and allows the teacher to holistically consider all components of TPACK.
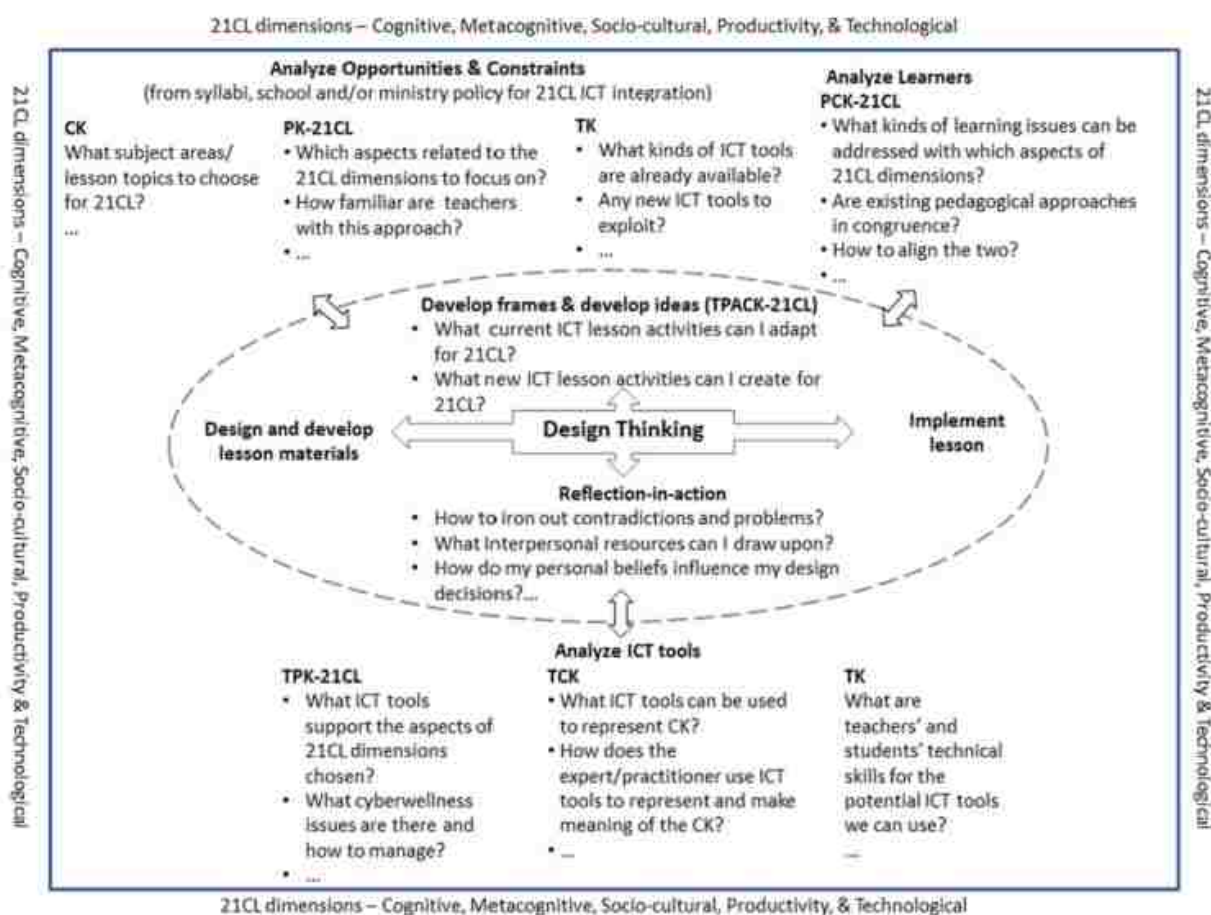
Figure 2. 21ˢᵗ century learners design thinking framework (Koh, Chai, Benjamin, & Hong, 2015). 21CL = 21st-century learners. Reprinted with permission (see Appendix A).

A recent study by Rosenberg and Koehler (2015) sought to add context to educational

research on the TPACK framework. The authors argued that context is an integral component of

TPACK research that is sometimes excluded from research studies. Therefore, the authors

attempted to understand how prevalent context is in TPACK studies. In this research study,

context refers to classroom and school demographics, student and teacher factors, and

community factors as a whole. These inclusions of context in TPACK research helped enrich the

study since the TPACK framework includes all of these factors within its domains. This study was a hybrid quantitative and qualitative study. The research questions were:

> (1) Among journal articles that make use of the TPACK framework, has context been included when authors describe, explain, or operationalize TPACK? (2) For the journal articles in which context was included, what aspects, as understood through a conceptual framework of context with three levels (micro, meso, and macro) and two actors (teacher and student), are included? (Rosenberg & Koehler, 2015, p. 190)

To select articles for the study, the researchers utilized recent literature reviews on TPACK and a database provided by TPACK.org of research studies on the subject. Overall, 192 articles from over 100 journals were analyzed. The journals were first qualitatively coded into one of six categories based on the context that was or was not included in the articles. Data were then quantitatively tabulated to find the frequency certain contexts were present. Rosenberg and Koehler (2015) discovered that the context was an important component to include in research on TPACK; however, it was only evident in 36% of the articles the authors reviewed. However, this 36% inclusion rate of TPACK context is an improvement over an older report by Kelly (2010) that suggested no studies on TPACK included appropriate context. In addition to including appropriate context, Rosenberg and Koehler (2015) discovered that context can substantially vary from study to study. For example, student contexts were sometimes completely disregarded, limiting the holistic view that the framework attempts to take into account. One of the key takeaways from recent studies is that the number of studies being performed on TPACK significantly increased from 61 in 2012 (Voogt, Fisser, Roblin, Tondeur, & Van Braak, 2012) to 74 in 2013 (Chai, Koh, & Tsai, 2013) to 193 in 2015 (Rosenberg & Koehler, 2015).

Similar to the research of Rosenberg and Koehler (2015), in a preliminary study of its kind considering tablet use among teachers in the United States, Blackwell, Lauricella, and Wartella (2016) looked at the specific factors that affect technology integration and TPACK. Although TPACK is developed to be generally examined among many contextual factors (Koehler & Mishra, 2009), Blackwell et al. (2016) believed that studying specific contextual factors may be more beneficial. The specific contextual factors included information such as attitudes of the educators, student profiles, and assistance provided by the school. When considering these different profiles, the teacher level factors (and especially the attitudes of the educators regarding the implementation of technology into the classroom) seemed to have the greatest impact on influencing technology usage.

Though all of the different domains of TPACK are critical for implementation of ICT in classroom lessons, some researchers (Chang, Tsai, & Jang, 2014) suggest that the TK domain is essential for teachers to develop skills in utilizing ICT and to effectively teach with ICT. Not surprisingly, the individual components of TPACK varied with the teaching experience of the educators. Teachers with less teaching experience seem to have greater TK than teachers with more teaching experience; teachers with more teaching experience seem to have higher CK than teachers with less teaching experience (Chang et al., 2014).

In an exploratory study by Kharade and Peese (2014), project-based learning where students utilized technology in a real-life teaching environment as opposed to direct technology instruction on specific technologies was used to see the effect of preservice teachers' TPACK scores and their intention to utilize ICT in teaching. The findings suggested that project-based learning can have a significant effect on promoting TPACK in teachers. Specifically, the preservice teachers seemed to have a better understanding of the interconnectedness of the domains and subdomains of TPACK because of the project-based learning.

Bilici, Guzey, and Yamak (2016) conducted a study on preservice teachers to determine their TPACK. Acknowledging that teachers are increasingly adopting technology in classrooms, the authors believed that utilizing technology in appropriate ways for effective teaching was critical. Therefore, the authors chose the TPACK framework as the best model for effective technology knowledge and usage. The authors conducted the study at a university and involved aspiring teachers in a science methods course. There was a total of 27 participants; 24 were female, and three were male. The average age of the participants was 22 years. Most of the participants had utilized some forms of technology as a part of their teacher education program (e.g., PowerPoint, video, simulations, and interactive boards), and everyone in the science methods course had been exposed to online tools like blogs and puzzle creators (Bilici et al., 2016). The study utilized a case study approach to ascertain a thorough understanding of the aspiring teachers' TPACK knowledge. Bilici et al. (2016) analyzed lesson plans of the preservice teachers and watched the aspiring teachers actually deliver lessons, which were recorded on video. The TPACK-based Lesson Plan Assessment Instrument developed by Bilici et al. (2012) was the instrument utilized for analysis of lesson plans. The instrument is broken up into four sections: (1) demographic information and data about the lesson, (2) the goals and objectives of the lesson, (3) TPACK domain indicators, and (4) an area for other notes relating to the lesson. Sections two and three of the TPACK Lesson Plan Assessment Instrument are scored on a Likert scale ranging from 0 (not present) to 4 (excellent). Bilici et al. (2016) analyzed the teaching videos using the TPACK Observation Protocol developed by Bilici et al. (2012). The TPACK Observation Protocol includes sections for: (1) demographic data, (2) instructional objectives, (3) classroom and lesson activities, (4) TPACK domain indicators, and (5) other notes relating to the lesson. The section for TPACK domain indicators is ranked on a Likert scale from 0 (not applicable) to 4 (excellent).

Results of the study indicated that the preservice teachers scored a mean of 2.19 on the

TPACK Observation Protocol and 2.33 on the TPACK Lesson Plan Assessment Instrument in

regard to science pedagogy (Bilici et al., 2016). According to the authors of the study, these

results indicate that the participants had the knowledge necessary to effectively teach their

science objectives. Furthermore, the fact that the scores were close for the lesson plans and the

teaching portions suggests that the presentation of lessons followed what the plans indicated. On

the TPACK Observation Protocol and TPACK Lesson Plan Assessment Instrument science

assessment domain, participants scored a mean of 3.00 and 1.21, respectively. Therefore, the

preservice teachers sufficiently assessed science instruction in the actual delivery of lessons, but

the same participants were inadequate at planning science assessments. Twenty-two of the 27

participants failed to indicate what assessments they planned to use on their lesson plans.

Furthermore, though the participants' questions were adequate, they were mostly lower-level

questions that did not require advanced thinking by the lesson participants. Further results of the

study indicated that participants scored a 2.45 mean score on the TPACK Observation Protocol

and 2.36 mean score on the TPACK Lesson Plan Assessment Instrument on the knowledge of

students' understandings of science concepts domain. Overall, this represents an adequate

performance by teachers on both assessments for this domain. Participants scored a 3.15 and

3.33 respectively on the TPACK Observation Protocol and the TPACK Lesson Plan Assessment

Instrument for the instructional strategies domain. This represents effective pedagogical

knowledge by the participants (Bilici et al., 2016). Bilici et al. (2016) concluded that the

preservice teachers overall displayed effective knowledge of the TPACK domains. The authors

noted that every participant utilized technology in the lessons that were planned and taught. The

authors believed that the comparisons of lesson plans and teaching observations allowed for a

thorough understanding of what was happening in the classrooms in regard to TPACK and that

the instruments used are effective in assessing preservice science teachers' TPACK scores. Since all of the teachers in the study were encouraged to practice technologies as a part of their science methods course, the authors concluded that practice utilizing technologies is key in linking theoretical knowledge to classroom usage (Bilici et al., 2016).

Related Literature

Factors of Technology Integration Relating to the STIR Survey

Pittman and Gaines (2015) completed a review of the literature and defined key components that affect whether a teacher will choose to utilize technology in the classroom. One of the most influential components is the attitude a teacher has toward technology usage. However, this attitude is fluid and can be changed (Inan & Lowther, 2010). Furthermore, the professional development a teacher receives is critical because in addition to providing the knowledge necessary for successful technology use, it can greatly affect the attitude of the teacher toward technology. Finally, the successful utilization of technology in ways tangential to direct classroom instruction can impact the utilization of technology for classroom teaching (Sang, Valcke, van Braak, Tondeur, & Zhu, 2011).

Professional development. Professional development is a broad tool that is utilized to train teachers on effective practices for instruction. Vu and Fadde (2014) conducted a study to understand how teacher preparation schools trained aspiring teachers to utilize technology in the classroom. This study encompassed 83 programs, and the authors found that 75% of teacher candidates did not take a specific course on technology integration. Therefore, it is important to note how significant on-the-job training can be for encouraging teachers to utilize technology. Preservice teachers are often unprepared to use technology successfully in the classroom because of a lag in colleges to adopt new technology and the depreciation of learned technologies before the teacher is in the classroom (Vu & Fadde, 2014).

Professional development is a crucial component of developing teachers' technology competencies. Professional development is often delivered face-to-face. However, Rivero (2010) noted that there are many resources that are available online that teachers can access in an asynchronous fashion without constraints of timing or schedules. Additionally, similar strategies of effective professional development should be used regardless of the delivery format. Therefore, the experiences of those who have asynchronous or synchronous learning should have commonalities.

Reeves (2010) provided a comprehensive framework for ensuring impactful professional learning and sustaining the results. First, professional development should be structured around clear objectives. Next, the vision of the professional development should be thoroughly communicated, and a holistic implementation strategy should be developed that includes all of the necessary components of training. Lastly, performance assessments should be administered to encourage teachers to continue utilizing the skills learned in the professional development session, which should encourage strengths and include areas for refinement (Reeves, 2010).

In addition to the general strategies for the implementation of professional development, there are some techniques that are specific to effective professional development for technology. Guzman and Nussbaumt (2009) recognized that training teachers on the job with appropriate methods for implementing technology was a key component of effective technology education in schools. The authors conducted a meta-analysis of the literature and identified six domains that are linked to effective teacher training for technology integration. Those six domains are instrumental and technological, pedagogical, didactic, evaluative, communicational, and attitudinal. Within each domain, the authors noted what should be included as a part of the professional development. For example, the didactic domain requires technology professional development organizers to create concrete examples of application of the technology into the

curriculum. The attitudinal domain suggests that professional development organizers should have a positive attitude toward technology use and have an emotional disposition that helps others change their attitudes.

Graves, Sales, Lawrenz, Robelia, and Richardson (2010) studied the effects of a self-paced technology training resource on the implementation of a prescribed curriculum with the goal of increasing students' reading comprehension. The researchers compared the effects of utilizing online training as opposed to synchronous, in-person training. Curriculum and reading experts designed the 13-week student instruction materials, and the teacher training was created utilizing an interactive DVD as the delivery medium. In all, the study was conducted across nine schools and 34 classrooms comprising 856 students in the fourth and fifth grades. Pretests and posttests were administered to both teachers and students to measure the progression of curriculum implementation understanding and reading comprehension respectively. Additionally, the research team conducted formal observations of the teachers to determine the effectiveness of the implementation. Finally, the researchers utilized surveys that asked the students questions that were designed to paint a picture of what happened in the classroom from the students' perspective. As a whole, the researchers concluded that the curriculum was implemented as intended. Additionally, the curriculum proved to be effective, with the students in the treatment group scoring higher than students who were in the control group across all of the individual subgroups. The researchers were able to conclude that teacher knowledge of implementation strategies was linked to the higher student success. Furthermore, the teachers who received the interactive technology training were significantly more knowledgeable in reading comprehension strategies than the control group, leading to the conclusion that the training was effective. Therefore, schools have an abundance of options when delivering

professional development opportunities beyond traditional forms of teacher learning. Professional development delivered online can be as effective as its analog counterpart.

Lee, Longhurst, and Campbell (2017) conducted a study on the learning and attitudes of teachers throughout a multiyear professional development experience in technology integration. In all, teachers received 240 hours of professional development after school and over breaks. A total of 36 teachers participated in the study, all of whom were eighth-grade public school science teachers in the western United States. To collect cases for the study, the researchers used three surveys to allow teachers to self-reported data. Additionally, archival data of student test scores were used to determine achievement. The results of the study (after comparing surveys at the beginning and end of the research) suggest that both teacher skills in integrating technology and positive beliefs about technology integration increased. Additionally, students of teachers who went through the technology professional development statistically outperformed those who did not go through the training.

Ertmer (2005) identified the concepts that should be addressed for effective professional development in technology: dialogue involving key members of the school and community at large that include pertinent pedagogical philosophies and ideas for utilizing technology to enhance the academic value of classrooms; personal learning communities within schools where teachers can share their experiences and grow together in a safe space; the ability to observe teachers using technology effectively; scaffolded introduction of new technology; and resources and assistance as teachers begin to master technological tools, change the way they teach, and begin to utilize different forms of technology. Research by Unger and Tracey (2013) concluded that there are seven components of technology professional development that affect the outcomes of the training: the relevance of the material being covered, the interactivity of the session, the learning that takes place, the access of the participants, the instructor leading the professional

development, the reactions of the participants, and the ease with which the material is understood.

Ertmer et al. (2012) conducted a study to understand how teachers' beliefs about educational practices impact the utilization of technological resources in the classroom. The research questions for the study were:

(1) How do the pedagogical beliefs and classroom technology practices of teachers, recognized for their technology uses, align? (2) To what extent do external, or first-order, barriers constrain teachers' integration efforts, leading to potential misalignment between beliefs and practices? (Ertmer et al., 2012, p. 425)

The researchers used a case study approach to study these questions. Documents from teacher websites and interviews with teachers were utilized as data sources. Additionally, a quantitative questionnaire that required teachers to self-report on Likert-type questions scaled 1 to 5 (1 = not at all, 5 = very much) related to barriers of technology and beliefs about educational technology was used. The sample was comprised of 12 teachers across kindergarten through Grade 12. The teachers were chosen using purposeful sampling, and the researchers sought teachers involved with key technical organizations such as the International Society for Technology in Education, Disney, and Apple. The sample was made up of 58.3% females and 41.7% males. Additionally, 75% taught at elementary schools while 25% were at secondary schools. Classroom resources of technology were varied, with some teachers having a plethora of technological resources while others were severely limited. Ertmer et al. (2012) found that all the internal barriers from the quantitative survey had a mean score of less than a 3 on a 5-point scale for all participants. This suggests that internal barriers to use were not a problem for this group. However, it must be noted that the sample was comprised of award-winning teachers who utilize technology in their classrooms. Therefore, it is reasonable to assume that this group was particularly apt at

overcoming challenges to utilizing technology. Ertmer et al. (2012) did note that external barriers played a role in this sample's decision to utilize technology. Support from the school district scored the highest ($M = 3.0$) with standards, monetary resources, availability of technology, time, and assessments also appearing as barriers. In regard to professional development, the researchers stated that teachers will often require a push from the school system to adopt new technological skills. Professional development plays a key role in making this knowledge accessible. Along with external pushes from organizations in the form of professional development, teachers must be willing to invest significant time outside of paid work days and have an acceptance of a certain level of risk to successfully integrate technology into the curriculum (Vannatta & Fordham, 2004). Therefore, the push for change and attitudes can often be affected by professional development requirements of the organization.

Realizing the disparity between the amount of technology that is available to teachers and the actual utilization of the available technology, Kopcha (2012) researched the effects of teachers' perceptions on the barriers of technology integration and implementation in the classroom. Using both surveys and interviews, Kopcha (2012) conducted a longitudinal survey that lasted two years and followed 18 primary school teachers. One elementary school had recently upgraded its technologies across the school, and it had implemented professional development for its teachers in the form of technology mentorships and teacher-directed professional learning communities. These long-term professional developments offer a support structure that supersedes one-time sessions. The researcher created a 15-question survey that was scored on a Likert-scale (0 = strongly disagree, 4 = strongly agree) and asked questions regarding barriers to technology use (e.g., whether the amount of planning time to prepare technology lessons is adequate). The results indicated that a lack of time, negative teacher beliefs about technology, a lack of vision for technology usage, a lack of access to information of

how to teach with technology, and a lack of professional development are barriers to technology usage. Participants consistently upheld the value of the technology mentorship in aiding their learning and encouraging the eventual implementation of technology in the classroom. Additionally, adequate time for implementation was a concern across both years of the study. Finally, the researcher noted that professional development positively affected the attitudes of the teachers toward technology usage (Kopcha, 2012). Therefore, in addition to adding to the knowledge of how to use technology, professional development helped shape another predictor of technology usage—teacher's attitudes.

Attitudes of teachers toward technology. Several studies have indicated that a teacher's attitude toward a technology can enhance or inhibit the successful implementation of technology into the classroom (Hung & Jeng, 2013; Kopcha, 2012; Sadaf et al., 2012). Inan and Lowther (2010) stated that the attitude a teacher possesses toward technology integration can significantly impact whether the teacher ultimately decides to integrate new technologies into his or her teaching. In a large study that included over 90 classrooms in four states, Baylor and Ritchie (2002) researched the motives held by teachers who chose to implement technology into the classroom. An openness to change was cited as a primary predictor of technology competency. Additionally, the professional development experiences of the teacher predicted the teacher's morale toward the use of technology. This finding highlights that professional development is vital in changing the attitudes of teachers toward the use of technology, and this openness to the idea will likely help increase the teacher's ability to effectively use the new technology.

Howard (2013) suggested that the complete knowledge a teacher has about technology can play a role on its usage in a classroom. Aversions to technology by teachers may be a product of uneasiness that can cause the teacher to be unable to fully realize the benefits of technology implementation. Specifically, the teacher may not necessarily be concerned about

whether the technology can be beneficial, but that its use may be difficult or that he or she may fail trying to use it. In cases like this, previous experiences with technology play a role in the decision of the teacher. Howard (2013) suggested being forward about the risks of technology use with teachers and communicating what could go wrong and how to avoid it. This may create an environment where teachers feel empowered to try new technologies. Furthermore, the author recommended alignment with school and community goals in technology usage encouraged by schools. An aligned vision can help teachers feel like they are accomplishing larger goals when they integrate technology into the classroom.

Teo (2011) recognized that the teacher is at the center of technology adoption in classrooms. Therefore, he developed a quantitative study that would help explain the reasons that impact why teachers choose to utilize technology in classrooms. The study was relatively large and included 592 teachers from 18 elementary schools and 13 secondary schools. An overwhelming majority were females (76.4%), the average age of the participants was 35.3, and teachers had been teaching in an educational setting an average of 9.26 years. Ninety-seven percent of respondents had a computer for personal use and spent about four hours a day utilizing computers for school-related reasons. A self-report survey was used and asked teachers to rate themselves 1 to 7 (1 = strongly disagree, 7 = strongly agree) on several factors of technology integration. These included "Perceived Usefulness (PU) (four items), Perceived Ease of Use (PEU) (five items), Subjective Norm (two items), Facilitating Conditions (three items), Attitude Towards Use (ATU) (three items), and Behavioural Intention to Use (BIU) (three items)" (Teo, 2011, p. 2435). A structural equation modeling technique was utilized to analyze for this study because it allows for a relationship to be considered between latent and observed data. The variables in the study (perceived usefulness, perceived ease of use, subjective norm, facilitating conditions, attitude towards use and behavioural intention to use) accounted for 61.3% of the

variance in a teacher's decisions to utilize technology in the classroom. Teo (2011) found that the usefulness a teacher sees in a given technology can be a very strong predictor of a whether the teacher includes the technology into lessons. Along with this, the attitude of the teacher regarding the usage of technology in the classroom and the conditions that are present in the room regarding technology implementation (e.g., availability) are also significant predictors of a teacher's intention to utilize technology.

Similar to the outcomes of Teo (2011), Kim et al. (2013) suggested that teachers believing that students have the potential to discover information for themselves while using technology can lead to a shift in the way that technology is implemented in classrooms. Furthermore, as teachers believe in the students' ability to discover and accomplish academic tasks with technology, students' own belief in themselves increases. However, this shift of teachers beginning to trust students' abilities often happens slowly, and large gains are not made from one experience. Principals can be key change agents by empowering faculty to utilize technology and providing methods for teachers to attain new technological goals (Kim et al., 2013); however, it should be noted that there is rarely one defining reason that teachers choose to utilize technology, and many different avenues can lead to encouragement of its use (Blackwell, Lauricella, Wartella, Robb, & Schomburg, 2013).

In contrast to other research noted above, Shin, Han, and Kim (2014) found that using technology does not change a teacher's beliefs about technology, though the authors hold that a teacher's attitude toward technology is still the biggest predictor of its usage. The authors note that while there may have been a surface-level shift in the way teachers view technology because of its usage, technology usage alone does not change the deeply held beliefs of the teacher regarding technology. According to Shin et al. (2014), a true shift in beliefs about technology happens when a teacher moves to a more constructivist approach toward technology in the

classroom. When this happens, a true change from teacher-centered teaching to student-centered teaching is likely. Similarly, when considering the holistic teaching abilities in a study exploring the relationship of preservice teachers' attitudes and creative teaching, Chang and Chen (2015) found that there was a positive relationship between the usage of technology in classrooms and creative teaching behaviors. This would seem to suggest that teachers who are more open to innovative methods of teaching are more likely to have a positive attitude about integrating technology into the curriculum.

In research related to that of the ease of use of technology, Rienties, Giesbergs, Lygo-Baker, Ma, and Reese (2014) found that there was not necessarily a significant relationship between the perceived usefulness of a particular technology and the ease of use of the technology. According to the authors, if instructors find a piece of technology easy to use, the educators are more likely to utilize the technology. Perhaps the usefulness of a piece of technology is affected by the desire to have a particular skill with technological resources.

General technology usage and access by students and teachers. At one point in time, male teachers were using technology in the classroom at a higher rate than females (Van Braak, 2001). However, some of the latest research (Chang et al., 2014) suggests that there is not a significant difference in TPACK scores (the knowledge required to utilize technology in lessons) between males and females. This would suggest that the gender gap of males versus females using technology may be closing. In 2003, the most frequent reason that teachers utilized technology in their daily work lives was to prepare lessons and communicate by email. The utilization of technology to deliver classroom lessons was much more scarce. Still, teachers reported valuing technologies for students and to utilize in the classroom as a priority (Russell, Bebell, O'Dwyer, & O'Connor, 2003). Though the usage of the technology has changed over time, research still suggests that the proportions of technology being utilized in the classroom are

still not aligned with the availability of technology in classrooms today (Kopcha, 2012).

Nonetheless, there are certain shifts happening, such as the prominence of the use of technology

to deliver classroom lessons even if it is as simple as a PowerPoint presentation (Kurt, 2013).

Some of the key ideas in regard to the adoption of technology in the classrooms are found

in research by Aldunate and Nussbaum (2013). The authors highlighted that different

technologies require teachers to use different methods to acquire the skills to utilize them. More

complex technologies require more extensive training or developmental time. Technologies that

are more difficult are more likely to be abandoned; technologies that teachers acquire the skills

for quickly are more likely to be sustainably integrated into the teacher's repertoire of tools.

However, those who adopt a technology early are more likely to continue to utilize it regardless

of its complexity. The early adoption process can also lead to a cycle where other teachers who

are not early adopters begin to utilize technologies because of the presence of early adopters.

This pattern is even more true with more complex technology—teachers are less likely to utilize

complex technologies without the presence of an early adopter to help them or model the

appropriate technology behaviors (Aldunate & Nussbaum, 2013).

When considering many of the variables that interact with the choice to integrate

technology into the classroom, Sang et al. (2011) found that the largest predictor of whether ICT

will be used in the classroom for lesson delivery is whether it is regularly used to prepare the

lessons. Furthermore, when teachers develop an effective way to manage students using ICT in

the classroom, they are more likely to include it in their lesson delivery. Other researchers (Teo,

2011) believed that the administration in a school can have significant impacts on technology

usage in the classroom. According to this study, one of the largest ways that administrators may

be able to effect change is by helping drive and manage positive attitudes about technology in

schools.

So, Choi, Lim, and Xiong (2012) hypothesized that using a computer in one's personal life would translate to pedagogical computer uses in the classroom. However, personal computer usage did not seem to be a predictor of computer usage in the delivery of classroom lessons in this study across two distinct populations. The authors noted that this result would appear to indicate that the ability to use a computer will not necessarily cause a teacher to use it in the classroom. The implication of this is that technical knowledge may not be enough to convince teachers to utilize technology in delivering instruction. So et al. (2012) stated that technological knowledge may not assimilate into pedagogical knowledge easily. The authors recommended that work be done on devising a method of connecting teachers' knowledge of technology with their pedagogical skills.

Zhao and Frank (2003) created a framework that helps to define the process under which technology is used in school (see Figure 3). In Phase 1, computer usage is primarily driven by the school district, which gives the teacher access to the new technology. In this phase, trainings provided by the district are available but are largely not a factor that affects adoption of new technology. In Phase 2, as a new technology is continued to be introduced, both social and political influences come into play, and pedagogical changes begin to take place. Teachers can then begin to influence each other in this stage. Some may be interested in the new technology, and others may question its value (as depicted by the question mark on top of the symbolic figure's head). A teacher's growth in their knowledge of how to use a new technology is denoted by the change in shape, and pressure from others helps affect the way the teacher interacts with the new technology. Relationships are a key part of this phase. Finally, in Phase 3, the teacher is able to fluidly integrate and utilize the technology, and the technology becomes a tool of the teacher. Social interactions continue to be important as they shape the overall climate of the classroom (Zhao & Frank, 2003).
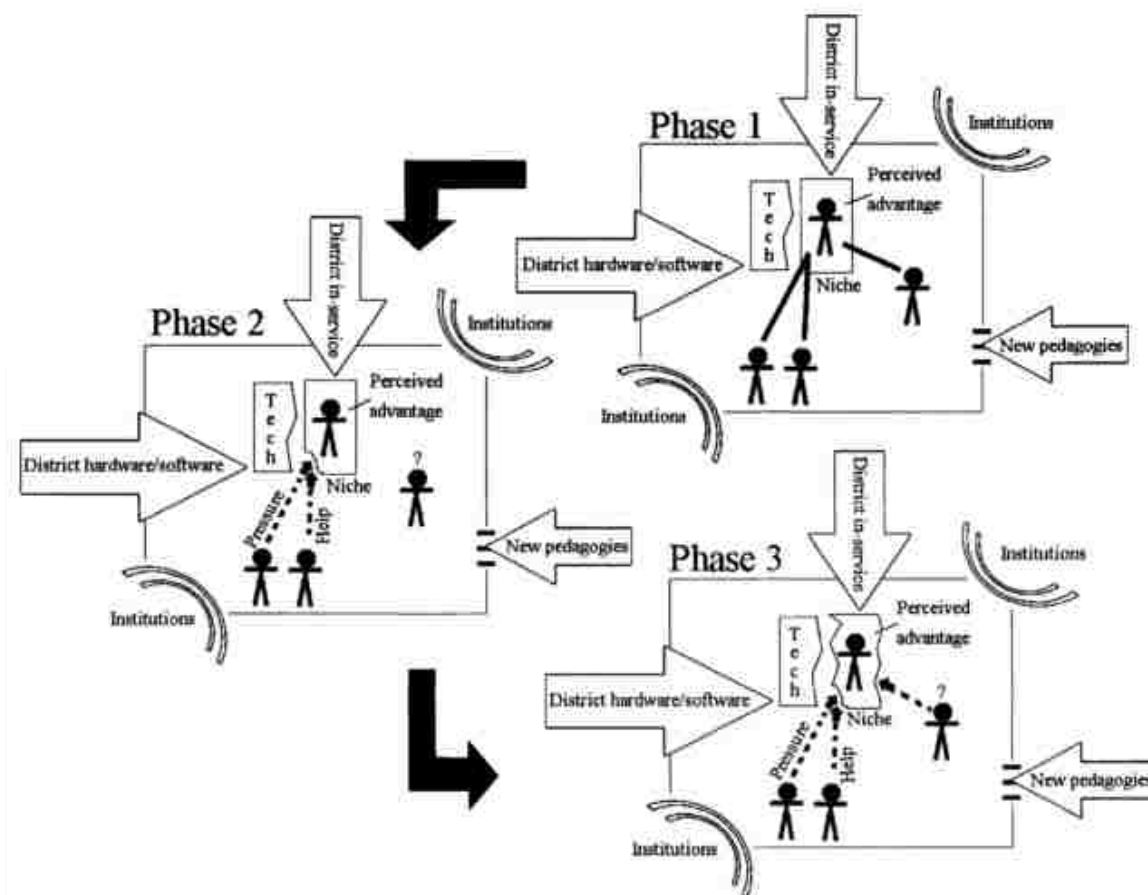
Figure 3. Technology adoption in schools (Zhao & Frank, 2003). Reprinted with permission (see Appendix B).

Carver (2016) explored the benefits of technology and barriers to use of technology of students and teachers in Grades 6–12. The author noted that average reading and mathematics scores were nearly the same as they were decades ago and that technology has not necessarily pushed scores up. Carver (2016) stated that it matters how technology is used in the classroom, not simply having technology, as it may not be used in beneficial ways. Carver (2016) used a mixed-methods approach to research and distributed open-ended surveys to students enrolled in online classes at a private, liberal arts college who were taking graduate classes through the education department. In all, 310 students were invited to take the survey, and 68 students comprised the final sample. Forty-one percent of respondents were elementary teachers in

grades K-2, 33% intermediate teachers in grades 3–5, and 19% taught in high school.

Demographic data showed that 74% of the teachers in the study taught in an area related to

English/language arts in some capacity, about 66% taught a STEM class, and less than 10%

taught a noncore class (e.g., band, art, computers, etc.). Links were distributed to a survey to the

graduate students that overviewed the reason for research, noted that the survey was voluntary

and anonymous, and collected demographic information. The survey was designed to answer

three research questions:

> (1) What factors impact technology use in K-12 instruction by teachers enrolled in online
>
> graduate studies in education programs? . . . (2) What factors impact how teachers
>
> enrolled in online graduate studies in education program incorporate technology in their
>
> K-12 instruction? . . . (3) What K-12 digital instructional benefits and/or barriers were
>
> identified by K-12 teachers enrolled in online graduate studies in education programs? (p.
>
> 112)

The survey asked quantitative questions related to the respondents' technology usage and

the barriers the respondents have witnessed for both students and teachers to access technology

at school. Respondents were asked to score on a Likert scale the frequency with which various

technologies were used in the classroom. Then, the survey asked the respondents to complete an

set of open-ended questions. The set included questions asking respondents about the barriers

faced in using technology in the classroom, the benefits of using technology in the classroom,

what motivates the frequency with which technology is used by teachers, and what factors affect

the frequency with which students use technology in the classroom. Qualitative data were coded

by the author and triangulated so that results could be validated (Carver, 2016).

Results of the study indicated that all teachers used a computer and most used a projector

(89%) at least one time a week. Additionally, the study showed that 93% of teachers used a

computer daily, and 85% of teachers used a projector daily. Fifty-six percent of teachers indicated that they used some form of interactive white board in the classroom, 48% used a digital camera, and 47% used an iPad at least once a month. Seventy-seven percent of respondents indicated that text messaging was never used as a part of the classroom, and 50% have never used a smartphone in a lesson (Carver, 2016). To analyze the qualitative data, researchers identified themes that appeared among the responses, tested for convergence within the data, checked for outliers from common themes, developed a narrative that led to recommendations, looked for patterns that may suggest the need for additional data, and aligned themes with other literature. The researcher found that 80% of those surveyed reported a concern with the availability of technology as a barrier to technology usage in the classroom. The skill level and knowledge of how to use technology was only cited as a barrier for using technology by 24% of respondents. Other barriers included the location of technology (6%), lack of classroom time (6%), and a lack of support staff to assist the instructor (3%). Additionally, the data showed that 59% of teachers in the survey thought that the use of technology would increase student engagement. Other benefits teachers noted were increases in understanding (15%), availability of differentiation through technology (9%), availability of new material (5%), and the development of research abilities of the students (3%). In regard to the reasons teachers ultimately decided to use technology in the classroom, data showed that about 50% of respondents made their decision on whether to use technology based on the availability of technology. About 25% of the time, the decision to use technology was based on instructional goals. Finally, the remaining 25% of respondents made decisions based on factors such as availability of time and policies of the school and district. Carver (2016) found that instructional concerns were only the predictor in technology usage in the classroom about 25% of the time. Additionally, Carver concluded that the availability of technology impacts the usage of

technology in the classroom more than the abilities of the teacher to use the technology.

Furthermore, the author noted that teachers often chose to use technology in their lessons

because they felt the technology would increase the engagement of students in the lesson rather

than for other possible benefits such as more thorough research. Carver suggested that if

teachers were more aware of varying technologies and how to use them, these same teachers may

develop more robust uses for technology in the classroom that included functionality such as

enhanced research skills by utilizing technology.

Technology Learning Strategies

In order to teach with technology, the teacher must be able to ensure the effectiveness and

efficiency of the technology integration on the curriculum. There are two approaches to enabling

this: curated resources and the SAMR model. The American Association of School Librarians

Best Websites for Teaching and Learning Committee is a recognized resource for materials that

have been vetted for effectiveness. The committee publishes a list of high-achieving sites on

various topics that can be utilized by teachers to support their technology integration. Using

these curated lists can be a stepping-stone for teachers to use expert lesson suggestions while

they develop their own best practices. As teachers become comfortable developing technology

integration on their own, the SAMR model can provide a framework for developing effective

curriculum (Jacobs-Israel, 2013).

The SAMR model (Jacobs-Israel, 2013) defines the four ways that technology can have

an impact on curriculum through two specific methods: transformation and enhancement (see

Figure 4). Within the transformation method, educators are able to require students to complete

new tasks that were not possible without technology (redefinition) or significantly redesign a

task utilizing a new technology (modification). Similarly, the enhancement domain includes

technology functioning as an exact substitute of a nontechnological tool (substitution) or as a

substitution tool that provides some type of enhancement over the nontechnological tool

(augmentation). These four methods can serve as a way to help teachers organize and plan their
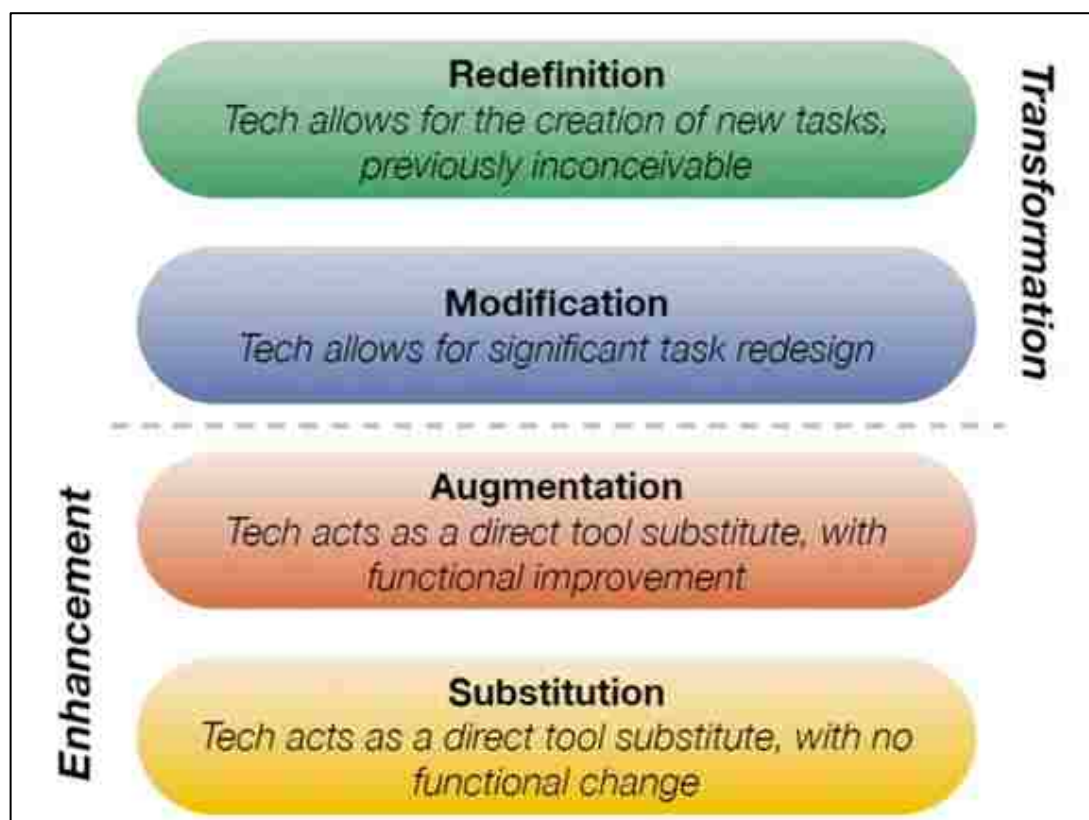
technology-integrated lessons (Green, 2014).

Figure 4. The SAMR model of technology integration (Puentedura, 2013). Reprinted with permission from a Creative-Commons license.

To comprehensively assess the teacher's technology integration into the classroom,

observers can use the International Classroom Observation Tool model that was developed by

the International Society for Technology Education. This model helps evaluators understand the

need for integrating technology, helps the teachers reflect on their practice, and can be utilized to

leverage professional development and growth conversations to help the teacher improve

(Penchev, 2013). Through scaffolds such as curated lists, integration models like SAMR, and

evaluation techniques such as the International Classroom Observation Tool, teachers can have

support structures in place to effectively integrate technology into the classroom even if it is new to their teaching style.

Once teachers learn a new technology, the question becomes how the school sustains the efforts of the teachers on learning a new technology and supports its integration into the classroom. One method is to provide continuous professional development through long-term academies. The academies would have an expert who has regular professional development meetings with the teachers and then follows up both in the classroom and with additional professional development sessions. Gerard et al. (2011) found that comprehensive professional development programs that lasted more than one year significantly improved students' educations. Long-term situated professional development would seem to be very effective at encouraging teachers to integrate technology; however, it is also costly and time consuming.

Summary

A model for understanding the knowledge a teacher needs to effectively use technology has been discussed, and research is clear that there is a relationship between technology integration factors and technology usage in classroom lessons. However, the purpose of this study was to examine the relationship of secondary teachers' TPACK and the key technology integration factors noted above. It makes sense that teachers who have a high knowledge of how to teach with technology should produce evidence of technology usage (integration factors). The authors of other research studies (Sadaf et al., 2012) often focused on preservice teachers or failed to look at integration factors within the context of the larger environment (Pittman & Gaines, 2015). Though the research was beneficial to further the study of integration factors of technologies in the classroom, the literature is not able to fully address the gap in knowledge necessary to understanding this area. This study aimed to fill a gap by studying inservice populations of technology integration factors and TPACK.

CHAPTER THREE: METHODS

Overview

This chapter will focus on how the study was conducted and lay the groundwork for replication. The chapter will begin with an overview of the research design, highlighting the nonexperimental, correlational nature of the study. Then, it will reintroduce the research question and state the null hypotheses of the study. Next, a discussion of the participants, setting, and instrumentation will follow. Finally, the procedures and methods of data analysis will be presented.

Design

This research study was conducted with a nonexperimental, correlational design. Nonexperimental designs are a form of social research that does not utilize a control group (Gall, Gall, & Borg, 2007). Correlational designs seek to describe the relationship between variables, as opposed to experimental and quasi-experimental studies, which attempt to establish cause and effect (Gall et al., 2007). This study sought to establish if a teacher's TPACK score as determined by the TPACK survey (Archambault & Crippen, 2009) and technology usage as determined by the STIR (Pittman & Gaines, 2015) are related. Because the study sought to understand a relationship between variables and not determine cause and effect, a nonexperimental, a correlational design was appropriate. Furthermore, because educational outcomes are rarely influenced by just one variable, correlational designs are helpful in educational studies because they allow for multiple variables to be analyzed in a single study (Gall et al., 2007).

In a correlation, the predictor variable is the assumed cause variable, and the criterion variable is the assumed effect variable (Gall et al., 2007). The instrument used in this study to measure the predictor variables of technology usage was the STIR (Pittman & Gaines, 2015).

The predictor variables from this survey are scores for technology access and support, professional development activities, teacher attitudes toward technology, and general technology usage. These variables were scored on a Likert scale and are considered interval variables for educational research analysis (Gall et al., 2007). Interval level variables allow for the use of parametric statistics, and the classification of Likert scales as interval variables is common in social science research even though they technically provide ordinal data.

The instrument used in this study to measure the criterion variable TPACK score was the TPACK survey. The subscales PK, TK, CK, TCK, PCK, and TPK were utilized to form the criterion variable (Archambault & Crippen, 2009). These subscales were scored on a Likert scale and are considered interval variables for educational research analysis (Gall et al., 2007).

Research Question

The research question for this study is:

RQ1: Is there a relationship between the technological pedagogical content knowledge of secondary teachers in East Tennessee and their technology integration?

Null Hypothesis

The null hypothesis for this study is:

H_0**1:** There is no significant relationship between the Technological Pedagogical Content Knowledge score as measured by the Technology Pedagogical Content Knowledge Survey (Archambault & Crippen, 2009) and the five factors of Technology Integration (technology access and support score, professional development score, attitudes score, technology use by students score, and general technology usage score) as measured by the Survey of Technology Integration and Related Factors (Pittman & Gaines, 2015) for secondary educators in East Tennessee.

Participants and Setting

The participants in this study were drawn from a convenience sample of secondary teachers in East Tennessee from two city school districts (See Appendices G and H). The districts have a student population of about 5,000 students and just over 300 teachers each. Convenience samples are a method of sampling from a population that is not random. They are usually from a population that is accessible to the researcher and provides the benefit of allowing a study to take place when the study might not have been conducted if random sampling were used (Gall et al., 2007). The participants came from a population of educators that use the online LMS, Blackboard, to deliver class instruction. Surveys were sent by district office staff to all secondary teachers. The sample that was drawn covered educators who taught required and elective courses, academic and vocational subjects, and who had various years of experience teaching.

For this study, the total number of participants sampled was 137. Because of missing data and pairwise case deletion, the final number of usable participants was 129, which is larger than the required sample size of 125 recommended by Gall et al. (2007). The authors recommended having at least 15 samples for each predictor variable in a multiple regression (Gall et al., 2007). A power analysis suggested that 123 participants are required for an 80% power (see Appendix C). In this sample, 63.5% of participants taught middle grades (6–8), and 36.5% taught high school grades (9–12). The average age of the participants was 43 years, and the average amount of teaching experience was 13 years. Thirty-six teachers reported having a bachelor's degree, 57 a master's degree, 34 an educational specialist degree, and 10 a doctoral degree. Twenty-nine teachers taught English language arts, 24 taught math, 22 taught social studies, five taught art or music, three taught physical education, and 39 taught other subjects. Selected data are summarized in the table below.

Table 1

Descriptive Statistics of Participants

	n	*%*
Grades taught		
Middle grades (6–8)	82	63.5
High school grades (9–12)	47	36.5
Degree		
Bachelor's	36	27.9
Master's	57	44.2
Educational Specialist	34	26.4
Doctoral	10	7.8
Subject taught		
English language arts	29	22.5
Math	24	18.6
Social studies	22	17.1
Art or music	5	3.9
Physical education	3	2.3
Other	39	30.2

Note. N = 129

The TPACK survey (Archambault & Crippen, 2009) and the STIR (Pittman & Gaines, 2015) were distributed online using the tool SurveyMonkey. Teachers received an email at their school email address with directions and information for accessing the survey. The email was sent via the school-wide listserv provided by the districts to all instructional staff members. Teachers were informed that participation was optional and were able to indicate that they wished to participate in the online survey by selecting "I agree." Teachers were able to complete the survey on the device of their choosing, in the location of their choosing, and at the time of their choosing within the month the survey was open for submissions.

Instrumentation

Two distinct instruments were utilized in this research to collect data from participants. The TPACK survey developed by Archambault and Crippen (2009) assessed the TPACK knowledge of teachers. The STIR developed by Pittman and Gaines (2015) assessed technology usage.

Technology Pedagogical Content Knowledge Survey

The TPACK survey was developed by Archambault and Crippen (2009) to measure teachers' TPACK. TPACK instruments typically measure a specific content area. However, the TPACK instrument by Archambault and Crippen (2009) is not content specific. The instrument measures the self-reported knowledge of those who utilize some form of online learning platform (e.g., Blackboard) and its relationship to pedagogy, content, and technology. The TPACK survey was based on a previous instrument developed by Archambault and Crippen (2006) that measured general technology teaching effectiveness knowledge.

The TPACK survey (Archambault & Crippen, 2009) has seven subscales and 24 questions total across the seven subscales that are scored using a 5-point Likert scale (1 = Poor, 5 = Excellent). Teachers are asked to self-rate on statements from each TPACK domain such as "My ability to use technological representations (i.e., multimedia, visual demonstrations, etc.) to demonstrate specific concepts in my content area" (Archambault & Crippen, 2009, p. 87). The PK domain measures a teacher's ability to teach effectively teach and includes three questions. The TK domain assesses how effectively a teacher can utilize technology in the classroom such as by troubleshooting student computer problems and includes three questions. The CK domain assesses a teacher's ability to effectively teach content and includes three questions. The TCK domain measures the effectiveness of a teacher's ability to take content knowledge and represent it in a technological form (e.g., online) for students and includes three questions. The PCK domain assesses a teacher's ability to effectively teach content-specific methods and includes four questions. The TPK domain measures the ability of a teacher to take sound pedagogical instruction and utilize technological methods to instruct teaching and includes four questions. Finally, the TPACK domain assesses the teacher's ability to interrelate technology, content, and pedagogical knowledge and includes four questions. This instrument has been utilized in

numerous studies (Archambault & Barnett, 2010; Crippen, Archambault, & Kern, 2012; Hao, 2016)

Participants self-reported on a 5-point Likert scale (1 = Poor, 5 = Excellent) on each subdomain of the TPACK survey (Archambault & Crippen, 2009). Then, a total score was derived by adding each of the subdomain items together for a total possible score ranging from 24 to 120 points. A low score of 24 indicates a low self-reported knowledge of teaching through online environments, and 120 indicates a high self-reported knowledge of teaching through online environments.

Construct validity for the TPACK survey (Archambault & Crippen, 2009) was initially assessed by having an expert review the instrument and make recommendations. The survey was further assessed for construct validity by utilizing a think-aloud strategy with volunteers. Finally, construct validity was assessed by doing think-aloud exercises with the survey. The authors note that that survey items were being consistently interpreted accurately among the different participants. The subscales of the survey were based on previous research (Archambault & Crippen, 2006) and include pedagogy, content, and technology with a reliability of α = .738, .911, and 928, respectively. Reliability for the survey as measured by Cronbach's alpha coefficient for the subscales ranged from .699 for the TCK domain to .888 for the TK domain. The survey was completed online utilizing SurveyMonkey. The total time to complete the survey was about 10 minutes, and results were exported directly from SurveyMonkey into SPSS. The authors of the instruments have provided express permission for the use of this survey in this research study (see Appendix D).

Survey of Technology Integration and Related Factors

The STIR was developed by Pittman and Gaines (2015) to measure various factors that impact and predict technology integration by teachers. This survey was based on an original

survey by An and Reigeluth (2012) that focused on using technology in learning-centered classrooms. The survey represents one of the first comprehensive instruments that aggregately assimilates several integration factors into one survey (Pittman & Gaines, 2015).

The STIR (Pittman & Gaines, 2015) has five subsections for the main survey and a section for teachers to rank barriers to technology use. The subscales are technology access and support, technology-related professional development, importance of technology in instruction, technology use by students, and technology use by participant. The survey has a total of 38 questions. The technology access and support subscale measures the technology that is available to the teacher and the amount of administrative or technological support received by the teacher and has eight questions. The technology related professional development subscale measures the quantity and quality of professional development trainings on technology the educator has received and has four questions. The importance of technology in instruction subscale measures teachers' attitudes toward integrating technology into the classroom and has eight questions. The technology use by students subscale measures the student's frequency of utilizing select technologies and includes eight questions. Finally, the technology uses by the participant subscale measures teachers' personal usage of general technology items and includes nine questions.

For the STIR survey (Pittman & Gaines, 2015), participants self-scored on a 5-point Likert scale that typically ranges from 1 to 5 (1 = Poor, 5 = Excellent). Each subscale was scored individually by summing the total scores for the subscale. The technology access and support score ranges from a low score of 8 to a high score of 38. The technology related professional development score ranges from a low score of 4 to a high score of 20. The importance of technology instruction score ranges from a low score of 8 to a high score of 40. The technology uses by students score ranges from a low score of 8 to a high score of 40.

Finally, the technology uses by participant score ranges from a low score of 9 to a high score of 45. Construct validity was assessed by having an expert in the field review the instrument and make recommendations. It was further assessed by a pilot study involving seven teachers who provided feedback and analysis of what was being asked in the study. The constructs measured include technology access and support, technology related professional development, the importance of technology in instruction, technology use by students, technology use by the participant, and barriers to technology integration. Reliability for the study using Cronbach's alpha coefficient for the subscales range from .773 to .776 (Pittman & Gaines, 2015). The survey was completed online utilizing SurveyMonkey, and the survey was administered immediately following the TPACK survey. The total time to complete the survey was about 10 minutes, and results were exported directly from SurveyMonkey into SPSS via a CSV file. The authors have provided express permission for the use of this survey in this research study (see Appendix E).

Procedures

The procedures for completing this study began with securing permission to use the instruments from their respective owners for the TPACK survey (see Appendix D) and the STIR survey (see Appendix E). Next, Institutional Review Board (IRB) approval from Liberty University was granted before the study could begin (see Appendix F). Next, superintendents for each school system were contacted to gain permission to administer surveys to teachers at the selected schools (see Appendices G and H). Surveys were loaded onto SurveyMonkey with directions on how to complete the study. Next, a messaged was drafted that provided an overview of the purpose of the research, instructions for how to complete the study, a link to the study, a message indicating that teachers could exit the survey at any time, a message indicating that participation is optional, and notice that participating in the survey represented informed

consent. This email was sent by the researcher to district staff and forwarded to instructional

staff by district office personnel. The survey was left open for one month. The data were

exported from SurveyMonkey as a CSV file and imported into SPSS. Data were then readied for

analysis by identifying any inconsistencies and identifying missing responses.

Data Analysis

The variables for the study came from Likert-style surveys. These types of data are often

treated as interval data for analysis in educational statistics (Gall et al., 2007). The dependent

variables were technology access and support score, professional development activities score,

teacher attitudes toward technology score, and general technology usage (Pittman & Gaines,

2015). The independent variable was the TPACK score (Archambault & Crippen, 2009). The

statistical procedure for this study was a canonical correlation. Canonical correlations allow for

multiple independent and dependent variables to be considered at the same time when several

bivariate correlations are impractical (Hair, Black, Babin, Anderson, & Tatham, 2009). When

there are multiple variables in a study, running several bivariate correlations increases the chance

of a Type I error beyond the specified limits, and a canonical correlation corrects for this.

Therefore, it was the most appropriate test for this study.

Data were downloaded from SurveyMonkey into a CSV file that was imported into

SPSS. SPSS was utilized to identify missing data to be recoded as "99" to indicate the omission.

Missing data were removed from the study using pairwise deletion. The individual questions for

each domain of the survey were added together to form a total score for the domain. The data

were screened to ensure that the following assumptions were met: independent observations, lack

of outliers, assumption of linearity, and normality. Independent observations were tested for

utilizing the Durbin-Watson statistic. Outliers were tested for using a box-and-whisker plot to

detect extreme values. Data that were outside the specified range on the plot were considered for

elimination. The assumption of linearity was tested by using a scatterplot. The data should form

a generally straight line. The data were screened for normality by using a histogram. The alpha

level for this study was .05, and R was used to report effect size. The SPSS output was exported

as a Word file to utilize for results and drawing conclusions. The following statistics are

reported: M, SD, N, df, r, r^2, F, p, B, regression equation, and power.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this correlational study was to understand the relationship between secondary teachers' TPACK score and their implementation of technology into the classroom. This chapter will lay out the findings of the study in regard to the research question. Descriptive statistics for the study are presented first, followed by the results of the canonical correlation.

Research Question

The research question for this study was:

RQ1: Is there a relationship between the technological pedagogical content knowledge of secondary teachers in East Tennessee and their technology integration?

Null Hypotheses

The null hypothesis for this study was:

$H_0 1$: There is no significant relationship between the Technological Pedagogical Content Knowledge score as measured by the Technology Pedagogical Content Knowledge Survey (Archambault & Crippen, 2009) and the five factors of Technology Integration (technology access and support score, professional development score, attitudes score, technology use by students score, and general technology usage score) as measured by the Survey of Technology Integration and Related Factors (Pittman & Gaines, 2015) for secondary educators in East Tennessee.

Descriptive Statistics

The study was comprised of 129 usable sets of complete data. The independent variable for this study was the TPACK survey. The dependent variables were the five domains of the STIR survey of technology access and support score, professional development score, attitudes

score, technology use by students score, and general technology usage score. Descriptive

statistics of the independent and dependent variable are presented in the table below.

Table 2

Descriptive Statistics of Variables

	N	M	SD
Independent variable			
TPACK survey	129	89.8	15.7
Dependent variables			
Technology access and support	134	24.0	4.8
Professional development	134	12.4	2.1
Teacher attitudes	135	33.9	4.9
Technology use of students	133	18.0	4.8
General tech use	133	25.3	4.4

The following figures display the scores or score ranges for each variable included in this

study. The independent variable is listed first followed by the dependent variables.
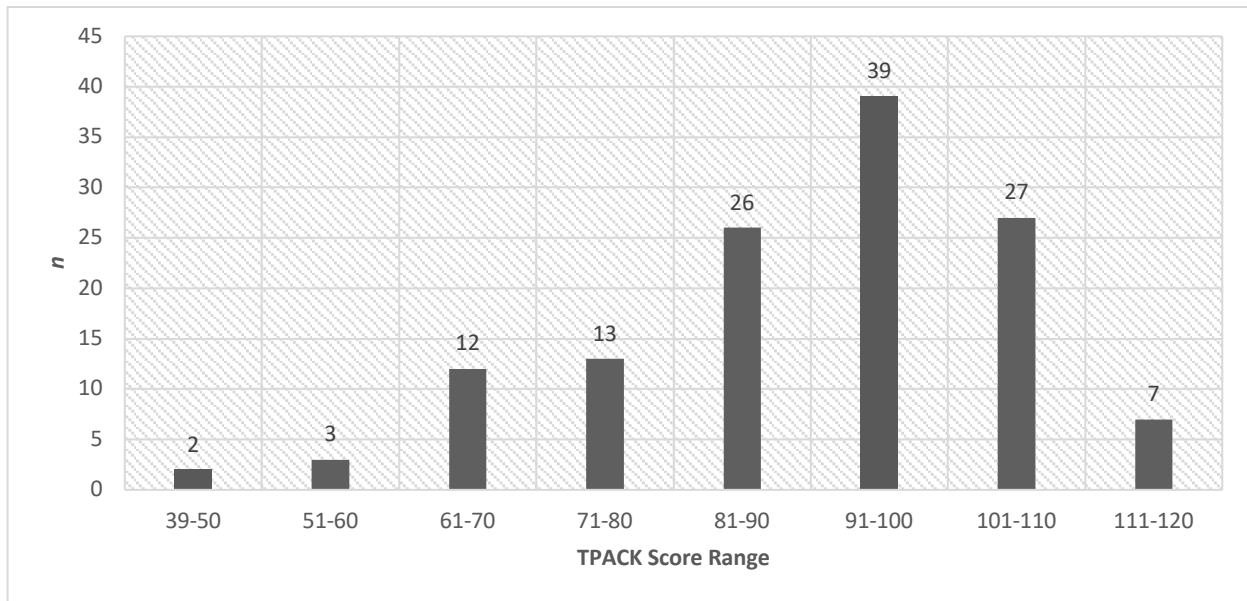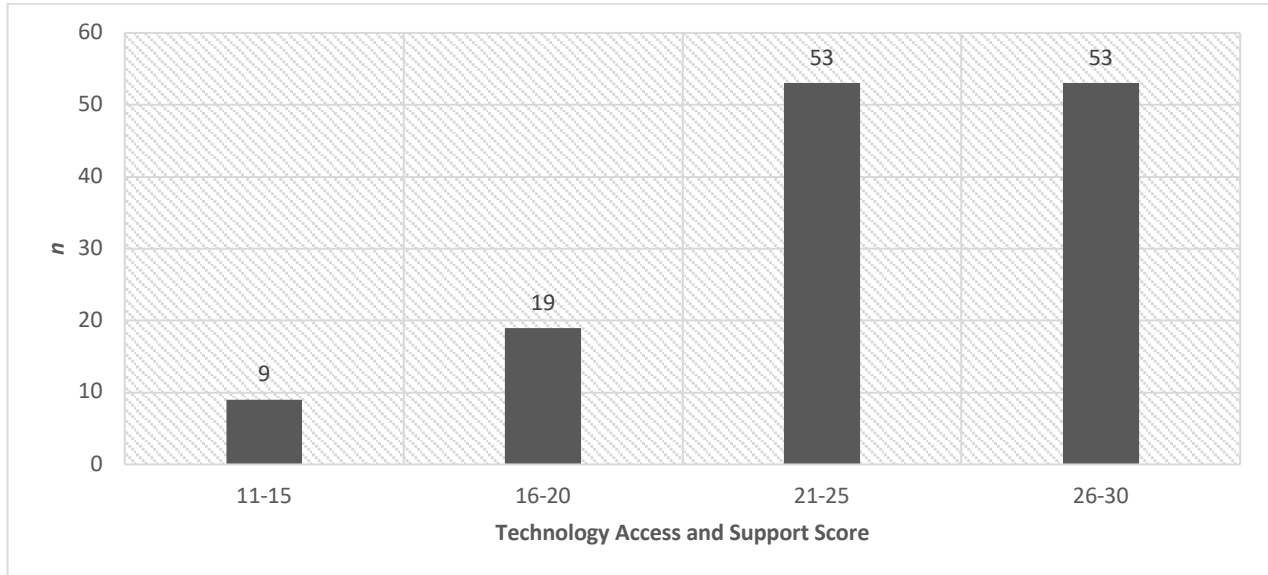

Figure 5. Bar graph of TPACK scores.

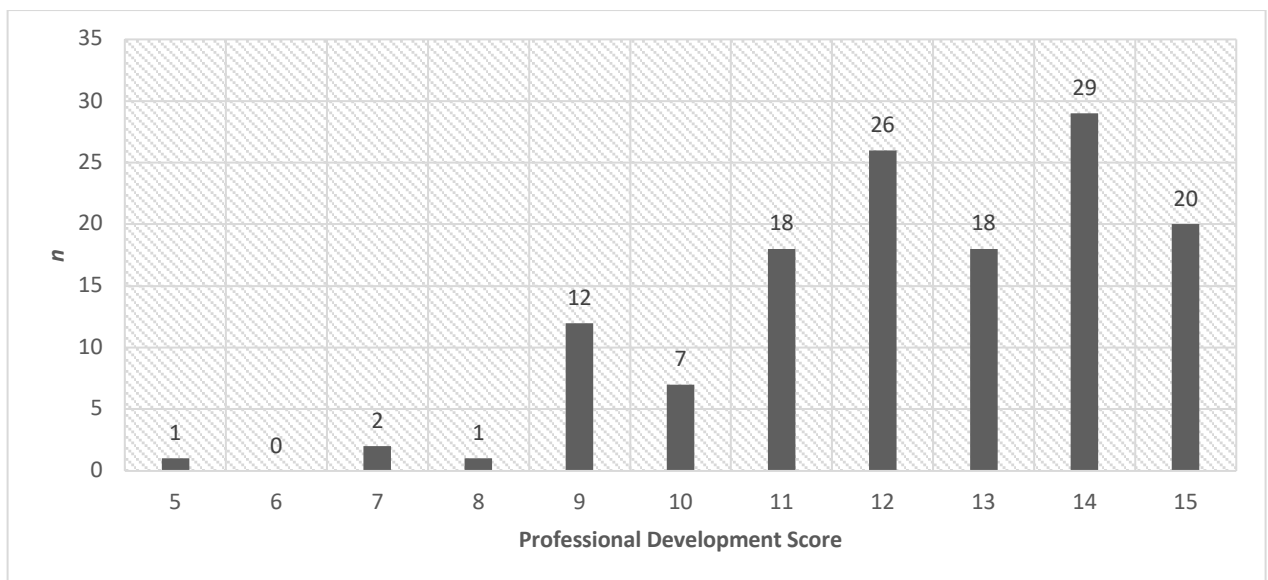*Figure 6.* Bar graph of technology access and support scores.

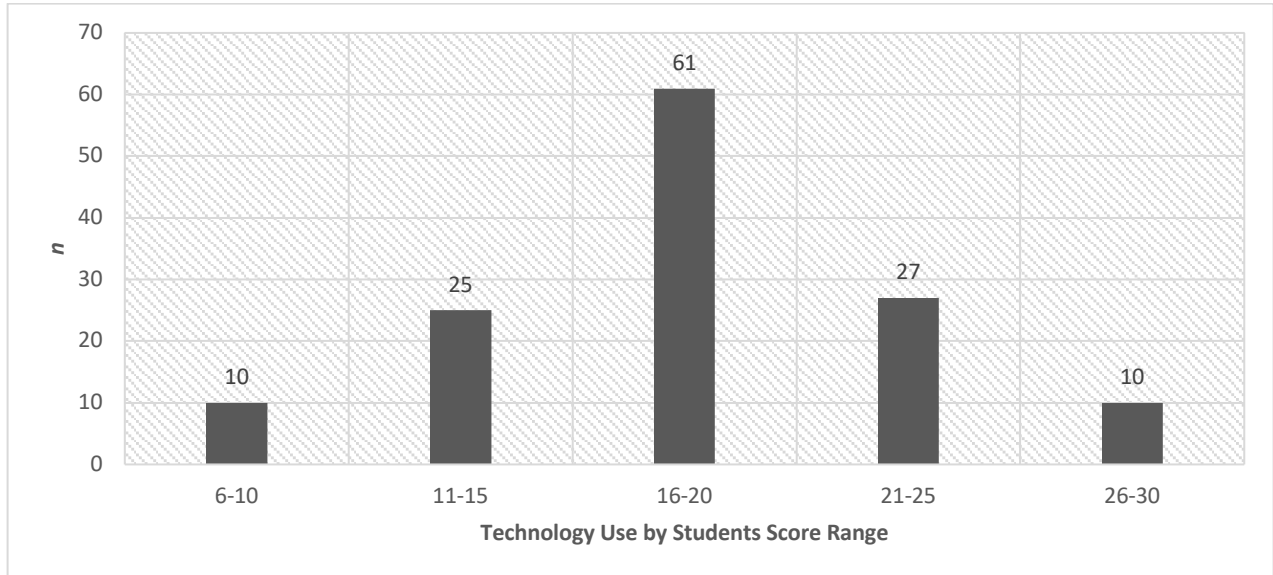*Figure 7.* Bar graph of professional development scores.

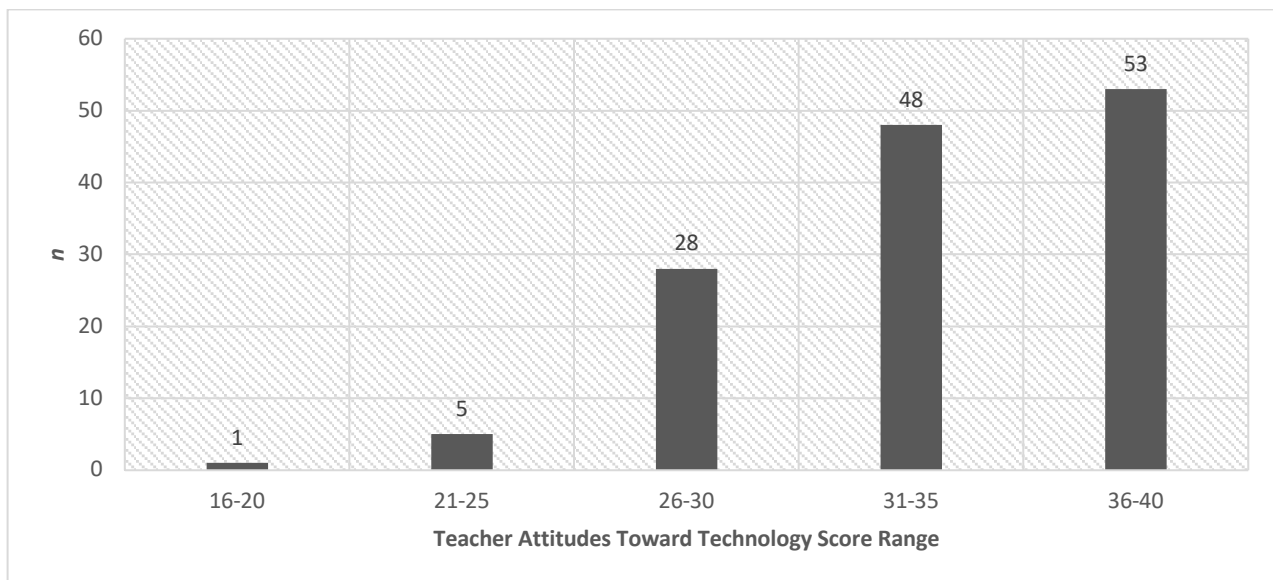*Figure 8.* Bar graph of technology use by students scores.

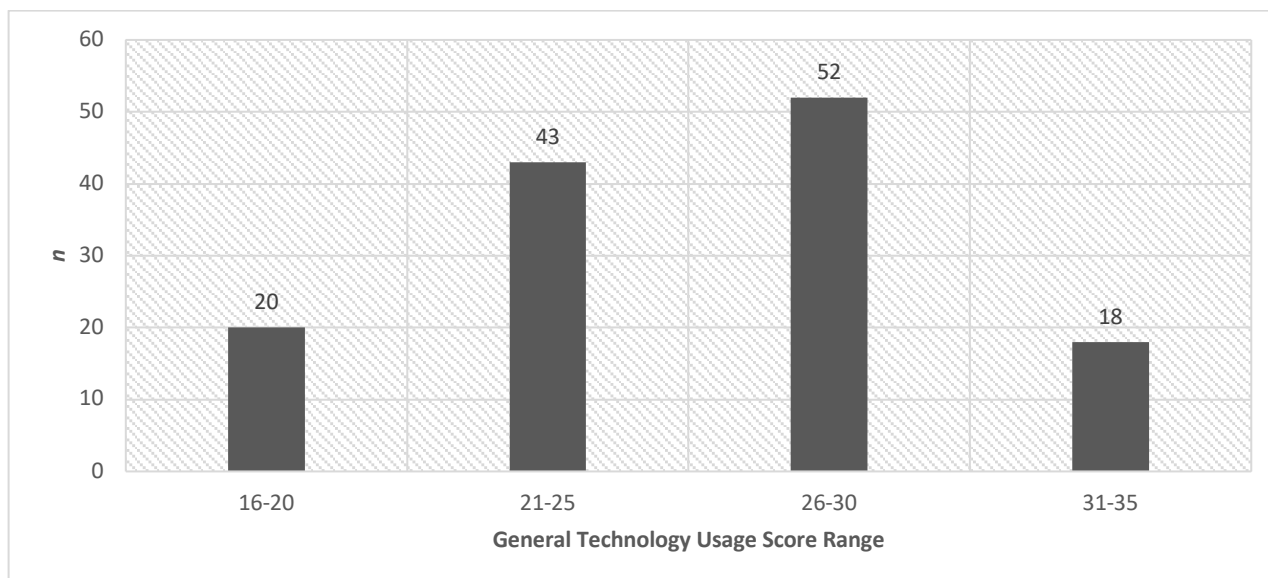*Figure 9.* Bar graph of teacher attitudes toward technology scores.

Figure 10. Bar graph of general technology usage scores.

Results

This section includes detailed information regarding the results of the study. First, the results of assumptions testing are discussed. Then, the canonical correlation results and related metrics are reported for each dependent variable.

The null hypothesis for the study was: There is no significant relationship between the Technological Pedagogical Content Knowledge score as measured by the Technology Pedagogical Content Knowledge Survey (Archambault & Crippen, 2009) and the five factors of Technology Integration (technology access and support score, professional development score, attitudes score, technology use by students score, and general technology usage score) as measured by the Survey of Technology Integration and Related Factors (Pittman & Gaines, 2015) for secondary educators in East Tennessee. Canonical correlations provide for multiple independent and dependent variables to be considered at the same time when several bivariate correlations are impractical (Hair et al., 2009). There were a total of 129 usable samples in the study out of the 137 participants.

Assumption Testing

       Independent observations. Data were screened for independent observations using the Durbin-Watson statistic. The Durbin-Watson statistic for this study was 1.78. This is between the critical values of 1.5 and 2.5. Therefore, there would appear to be no auto-correlation of the data, and the assumption of independent observations is tenable.

       Outliers. Data were screened for outliers using a box-and-whisker plot to detect extreme values. Data that were outside the specified range on the plot were considered for elimination. Below are the box-and-whisker plots for the variables.
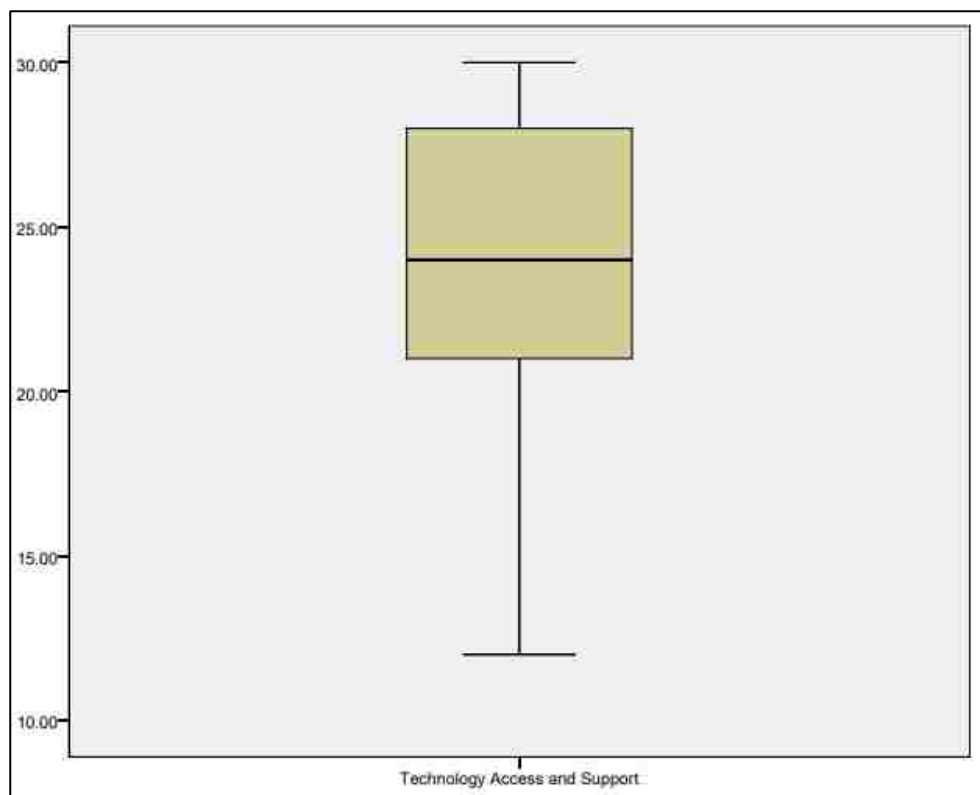

Figure 11. Box-and-whisker plot of technology access and support scores.
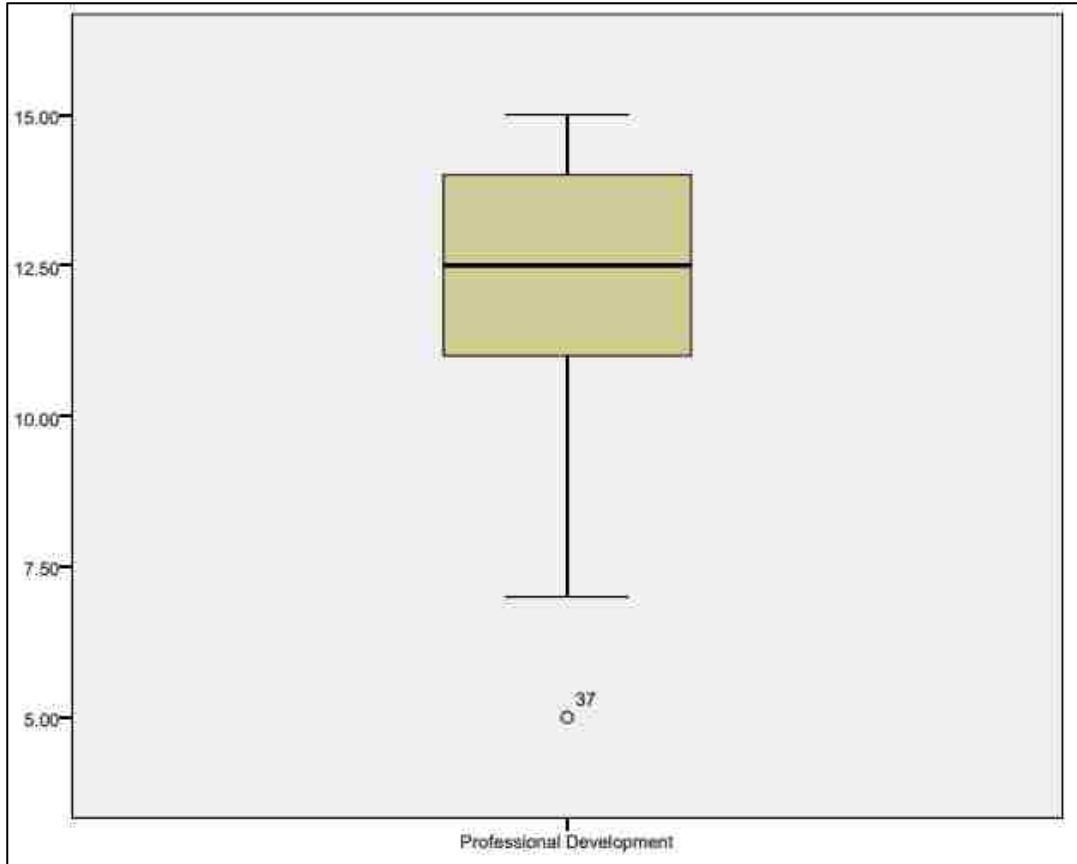
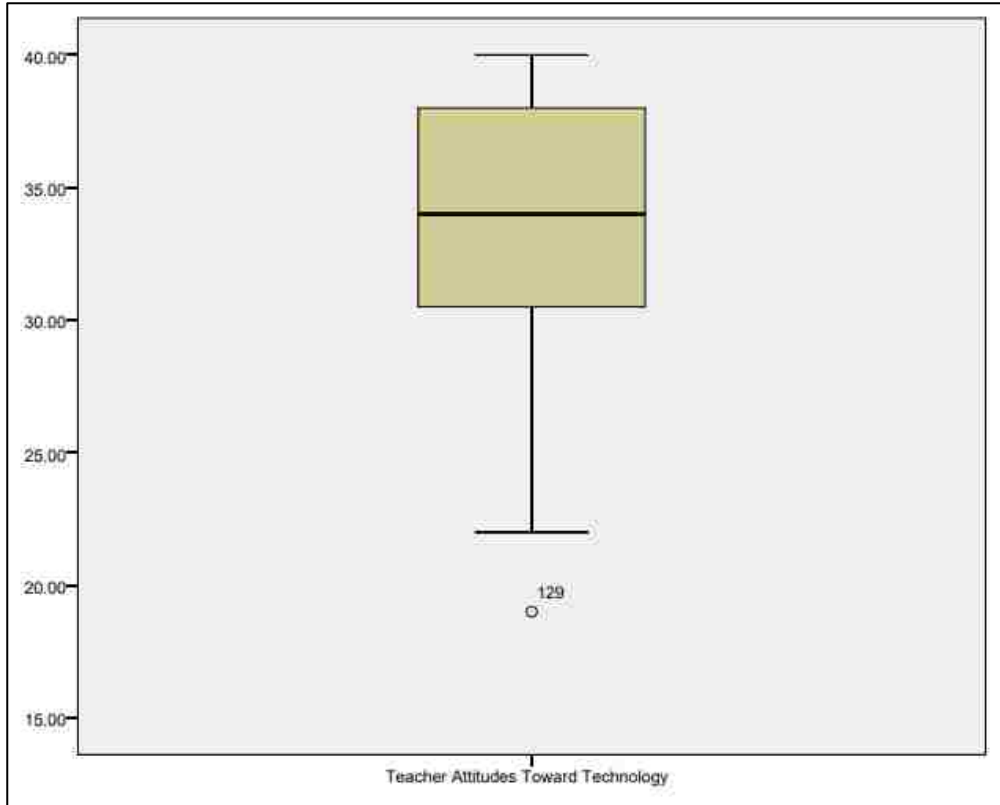*Figure 12.* Box-and-whisker plot of professional development scores.

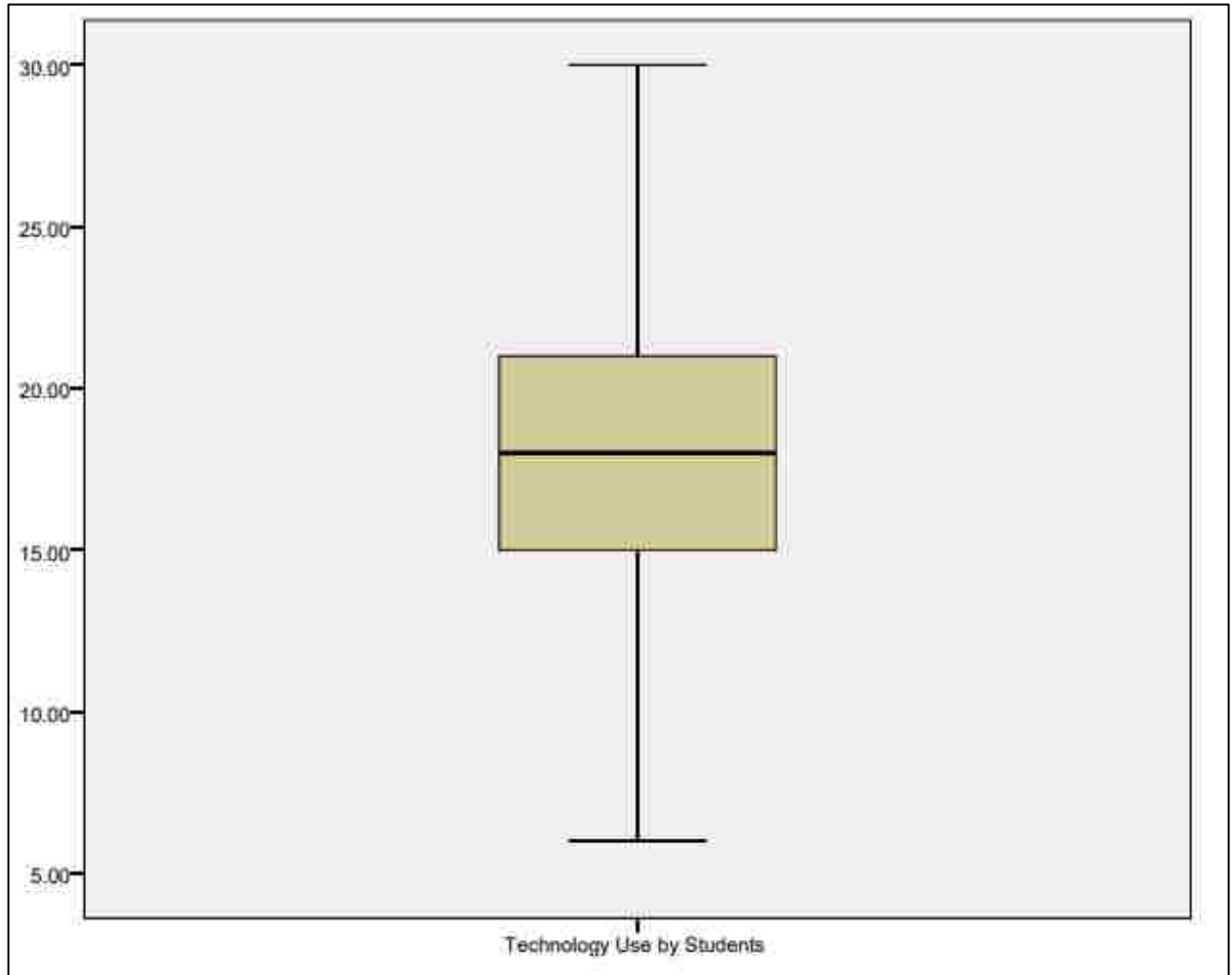*Figure 13.* Box-and-whisker plot of teacher attitudes toward technology scores.

Figure 14. Box-and-whisker plot of technology use by students scores.
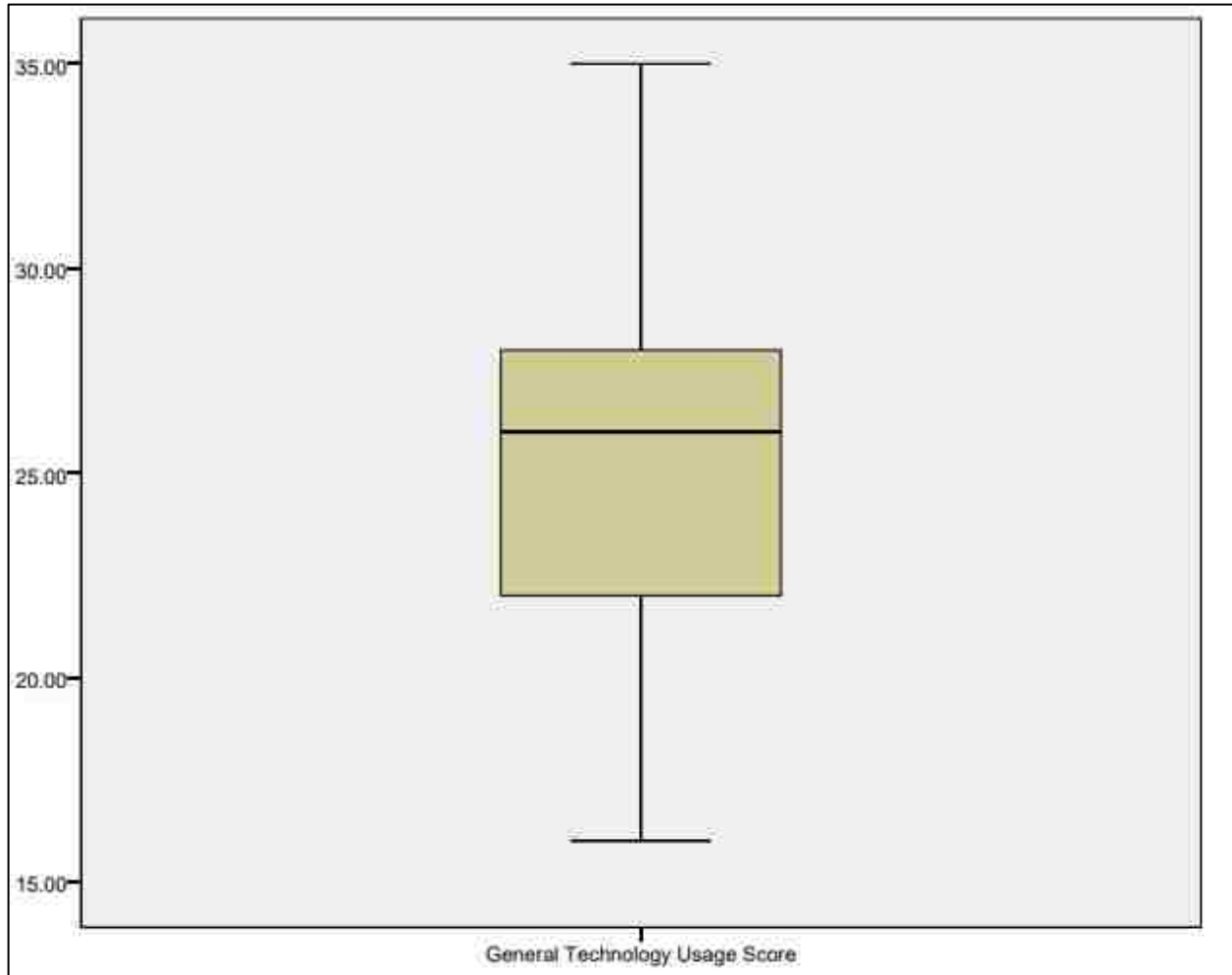
Figure 15. Box-and-whisker plot of general technology usage scores.
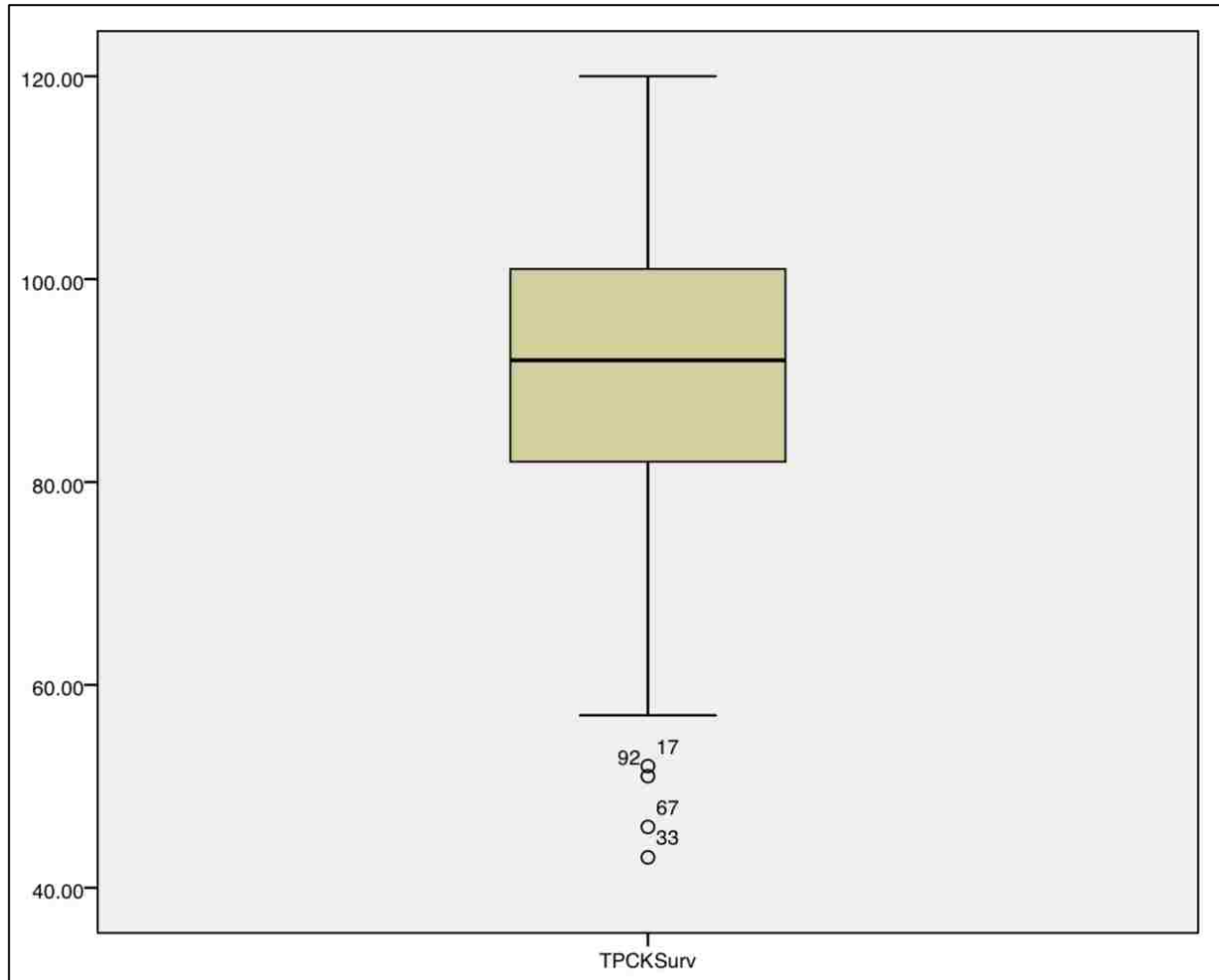
Figure 16. Box-and-whisker plot of TPACK scores.

Though some variables had minimal outliers, no data were determined to be an extreme outlier that were consequential to the effects of the study. Therefore, no data were deemed necessary for elimination or transformation.

Assumption of linearity. The assumption of linearity was tested by utilizing a scatterplot. The data should form a generally straight line. The scatterplots for the variables are provided below.
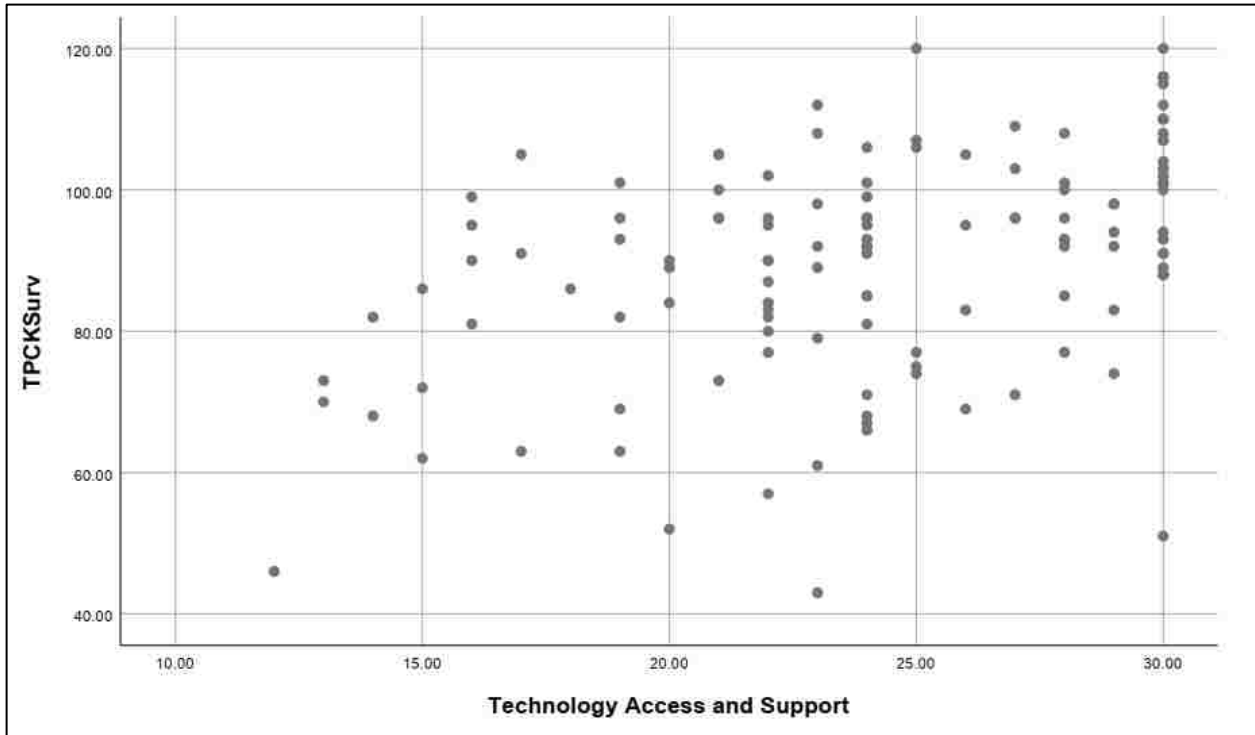
Figure 17. Scatterplot of technology access and support scores with the TPACK survey scores.
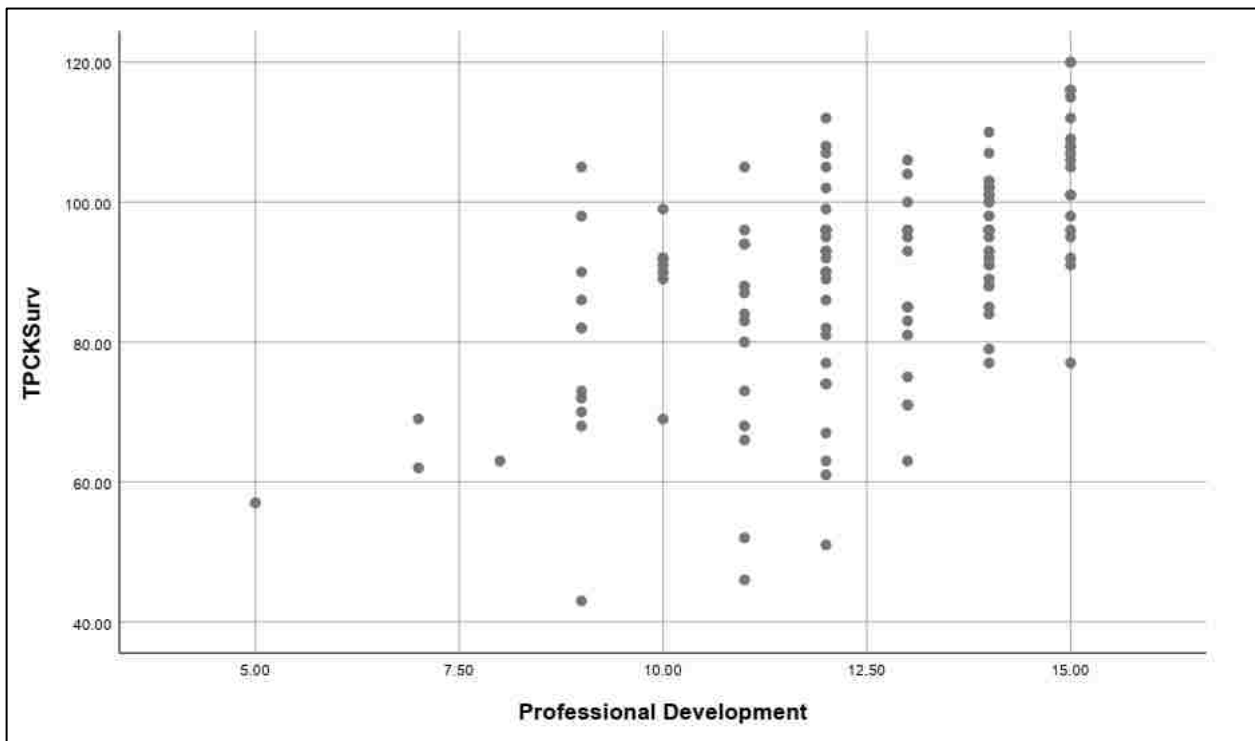
Figure 18. Scatterplot of professional development scores with TPACK survey scores.
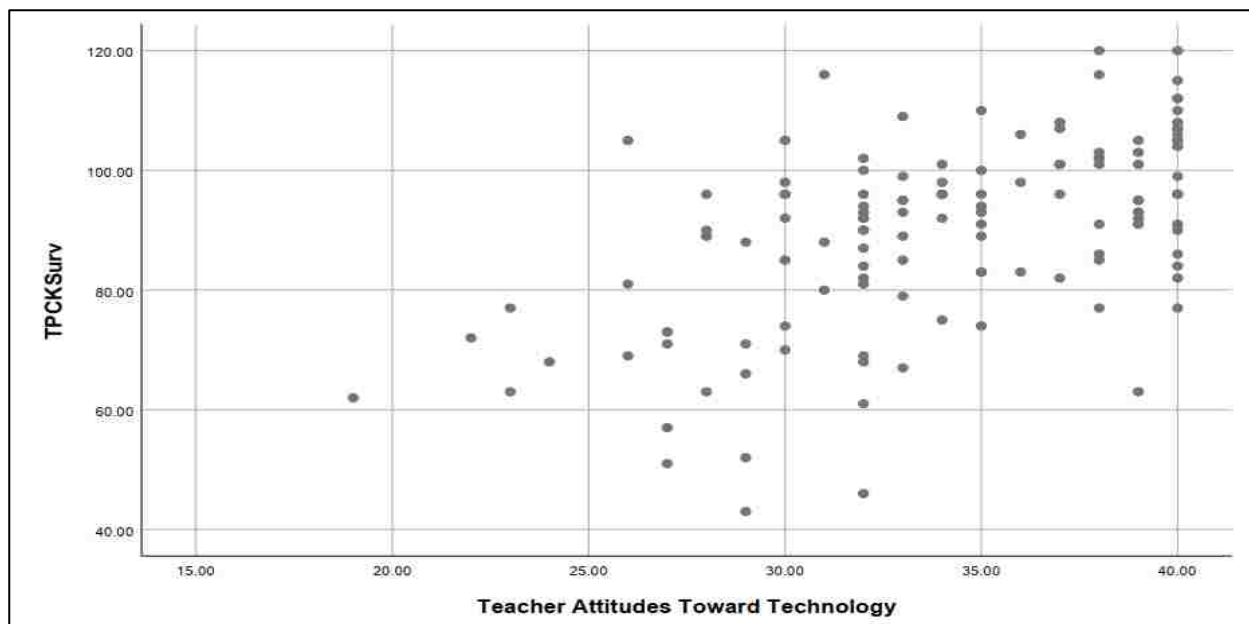
Figure 19. Scatterplot of teacher attitudes toward technology scores with TPACK survey scores.
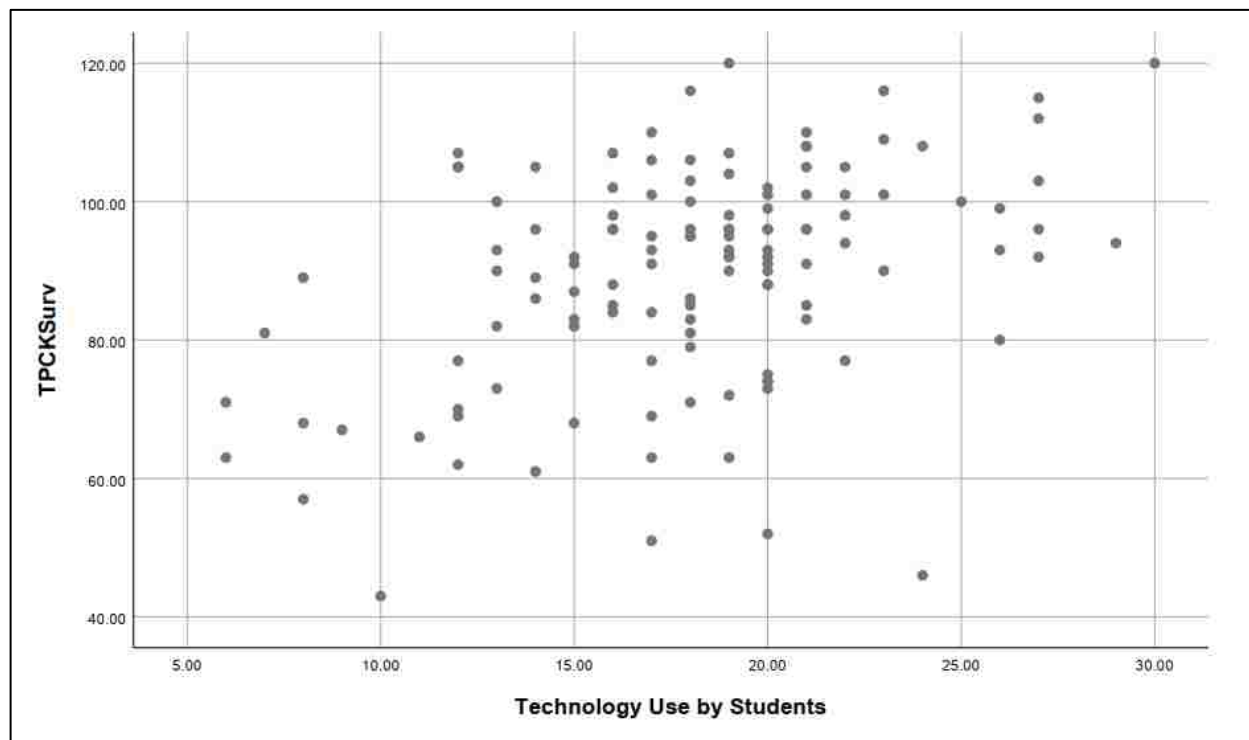
Figure 20. Scatterplot of technology use by students scores with TPACK survey scores.
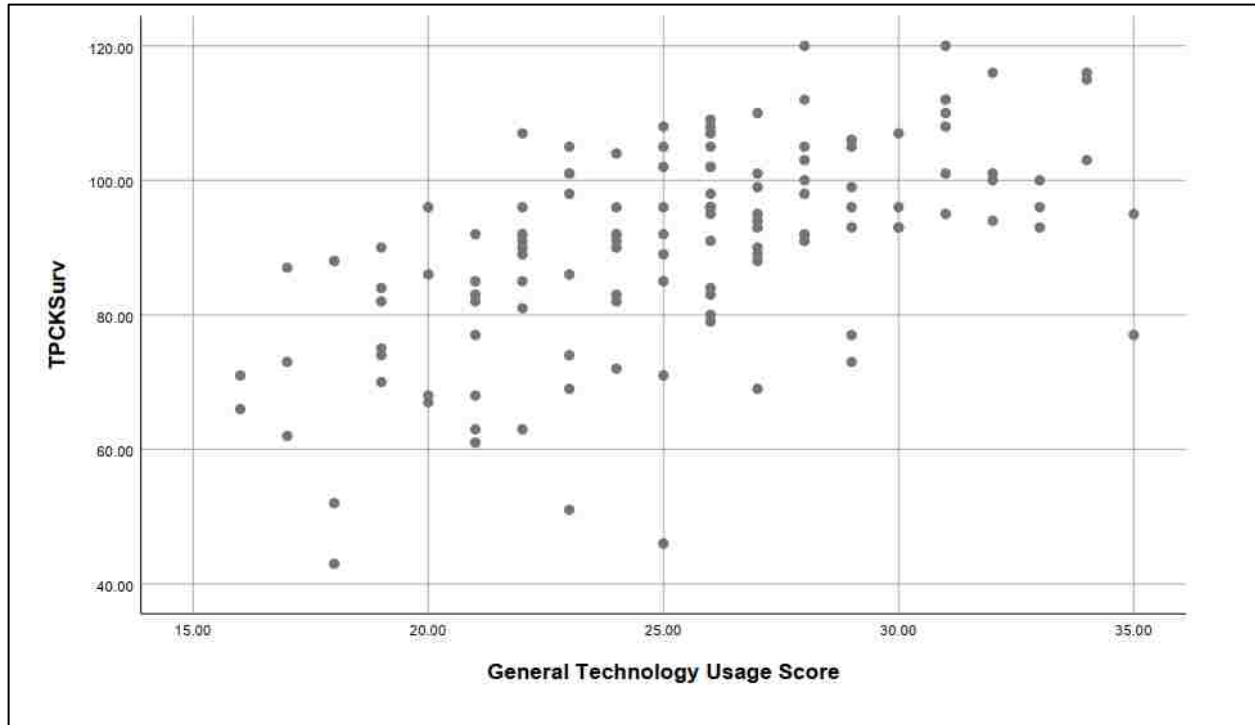
Figure 21. Scatterplot of general technology usage scores with TPACK survey scores.

After considering all the scatterplots, it was determined that the data do not violate the

assumption of linearity. The data generally form a straight line with no curves, making the

assumption tenable.

Normality. Data were screened for normality using a histogram. The data form an

acceptable, though right-skewed, bell shape. A Q-Q normality plot is also included, showing a

generally straight line.
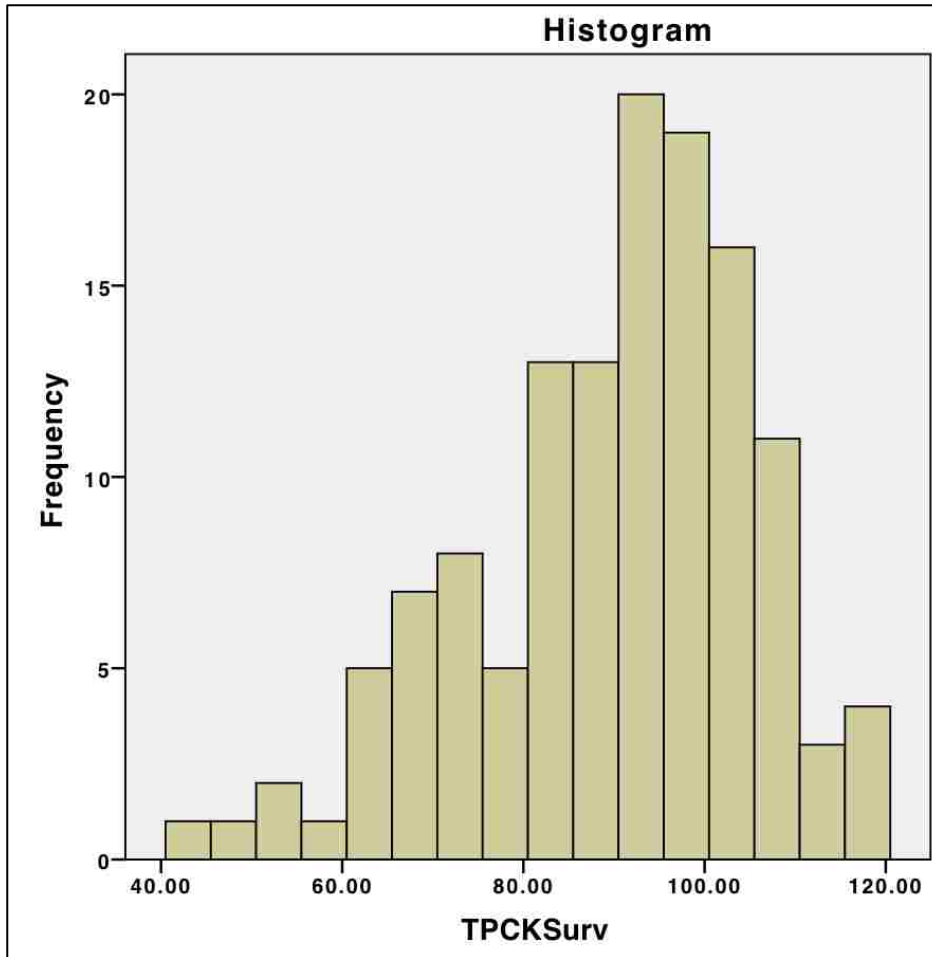
Figure 22. Histogram of TPACK survey scores.
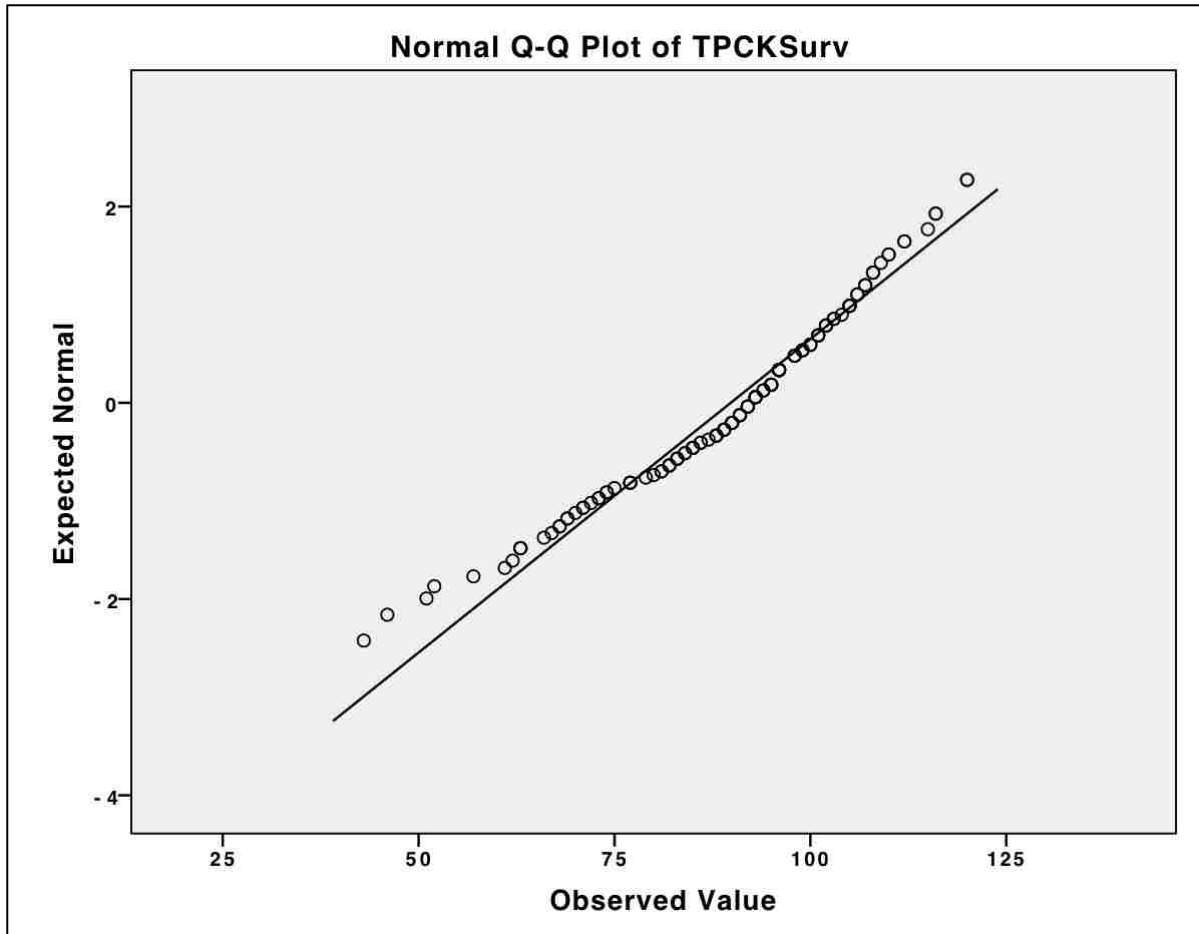
Figure 23. Q-Q Plot of TPACK survey scores.

Canonical Correlation Results

The null hypothesis for the study was: There is no significant relationship between the Technological Pedagogical Content Knowledge score as measured by the Technology Pedagogical Content Knowledge Survey (Archambault & Crippen, 2009) and the five factors of Technology Integration (technology access and support score, professional development score, attitudes score, technology use by students score, and general technology usage score) as measured by the Survey of Technology Integration and Related Factors (Pittman & Gaines, 2015) for secondary educators in East Tennessee. A canonical correlation was used to measure the independent variable of the TPACK survey (Archambault & Crippen, 2009) with the

dependent variables of the STIR (Pittman & Gaines, 2015). Figure 24 below shows the design

layout of the canonical correlation.
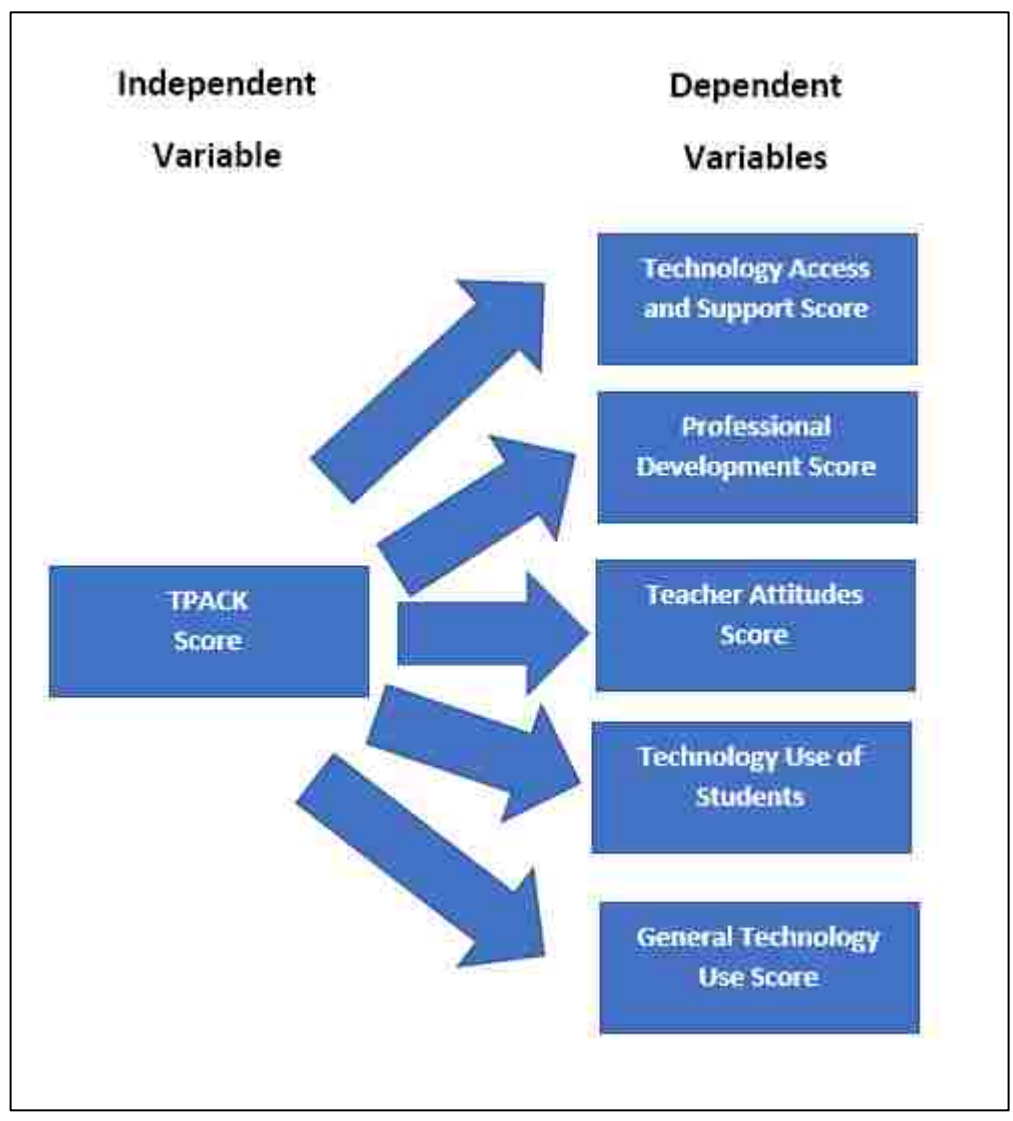
Figure 24. Canonical correlation study design.

Wilks Λ is a common statistic for determining the significance for the overall design of

the study (Pedhazur, 1997). This metric was used for this study. In a canonical correlation, the

study as a whole is determined to be statistically significant. Then, the data are processed

through follow-up comparisons. The alpha used for the study was .05. The original test was

determined to be statistically significant with $\Lambda = .525$, $df = 110.0$, and $p = <.001$. With the

overall design of the study determined to be statistically significant, the follow-up comparisons were processed. The following table displays the results of the subsequent statistical analyses of the canonical correlation.

Table 3

Results of the Canonical Correlation

Dependent variable	r	r^2	F	B	p
Tech access and support	.408	.167	27.5	.128	*
Professional development	.510	.260	2.9	.065	*
Teacher attitudes	.520	.271	15.8	.157	*
Technology use of students	.394	.155	16.8	.115	*
General tech use	.584	.341	13.3	.169	*

Note. * $p < .001$

Summary

In conclusion, the overall canonical correlation design was statistically significant at the *p* < .001 level with a Λ = .525. Therefore, follow-up comparisons could be made for each dependent variable against the independent variable of TPACK score. These tests showed that each relationship between the dependent variable and independent variable was statistically significant at the *p* < .001 level. Technology access and support accounted for 16.7% of the variance in TPACK scores. Professional development accounted for 26.0% of the variance in TPACK scores. Teacher attitudes toward technology accounted for 27.1% of the overall variance in TPACK scores. The technology usage of students accounted for 39.4% of the variance in TPACK scores. Finally, general technology usage of the teacher accounted for 34.1% of the variance in TPACK scores.

CHAPTER FIVE: CONCLUSIONS

Overview

This chapter will focus on providing the contextual conclusions of this research study. It will begin with an overview of the research and a summation of the results and how they fit into the overall body of knowledge on TPACK. This section will be organized by dependent variable. Next, the implications of this research will be discussed, showing how this study adds to the academic body of knowledge. Finally, limitations of the study are discussed and recommendations for future research are proposed.

Discussion

The purpose of this quantitative, correlational study was to examine the relationship between secondary teachers' self-reported TPACK and their level of technology integration. Theory drives practice. Therefore, given that TPACK scores are indicative of the knowledge a teacher has of effectively implementing technology in the classroom (Schmidt et al., 2009), if a teacher has a high TPACK score, there should be practical applications of this knowledge enacted in the classroom. A canonical correlation was used to examine the strength of the relationship between each dependent variable and the independent variable. A review of the literature found that there is often a correlation between TPACK and integration factors. However, the authors of other research studies in this area (Sadaf et al., 2012) often focused on preservice teachers or failed to look at integration factors within the context of the larger environment (Pittman & Gaines, 2015). Therefore, this study sought to fill the knowledge gap by showing the correlation between TPACK scores and technology integration factors in inservice teacher populations.

Two research instruments were used in this study: the TPACK (Archambault & Crippen, 2009) and the STIR (Pittman & Gaines, 2015). The TPACK survey measures teachers' TPACK

score, which is designed to show the knowledge a teacher has to effectively teach with

technology. This score was used as the independent variable in the study. STIR measures

various factors that impact and predict technology integration by teachers. The five dependent

variables of this study were: technology access and support, professional development, teacher

attitudes toward technology, technology usage of students, and general technology usage by the

teacher.

Technology Access and Support

Technology access and support refers to the technology (both hardware and software)

that is available to the teacher (e.g., computers, Internet access, software programs) and support

that is made available to the teacher in regard to using this technology (e.g., manuals, FAQ, etc.).

It is important to note the distinction between technology support and professional development.

Technology support would be tools that the teacher can utilize while professional development is

purposeful, planned training by the school or school district to train a teacher (Pittman & Gaines,

2015). This canonical correlation found a statistically significant relationship between a

teacher's technology access and support and TPACK score, with this variable accounting for

16.7% of a teacher's overall TPACK score variance ($p < .001$).

This finding aligns with other research. Carver (2016) found that 80% of the people

reported that the availability of technology is one of the largest hindrances of technology

implementation in the classroom. Moreover, 25% of the time, the lack of or existence of

available technology was the determining factor of whether technology would be implemented in

the classroom. The researcher concluded that availability of technology was a more significant

predictor of technology integration than the abilities of the teacher to use the technology.

Additionally, availability of technology can affect teachers' ability to learn how to use

technologies in general. This could lead to teachers being out of touch with newer technologies (Vu & Fadde, 2014).

Professional Development

Professional development refers to the training activities teachers receive from the school or school district to further their knowledge or usage of technology (Pittman & Gaines, 2015). This canonical correlation found a statistically significant relationship between professional development and TPACK score, with this variable accounting for 26.0% of a teacher's overall TPACK score variance ($p < .001$).

This research is in line with a study by Ertmer et al. (2012) that concluded that teachers often require a push from the school system through professional development to integrate technology into the classroom. Therefore, professional development can often become the catalyst that eventually leads teachers to adopt and implement technology into their classrooms. Similarly, Kopcha (2012) found in a longitudinal survey spanning two years that teachers need professional development in order to know how to integrate technology into their classrooms. Specifically, Kopcha (2012) noted that job-embedded, long-term professional development was the most effective means to technology integration.

Further giving credit to the impact of professional development on technology integration, a study by Lee et al. (2017) found that the ability of teachers to utilize technology in the classroom does grow with time. This growth also leads to a greater comfort with technology integration and allows teachers to utilize newer technologies as they become available. Therefore, professional development can have lasting impacts beyond the initial training that is provided on a specific product.

Teacher Attitudes Toward Technology

Teacher attitudes toward technology refers to the beliefs held by the teacher about technology in relation to its integration and effectiveness (Pittman & Gaines, 2015). This canonical correlation found a statistically significant relationship between a teacher's attitudes toward technology and TPACK score, with this variable accounting for 27.1% of a teacher's overall TPACK score variance ($p < .001$).

There is a wealth of literature that supports the idea that the attitudes a teacher has toward technology integration affects its implementation into the classroom. Howard (2013) found that the knowledge a teacher has about technology plays a vital role in its usage in the classroom. Specifically, if a teacher feels an aversion to a technology, he or she may not be able to fully realize the benefits of implementing it into the classroom. Chang and Chen (2015) found a link between creative teaching behaviors and the use of technology in the classrooms. Hung and Jeng (2013) believe that the positive attitudes a teacher has toward technology can affect the implementation of it in the classroom. Conversely, negative attitudes toward a technology are believed to hinder the implementation of a technology into the classroom. Teo (2013) concluded that the most impactful way that administrators can affect change on technology implementation in the classroom is to drive positive attitudes about the utilization of technology in schools. Blackwell et al. (2016) surmised that teachers' personal attitudes seemed to have the greatest impact on technology usage.

Contrasting this research study, Shin et al. (2014) held that a teacher's attitudes toward technology is the single largest predictor of its usage. In the current research study, teacher attitudes toward technology was found to have the second highest effect on TPACK scores, with general technology usage having an $r^2 = .341$. Additionally, it should be noted that Rienties et al. (2014) found that there was no statistically significant relationship between the teacher's

perception of the usefulness of a technology and the integration of the technology. Rather, instructors are more likely to integrate easier-to-use technologies than ones that they believe to be the most useful.

Technology Usage of Students

Technology usage of students refers to the ways in which a student uses technology in the classroom and in his or her daily life (Pittman & Gaines, 2015). This canonical correlation found a statistically significant relationship between student use of technology and a teacher's TPACK score, with this variable accounting for 15.5% of a teacher's overall TPACK score variance ($p < .001$).

Kim et al. (2013) suggested that when teachers have the belief that students can discover things for themselves when utilizing technology, there can be a change in the way technology is implemented in the classroom. This could help explain why a teacher's TPACK score may be affected by the technology that he or she sees students using in their classrooms. Carver (2016) found that a majority of the participants in his survey (59%) believed that technology usage increases student engagement. This belief would seem to transfer to integration and TPACK score enhancement.

General Technology Usage by the Teacher

General technology usage by the teacher refers to the ways in which a teacher uses technology in the classroom and in his or her daily life (Pittman & Gaines, 2015). This canonical correlation found a statistically significant relationship between a teacher's use of technology and a teacher's TPACK score, with this variable accounting for 34.1% of a teacher's overall TPACK score variance ($p < .001$).

This finding is consistent with other studies in the TPACK literature. Aldunate and Nussbaum (2013) found that the ease of use of a technology affects how it is utilized in the

classroom. Technologies that are more difficult to use are more likely to be abandoned. However, as teachers use new technologies more and more, they are more likely to be open to utilizing other, newer technologies in a cycle of technology adoption. Bilici et al. (2016) reached a similar conclusion, stating that teachers must practice with available technologies in order to link theoretical knowledge to classroom usage.

So et al. (2012) believed that personal computer usage in one's personal life would have pedagogical implications in the classroom. However, the research of these authors found that one's own personal computer usage does not seem to predict whether technology will be utilized to deliver classroom lessons. Moreover, the authors theorized that technological knowledge may not translate into the knowledge required to teach with technology very easily. This finding would seem to contrast with this study's, which was that a teacher's general use of technology is the largest predictor on TPACK scores of the five integration factors considered ($r^2 = .341$, $p < .001$).

Implications

The premise of the research study was that theory leads to practice. Therefore, if teachers know how to teach with technology (as measured by TPACK), there should be technology integration in the classrooms (as measured by the five integration factors of the STIR survey). This study presents compelling evidence that there is a link between TPACK scores and the technology integration factors of technology access and support, professional development, teacher attitudes toward technology, technology usage of students, and the general technology usage of the teacher. Even with this link established, the idea that correlation does not equal causation must be an integral part of the analysis. Though there is a clear predictor relationship established by the data, it cannot be said for certain that professional development, for example, leads to higher TPACK scores for teachers in East Tennessee (or vice versa). With that being

established, there are several interesting pieces of data that have implications for teachers in the classroom, for administrators at the school and district offices, and for postsecondary educators in teacher preparatory schools.

First, the data establish that no one variable solely affects a teacher's TPACK score (or how well he or she knows how to teach with technology). It is a symphony of many factors contributing to the knowledge of effective technology integration. This is consistent with the research of Blackwell et al. (2013), who suggested that there is rarely one specific reason that leads to teachers utilizing technology. The authors note that there are many different avenues that can lead to encouragement of its use. Though some factors appear to have a greater effect on the variance in TPACK scores, the absence of any one of these variables is notable. Teachers should seek holistic development and a well-rounded approach that is made up of both theoretical learning (e.g., professional development) and practical implementations of technology (e.g., general technology usage by the teacher) if they wish to increase their TPACK score.

Though the literature reviewed for this study establishes that a teacher's attitude toward technology integration ($r^2 = .271$) is one of the greatest predictors of its eventual integration, it is interesting to note that general technology usage of the teacher ($r^2 = .341$) had a stronger relationship with the TPACK score. It is conceivable that teachers who utilize technology more in their personal lives are more likely to have positive attitudes about its integration into the classroom. However, the relationship between the variables could also be less theoretical (i.e., how a teacher feels about the integration of technology) and have more to do with practical applications of technology. A teacher might feel more comfortable with technology integration if he or she uses it himself or herself for non-school related tasks.

Though it had the weakest relationship among the dependent variables in this study, the technology usage of students' effect on TPACK scores ($r^2 = .155$) highlights the possibility that

student knowledge of technology can impact the teacher's understanding of how to utilize technology in the classroom. Perhaps there is knowledge transference from the student to the teacher, or perhaps the teacher feels more comfortable utilizing technology because he or she believes the student will be able to handle any misunderstandings on the part of the teacher or glitches with the technology's correct operation.

The relatively strong relationship between professional development and TPACK scores (r^2 = .260) accents the importance of its inclusion in schools and financial backing from funding bodies. A study by Vu and Fadde (2014) concluded that 75% of teacher candidates do not take any courses on integrating technology into the classroom. Professional development is a critical component that affects TPACK scores, and this training often becomes the complete burden of the school system. Professional development can provide both theoretical and practical support for technology integration: teachers can learn how to use a technology, envision it in action in their classrooms or see peers using it, and receive the ongoing support that makes them feel comfortable in the actual implementation.

Interestingly, technology access and support (r^2 = .167) had a smaller effect size on TPACK scores than most of the other dependent variables. It would seem logical that teachers who have access to technology would use the technology more and therefore have a higher TPACK score. Perhaps this finding highlights that teachers can envision ways to use technology in the classroom even if they do not have the funds to purchase such technologies for use. In light of this finding, schools and districts might be able to utilize a TPACK survey to determine how to allocate limited funds. Additionally, the lower effect size of technology access could highlight the theoretical nature of TPACK and underscore that knowing how to teach with technology does not necessarily lead to it being implemented in the classrooms.

Limitations

Several limitations to this study exist. First, the participants were chosen through convenience sampling. Additionally, the sample was derived from one region of East Tennessee. Though participants were selected from two school districts, the sample may not be representative of other populations. Therefore, results cannot necessarily be applied to any other population.

Additionally, participants were recruited from a pool of educators who used the online LMS Blackboard. Differences among teachers who do not utilize this specific online LMS or utilize no LMS at all make it difficult to generalize the results beyond the population of this study. Furthermore, the restricted timespan of the survey is another limitation. Because the study used one data point from participants and was not conducted over a period of time, inherent vulnerabilities and limitations to the generalizability of the data to a wider audience become evident.

Finally, another limitation of the study comes from the inherent qualities of the subject. Latent variables are common in educational studies. These are variables that are not observable but inferred from other variables. Because latent variables existed in both surveys used in the study (e.g., TPACK score, professional development score), a canonical correlation was chosen to help account for and mitigate the chance of a Type I error in the study. Though every precaution has been taken to produce meaningful data, the inherent method of defining variables in education by nonobservable and self-reported "feelings" can lead to inaccurate results. Though the very strong relationships found in the primary design and follow-up tests on the individual variables do help reduce the concerns of the latent variables, the risk cannot be completely mitigated by these results alone.

Recommendations for Future Research

This study focuses on TPACK and integration factors of technology in the classroom. Throughout the course of this study, further considerations for additional research that will increase the body of knowledge on these topics have become apparent. These include:

1. Research into TPACK and technology integration factors in varying populations and geographic areas. This study focused on two school districts in East Tennessee. Further research is suggested to be conducted on a larger population and in more diverse geographical areas.

2. Research into TPACK and technology integration factors in populations that do not utilize Blackboard or who do not use an LMS at all. This research study utilized a sample of educators who used the online LMS Blackboard. Because part of the design of the TPACK survey (Archambault & Crippen, 2009) used in this study measured effectiveness of using these platforms, a single LMS was utilized to limit the LMS from becoming a confounding variable. The test could be repeated as is with a different LMS.

3. Similar research designs with different technology integration factors being considered for variables. The STIR (Pittman & Gaines, 2015) highlights five of the most influential factors of technology integration into the classroom. However, these five integration factors do not make up the entirety of reasons teachers choose to utilize technology in the classroom. Further research with similar designs and different integration factors should be considered.

4. TPACK and technology integration factors research with teaching experience considered as a covariate. Though teaching experience was collected as a demographic variable for this study, it was not used in the formal research design. Further research that looks at

technology integration's effect on TPACK with teaching experience considered as a covariate could extend the understanding of TPACK overall.

5. A longitudinal study of the TPACK and STIR surveys over time. Technology is a changing medium. This study looked at a snapshot of the participants at one moment in time. A longitudinal study that looked at TPACK and technology integration factors over time could help researchers understand the effects of experience on TPACK.

Summary

This study sought to understand if there was a link between knowing how to teach with technology and its implementation into the classroom. By using the TPACK survey (Archambault & Crippen, 2009) and the STIR (Pittman & Gaines, 2015) a design was developed to assess the relationship between a teacher's TPACK score and the five integration factors of the STIR survey. A canonical correlation was used for the study, whose sample was 137 participants from two school districts in East Tennessee. The research presented in this study concluded that there is a statistically significant link between TPACK scores and the five integration factors ($\Lambda = .525$, $p < .001$) with the implications of the study having impactful results for teachers, administrators, and postsecondary instructors.

REFERENCES

Aldunate, R., & Nussbaum, M. (2013). Teacher adoption of technology. *Computers in Human Behavior, 29*(3), 519–524. doi:10.1016/j.chb.2012.10.017

An, Y., & Reigeluth, C. (2012). Creating technology-enhanced, learner-centered classrooms: K-12 teachers' beliefs, perceptions, barriers, and support needs. *Journal of Digital Learning in Teacher Education, 28*(2), 54–62.

Archambault, L. M., & Barnett, J. H. (2010). Revisiting technological pedagogical content knowledge: Exploring the TPACK framework. *Computers & Education, 55*(4), 1656–1662.

Archambault, L. M., & Crippen, K. J. (2006). The preparation and perspective of online K-12 teachers in Nevada. In T. Reeves & S. Yamashita (Eds.), *Proceedings of the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 1836–1841). Chesapeake, VA: Association for the Advancement of Computers in Education.

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education, 9*(1), 71–88. doi:10.1080/0158791022000009213

Baylor, A., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers & Education, 39*(4), 395–414. doi:10.1016/S0360-1315(02)00075-1

Bilici, S. C., Guzey, S. S., & Yamak, H. (2016). Assessing pre-service science teachers' technological pedagogical content knowledge (TPACK) through observations and lesson plans. *Research in Science & Technological Education, 34*(2), 237–251. doi:10.1080/02635143.2016.1144050

Bilici, S. C., Yamak, H., Kavak, N., S. Guzey, S. S., Donna, J. D., & Roehrig, G. (2012). *Evaluating pre-service science teachers' self-efficacy toward TPACK*. Poster session presented at the Colloquium on P-12 STEM Education Research, Minnesota, MN.

Blackwell, C. K., Lauricella, A. R., & Wartella, E. (2016). The influence of TPACK contextual factors on early childhood educators' tablet computer use. *Computers & Education, 98*, 57–69. doi:10.1016/j.compedu.2016.02.010

Blackwell, C. K., Lauricella, A. R., Wartella, E., Robb, M., & Schomburg, R. (2013). Adoption and use of technology in early education: The interplay of extrinsic barriers and teacher attitudes. *Computers & Education, 69*, 310–319. doi:10.1016/j.compedu.2013.07.024

Carver, L. B. (2016). Teacher perception of barriers and benefits in K-12 technology usage. *The Turkish Online Journal of Educational Technology, 15*(1), 110–116.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of Technological Pedagogical Content Knowledge. *Educational Technology & Society, 16*(2), 21–51.

Chang, C., & Chen, I. (2015). Correlation between pre-service teachers' information technology integration attitude and creative teaching behavior. *Creative Education, 6*, 1802–1814. doi:10.4236/ce.2015.616184

Chang, Y., Tsai, M. F., & Jang, S. J. (2014). Exploring ICT use and TPACK of secondary science teachers in two contexts. *US-China Education Review*, *4*(5), 298–311.

Comas-Quinn, A. (2011). Learning to teach online or learning to become an online teacher: An exploration of teachers' experiences in a blended learning course. *ReCALL, 23*(3), 218–232. doi:10.1017/S0958344011000152

Crippen, K. J., Archambault, L. M., & Kern, C. L. (2013). The nature of laboratory learning experiences in secondary science online. *Research in Science Education, 43*(3), 1029–1050. doi: 10.1007/s11165-012-9301-6

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25–40. doi:10.1007/BF02504683

Ertmer, P. A., Ottenbreit-Leftwich, A., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, *59*, 423–435. doi:10.1016/j.compedu.2012.02.001

Gall, M. D., Gall, J. P., & Borg, W. D. (2007). *Educational research: An introduction* (8th ed.). Boston, MA: Pearson.

Gerard, L. F., Varma, K., Corliss, S. B., & Linn, M. C. (2011). Professional development for technology-enhanced inquiry science. *Review of Educational Research, 81*(3), 408–448. doi:10.3102/0034654311415121

Graham, J., & Semic, W. G. (2006). A model for effectively integrating technology across the curriculum: A three-step staff development program for transforming practice. *International Journal of Information and Communication Technology Education, 2*(1), 1–11.

Graves, M., Sales, G. C., Lawrenz, F., Robelia, B., & Richardson, J. W. (2010). Effects of technology-based teacher training and teacher-led classroom implementation on learning reading comprehension strategies. *Contemporary Educational Technology*, *1*(2), 160–174.

Green, L. S. (2014). Through the looking glass. *Knowledge Quest, 43*(1), 36–43.

Guzman, A., & Nussbaumt, M. (2009). Teaching competencies for technology integration in the classroom. *Journal of Computer Assisted Learning, 25*(5), 453–469. doi:10.1111/j.1365-2729.2009.00322.x

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2009). *Multivariate data analysis* (7th ed.). Upper Saddle River, NJ: Prentice Hall.

Hao, Y. (2016). The development of pre-service teachers' knowledge: A comteplative approach. *Computers in Human Behavior, 60*, 155–164. doi: 10.1016/j.chb.2016.02.054

Howard, S. (2013). Risk-aversion: Understanding teachers' resistance to technology integration. *Technology, Pedagogy and Education, 22*(3), 357–372. doi:10.1080/1475939X.2013.802995

Hung, W., & Jeng, I. (2013). Factors influencing future educational technologists' intentions to participate in online teaching. *British Journal of Educational Technology, 44*(2), 255–272. doi:10.1111/j.1467-8535.2012.01294.x

Inan, F., & Lowther, D. (2010). Factors affecting technology integration in K-12 classrooms: A path model. *Educational Technology Research and Development*, *58*(2), 137–154. doi:10.1007/s11423-009-9132-y

Jacobs-Israel, M. (2013). Redefining technology in libraries and schools: AASL best apps, best websites, and the SAMR model. *Teacher Librarian, 41*(2), 16–18.

Kelly, M. A. (2010). Technological Pedagogical Content Knowledge (TPACK): A content analysis of 2006–2009 print journal articles. In D. Gibson, & B. Dodge (Eds.), *Proceedings of the Society for Information Technology & Teacher Education International Conference* (pp. 3880–3888). Chesapeake, VA: AACE.

Kharade, K., & Peese, H. (2014). Problem-based learning: A promising pathway for empowering preservice teachers for ICT-mediated language teaching. *Policy Futures in Education*, *12*(2), 262–272. doi:10.2304/pfie.2014.12.2.262

Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education, 29*, 76–85. doi:10.1016/j.tate.2012.08.005

Koehler, M. (2012). Using the TPACK image. Retrieved from http://www.tpack.org/

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research, 32*(2), 131–152.

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on Innovation and Technology (Ed.), *The handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3-29). Mahwah, NJ: Lawrence Erlbaum Associates.

Koehler, M. J., & Mishra, P. (2009). What is Technological Pedagogical Content Knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70. doi:10.1016/j.compedu.2010.07.009

Koehler, M. J., Mishra, P., Hershey, K., & Peruski, L. (2004). With a little help from your students: A new model for faculty development and online course design. *Journal of Technology and Teacher Education, 12*(1), 25–55.

Koehler, M. J., Shin, T. S., & Mishra, P. (2011). How do we measure TPACK? Let me count the ways. In R. N. Ronau, C. R. Rakes, & M. L. Niess (Eds.), *Educational technology, teacher knowledge, and classroom impact: A research handbook on frameworks and approaches* (pp. 16–31). Hershey, PA: Information Science Reference.

Koh, J. H. L., Chai, C. S., Benjamin, W., & Hong, H. Y. (2015). Technological Pedagogical Content Knowledge (TPACK) and design thinking: A framework to support ICT lesson design for 21st century learning. *The Asia-Pacific Education Researcher*, *24*(3), 535–543. doi:10.1007/s40299-015-0237-2

Kopcha, T. J. (2010). A systems-based approach to technology integration using mentoring and communities of practice. *Education Technology Research Development, 58*(2), 175–190. doi:10.1007/s11423-008-9095-4

Kopcha, T. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education*, *59*(4), 1109–1121. doi:10.1016/j.compedu.2012.05.014

Krajcik, J., & Varelas, M. (2007). Ninth-grade student engagement in teacher-centered and student-centered technology-enhanced learning environments. *Science Education, 91*(1), 36–74.

Kurt, S. (2013). Examining teachers' use of computer-based technologies: A case study. *Education and Information Technologies, 18*(4), 557–570. doi:10.1007/s10639-012-9199-7

Kurt, S., & Muhammed, C. (2012). Barriers to teachers' use of technology. *International Journal of Instructional Media, 39*(3), 225–238.

Lee, H., Longhurst, M., & Campbell, T. (2017). Teacher learning in technology professional development and its impact on student achievement in science. *International Journal of Science Education, 39*(10), 1282–1303. doi:10.1080/09500693.2017.1327733

Magidin de Kramer, R., Masters, J., O'Dwyer, L., Dash, S., & Russell, M. (2012). Relationship of online teacher professional development to seventh-grade teachers' and students' knowledge and practices in English language arts. *The Teacher Educator 47*(3), 236–259. doi:10.1080/08878730.2012.685795

Miranda, H., & Russell, M. (2012). Understanding factors associated with teacher-directed student use of technology in elementary classrooms: A structural equation modeling

approach. *British Journal of Educational Technology, 43*(4), 652–666.

doi:10.1111/j.1467-8535.2011.01228.x

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework

for teacher knowledge. *The Teachers College Record, 108*(6), 1017–1054.

Munzur, Z. (2013). Technology is our friend: Using technology to teach English learning

strategies. *Journal of Education and Future*, *2013*(4), 51–64.

Murphy, E., Rodriguez-Manzanares, M. A., & Barbour, M. (2011). Asynchronous and

synchronous online teaching: Perspectives of Canadian high school distance education

teachers. *British Journal of Educational Technology, 42*(4), 583–591.

doi:10.1111/j.1467-8535.2010.01112.x

Oliver, K., Kellogg, S., Townsend, L., & Brady, K. (2010). Needs of elementary and middle

school teachers developing online courses for a virtual school. *Distance Education, 31*(1),

55–75.

Pedhazur, E. J. (2007). *Multiple regression in behavioral research: Explanation and prediction*.

Orlando, FL: Harcourt Brace College Publishers.

Penchev, N. (2013). Supporting technology integration in the classroom. *Middle Ground, 16*(4),

24–25.

Pittman, T., & Gaines, T. (2015). Technology integration in third, fourth, and fifth grade

classrooms in a Florida school district. *Educational Technology Research and

Development, 63*, 539–554.

Puentedura, R. (2013). *SAMR: Beyond the basics.* Retrieved from

http://www.hippasus.com/rrpweblog/archives/2013/04/26/SAMRBeyondTheBasics.pdf

Reeves, D. B. (2010). *Transforming professional development into student results.* Alexandria,

VA: ASCD.

Rhoades, E., Friedel, C., & Irani, T. (2008). Classroom 2.0: Student's[1] feelings on new technology in the classroom. *NACTA*, *52*(4), 32–38.

Rienties, B., Giesbers, B., Lygo-Baker, S., Ma, H. W. S., & Rees, R. (2014). Why some teachers easily learn to use new virtual learning environment: A technology acceptance perspective. *Interactive Learning Environments, 24*(3), 1–14. doi:10.1080/10494820.2014.881394

Rivero, V. (2010, March/April). Technology-based professional development. *Multimedia and Internet at Schools*, 19–23.

Rosenberg, J. M., & Koehler, M. J. (2015). Context and Technological Pedagogical Content Knowledge (TPACK): A systematic review. *Journal of Research on Technology in Education*, *47*(3), 186–210. doi:10.1080/15391523.2015.1052663

Ruggiero, D., & Mong, C. J. (2015). The teacher technology integration experience: Practice and reflection in the classroom. *Journal of Information Technology Education: Research, 14*, 161-178.

Russell, M., Bebell, D., O'Dwyer, L., & O'Connor, K. (2003). Examining teacher technology use: Implications for preservice and inservice teacher preparation. *Journal of Teacher Education, 54*(4), 297–310. doi:10.1177/0022487103255985

Sadaf, A., Newby, T. J., & Ertmer, P. A. (2012). Exploring factors that predict preservice teachers' intentions to use Web 2.0 technologies using decomposed theory of planned behavior. *Journal of Research on Technology in Education, 45*(2), 171–195. doi:10.1080/15391523.2012.10782602

Sang, G., Valcke, M., van Braak, J., Tondeur, J., & Zhu, C. (2011). Predicting ICT integration into classroom teaching in Chinese primary schools: Exploring the complex interplay of

---

[1] The published article includes this typo.

teacher-related variables. *Journal of Computer Assisted Learning, 27*(2), 160–172. doi:10.1111/j.1365-2729.2010.00383.x

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological Pedagogical Content Knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, *42*(2), 123–149. doi:10.1007/978-1-60761-303-9

Shin, W. S., Han, I., & Kim, I. (2014). Teachers' technology use and the change of their pedagogical beliefs in Korean educational context. *International Education Studies, 7*(8), 11-22. doi:10.5539/ies.v7n8p11

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

So, H. J., Choi, H., Lim, W. Y., & Xiong, Y. (2012). Little experience with ICT: Are they really the Net Generation student-teachers? *Computers & Education, 59*(4), 1234–1245. doi:10.1016/j.compedu.2012.05.008

Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers & Education, 57*, 2432–2440. doi:10.1016/j.compedu.2011.06.008

Unger, K., & Tracey, M. (2013). Examining the factors of a technology professional development intervention. *Journal of Computing in Higher Education, 25*(3), 123–146. doi:10.1007/s12528-013-9070-x

U.S. Congress Office of Technology Assessment. (1995). *Teachers and technology: Making the connection*. Washington, DC: U.S. Government Printing Office.

Van Braak, J. (2001). Individual characteristics influencing teachers' class use of computers. *Journal of Educational Computing Research, 25*(2), 141–157 doi:10.2190/81YV-CGMU-5HPM-04EG

Vannatta, R., & Fordham, N. (2004). Teacher dispositions as predictors of classroom technology use. *Journal of Research on Technology in Education, 36*(3), 253–271. doi:10.1080/15391523.2004.10782415

Venezky, R. (2004). Technology in the classroom: Steps toward a new vision. *Education, Communication, & Information, 4*(1), 3–21.

Voogt, J., Fisser, P., Roblin, N. P., Tondeur, J., & Van Braak, J. (2012). Technological Pedagogical Content Knowledge—A review of the literature. *Journal of Computer Assisted Learning*, *29*, 109–121. doi:10.1111/j.1365-2729.2012.00487.x

Vu, P., & Fadde, P. (2014). A snapshot of technology integration training in teacher education programs. *International Journal of Psychology: A Biopsychosocial Approach, 14*, 139–150. doi:10.7220/2345-024X.14.7

Wang, S., Hsu, H., Campbell, T., Coster, D., & Longhurst, M. (2014). An investigation of middle school science teachers and students use of technology inside and outside of classrooms: Considering whether digital natives are more technology savvy than their teachers. *Education Technology Research Development, 62*(6), 637–662. doi:10.1007/s11423-014-9355-4

Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American Educational Research Journal*, *40*(4), 807–840. doi:10.3102/00028312040004807

APPENDIX A

RE: Article Figure-- Dissertation Usage Request

KOH Hwee Ling Joyce (LST) ████████████

Sun 4/17/2016 9:57 PM

To: Raper, Randal Cody ████████████

Cc: CHAI Ching Sing (LST) ████████████

Dear Randal,

Yes, you can have permission to use the figure. Please cite the article and Figure when using it: Koh, J. H. L., Chai, C. S., Benjamin, W., & Hong, H.-Y. (2015). Technological Pedagogical Content Knowledge (TPACK) and Design Thinking: A Framework to Support ICT Lesson Design for 21st Century Learning. *The Asia-Pacific Education Researcher*, 24(3), 535–543. doi:10.1007/s40299-015-0237-2

Thanks.

Regards,
Joyce

From: Raper, Randal Cody [mailto ████████████
Sent: Sunday, 17 April, 2016 10:00 PM
To: KOH Hwee Ling Joyce (LST)
Subject: Article Figure-- Dissertation Usage Request

Dr. Koh,

I am a doctoral student at Liberty University in Lynchburg, VA. I am in the process of writing my dissertation, and I would like to request permission to use "Figure 1: 21st CL ICT design thinking framework" from the publication listed below in my dissertation's literature review.

Koh, J. H. L., Chai, C. S., Benjamin, W., & Hong, H.-Y. (2015). Technological Pedagogical Content

Knowledge (TPACK) and Design Thinking: A Framework to Support ICT Lesson Design for 21st

Century Learning. *The Asia-Pacific Education Researcher*, 24(3), 535–543. doi:10.1007/s40299-

015-0237-2

May I use your figure in my research?

Sincerely,

R Cody Raper
E: ████████████

APPENDIX B

Re: Article Figure Usage Request

Yong Zhao <▮▮▮▮▮▮▮▮▮▮▮▮▮>

Mon 4/18/2016 9:56 AM

To: Raper, Randal Cody ▮▮▮▮▮▮▮▮▮

Thanks. Yos

Yong Zhao
http://zhaolearning.com

Sent from my iPhone

On Apr 16, 2016, at 6:17 PM, Raper, Randal Cody ◄▮▮▮▮▮▮▮► wrote:

Dr. Zhao,

I am a doctoral student at Liberty University in Lynchburg, VA. I am in the process of writing my dissertation, and I would like to request permission to use "Figure 2: The interactive process of technology adoption in schools" from the publication listed below in my dissertation's literature review.

Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological

perspective. *American Educational Research Journal, 40*(4), 807-840.
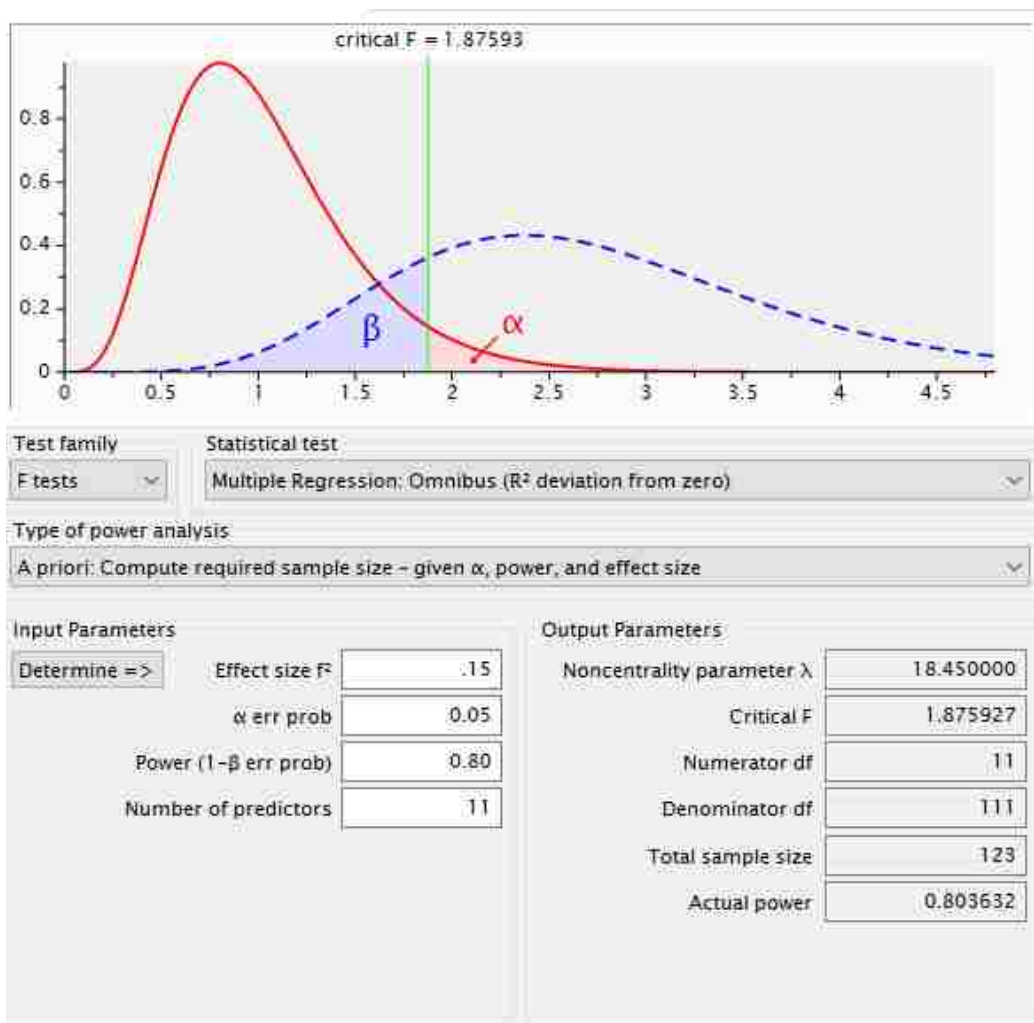
doi:10.3102/00028312040004807

May I use your figure in my research?

Sincerely,

R Cody Raper

APPENDIX C

G-Power Statistical Power Analysis

critical F = 1.87593

Test family	Statistical test
F tests	Multiple Regression: Omnibus (R² deviation from zero)

Type of power analysis

A priori: Compute required sample size – given α, power, and effect size

Input Parameters			Output Parameters	
Determine =>	Effect size F²	.15	Noncentrality parameter λ	18.450000
	α err prob	0.05	Critical F	1.875927
	Power (1–β err prob)	0.80	Numerator df	11
	Number of predictors	11	Denominator df	111
			Total sample size	123
			Actual power	0.803632

APPENDIX D

Re: TPACK Survey

Leanna Archambault ◄ ███████████████████████ ►

Sat 11/14/2015 3:47 PM

To Raper, Randal Cody ████████████ :

Hello Mr. Raper,

Thank you very much for contacting me for permission to use my TPACK survey in your doctoral research. I would be happy for you to do so. For attribution, the following citation should be used:

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education, 9*(1), 71-88.

Many thanks,
Leanna

Leanna Archambault, Ph.D.
Associate Professor
Arizona State University
Mary Lou Fulton Teachers College
████████████

On Nov 13, 2015, at 6:17 PM, Raper, Randal Cody ◄ ████████████ ► wrote:

Dr. Archambault,

I am a doctoral student at Liberty University in Lynchburg, VA. I would like to request to use your TPACK survey in my doctoral dissertation. Would you allow this use?

Thank you for your consideration, and please let me know if you have any questions.

Sincerely,

R Cody Raper
E: ████████████

APPENDIX E

Re: Survey of Technology Integration and Related Factors (STIR)

Trudi Gaines ◄ ▇▇▇▇▇▇ ►

Sat 9/12/2015 2:45 PM

To Raper, Randal Cody ▇▇▇▇▇▇

◄ ▇▇▇▇▇▇ ▇▇▇▇▇▇

Dear Cody,

Thank you so much for your interest in our measuring instrument. We are happy to give permission with ownership of the instrument clearly indicated in your dissertation or in any subsequent publications you may have that include your findings from this instrument.

We would also be happy to receive a copy of your methods and results section and or a link to the final copy of your dissertation.

Best of luck to you in your research and writing.

Dr. Trudi Gaines

Trudi Gaines, EdD, LMHC
Assistant Professor
Department of Teacher Education and Educational Leadership
College of Education and Professional Studies
▇▇▇▇▇▇

On Sat, Sep 12, 2015 at 1:36 PM, Raper, Randal Cody ◄ ▇▇▇▇▇▇ ► wrote:

Researchers:

Hello, my name is Cody Raper. I am a doctoral student at Liberty University in Lynchburg, VA. I am planning my dissertation study at this time. I would like to utilize your instrument "Survey of Technology Integration and Related Factors (STIR)" in a study I plan to do for my doctoral dissertation. May I use your instrument in my study?

APPENDIX F

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

October 31, 2017

Randal Cody Raper
IRB Exemption 3029.103117: The Relationship between Secondary Teachers' Technological
Pedagogical Content Knowledge and Technology Integration Factors

Dear Randal Cody Raper,

The Liberty University Institutional Review Board has reviewed your application in accordance
with the Office for Human Research Protections (OHRP) and Food and Drug Administration
(FDA) regulations and finds your study to be exempt from further IRB review. This means you
may begin your research with the data safeguarding methods mentioned in your approved
application, and no further IRB oversight is required.

Your study falls under exemption category 46.101(b)(2), which identifies specific situations in
which human participants research is exempt from the policy set forth in 45 CFR 46:101(b):

> (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey
> procedures, interview procedures or observation of public behavior, unless:
> (i) information obtained is recorded in such a manner that human subjects can be identified, directly or
> through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside
> the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the
> subjects' financial standing, employability, or reputation.

Please note that this exemption only applies to your current research application, and any
changes to your protocol must be reported to the Liberty IRB for verification of continued
exemption status. You may report these changes by submitting a change in protocol form or a
new application to the IRB and referencing the above IRB Exemption number.

If you have any questions about this exemption or need assistance in determining whether
possible changes to your protocol would change your exemption status, please email us at
█████████████

Sincerely,

█████████████

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
The Graduate School

LIBERTY
UNIVERSITY.
Liberty University | Training Champions for Christ since 1971

APPENDIX G

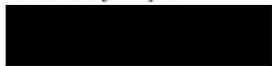Director of Schools   Assistant Director
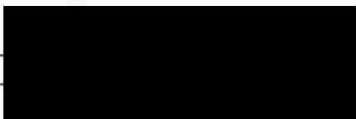
November 7, 2016

Mr. Cody Raper

[redacted]

Dear Mr. Raper,

As you conduct research for your dissertation focusing on the TPACK model of instructional technology, I grant permission for you to distribute surveys to [redacted] Schools teachers. I look forward to reviewing and discussing the results of your research.

Sincerely,

Director of Schools

APPENDIX H

███████████████████████

Director of Schools   _Assistant Director of Schools_

November 11, 2016

Dear Mr. Raper:

You are hereby granted permission to conduct your research project exploring the relationship between the TPACK scores of teachers and the frequency of technology use in the classroom. Permission is granted with the understanding that teachers will be informed that participation is voluntary and no personally identifying information will be collected. I look forward to seeing the results.

Good luck.

Sincerely,

███████████

Director of Schools