EVALUATION OF KENYAN PRE-SERVICE TEACHERS' PREPAREDNESS TO INTEGRATE EDUCATIONAL TECHNOLOGY IN CLASSROOMS

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A case study was used to survey 308 teacher trainees in western Kenya to investigate the extent to which pre-service teachers in two Kenyan teacher training colleges are prepared to integrate technology in teaching. . The study uses the technological pedagogical and content knowledge (TPACK) framework to understand the knowledge needed by the pre-service teachers to integrate technology effectively. Data was gathered using the Survey of Pre-Service Teachers' Knowledge of Teaching and Technology and three open-ended questions. Data from the survey does not distinguish the TPACK variable among the respondents. The data suggests that the pre-service teachers rate themselves highly on the other six TPACK subscales of technological knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological pedagogical knowledge, and technological content knowledge. Further, the data suggests that the respondents' personal use of technology, to a large extent, influences how they use technology in classrooms. Lastly, the data indicates that the survey instrument is inadequate in capturing all the TPACK subscales in this population as it shows weak internal consistency. These findings imply that faculty in these colleges need to be more intentional and deliberate in teaching the trainees how to integrate technology in lessons. Policymakers and college administrators may also influence the teachers' personal use of technology to inculcate into the trainees tested methods of technology integration. Another implication is that future research could employ other supplementary methods, in addition to surveys, to find out the levels of technology integration in the teacher trainees.

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CHAPTER 1

INTRODUCTION

Learning institutions are increasingly adopting technology to engage and educate learners. Some learning environments are now rich with technology that can, for example, make it easier for teachers to reach learners. With all the probable advantages of educational technology in mind, teachers must be able to use this technology effectively in modern-day classrooms and learning environments. Teacher training faculty must teach pre-service teachers how to integrate technology to ensure that they can use it in classrooms, and students take advantage of the affordances of technology. The integration of technology in education has increasingly become an essential concern for education planners (Agyei & Voogt, 2011b). The quantity and quality of pre-service technology experienced by trainees in teacher education programs critically influence new teachers' adoption of technology (Tondeur, van Braak, Sang, Voogt, Fisser, & Ottenbreit-Leftwich, 2012).

Some research studies on the preparation of pre-service teachers to use educational technology in developing countries (Admiraal et al., 2017; Bang & Luft, 2013; Martin, 2015; Tondeur et al., 2012) show that teachers play a critical role in learner success. These studies note that pre-service teachers do this by organizing the learning environment to provide students with active, hands-on learning and authentic tasks and audiences for their work (Austin, Orcutt, & Rosso, 2001). Educational technologies may assist teachers in developing learning activities that have real-world applications and have authentic audiences. Teachers can demonstrate complex concepts through expert manipulation of technological tools.

Additionally, Tondeur, Roblin, van Braak, Voogt, and Prestridge (2017a) note that pre-service teachers should be prepared to integrate technology adequately into their educational practice. Tondeur et al. state that teachers' training institutions should provide pre-service teachers with the necessary competencies to teach with technology. Training future teachers to use technology effectively could be a global problem. Through this study, I explore the current state of this problem in selected pre-service teacher preparation colleges in the Kenyan context.

Some researchers have identified several barriers to the integration of technology in classrooms, including teachers' lack of vision, lack of access to infrastructure, time, opportunities for assessment, and professional development or training (Franklin, Turner, Kariuki, & Duran, 2001). Education policymakers have expended many resources on schools' technology budgets. However, there is still a need for teacher in-service and training on the use of technology applications and ongoing curriculum support so that the teachers can incorporate technology into the curriculum in meaningful ways (Ertmer, 1999). Nevertheless, one early study suggested that there is a gap between what pre-service teachers learn in their course and how teachers use technology in classrooms (Tondeur et al., 2012).

Although some researchers have done studies done in developed countries, there is limited research on the effect of preparing pre-service teachers in developing countries, especially countries in Sub-Saharan Africa, on how to integrate technology in classrooms. Researchers have done some studies in South Africa (Adegbenro, Gumbo, & Olakanmi, 2017; Chisango & Marongwe, 2018; Tarling & Ng'ambi, 2016; Voogt & Tondeur, 2015). The United Nations Educational Scientific and Cultural Organization (UNESCO), through the Rwanda Ministry of Education (2017), has also conducted studies on the integration of information communication technology (ICT) by Rwandese teachers. Known as the UNESCO ICT competency framework (ICT CFT), this framework outlines the competencies that teachers need to integrate ICT into their professional practice. However, another report by the UNESCO Institute for Statistics (UIS) (Wallet, 2015) notes that the most significant obstacle in measuring ICT in education in Sub-Saharan Africa is the lack of systematic data collection. The report notes that in many countries in this region, the integration of ICT is a low priority when compared to other objectives, including increasing enrollment rates, decreasing the proportion of out-of-school children, and ensuring an adequate number of trained teachers. The lack of data in these countries compounds the absence of a formal policy on educational technology use, limited financial resources, poor infrastructure, and teachers who lack technical skills for e-learning. In this paper, I use Alonso, López, Manrique, & Viñes', 2005) educational-paradigm-orientation to define e-learning as the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote learning and collaboration.

However, there is limited literature on how Kenyan training colleges train pre-service teachers on how to integrate technology. Researchers have carried out studies on Kenyan pre-service teachers' attitudes, beliefs, computer competence, and their self-efficacy (Wambiri & Ndani, 2016); factors influencing the adoption of educational technology (Ahmed, 2016); and pre-service teachers' institutional preparedness to adopt e-learning (Kiilu, Nyerere, & Ogeta, 2018). The study by Kiilu et al. examines training institutions' readiness indicators, which include the availability of infrastructure, internet connectivity, and competency using a United Nations Educational Scientific and Cultural Organization's (UNESCO) Institute of Statistics (UIS) instrument that designed to measure institutional factors.

Because the Kenyan government has spent almost 134 million US dollars to equip elementary schools with learning technologies (Rotich, 2017), there is a pressing need to evaluate the preparedness of Kenyan pre-service teachers to integrate technology into their classrooms. The problem is that there are few studies on the integration of technology in the curriculum of pre-service teachers' colleges in Kenya. This information would be useful in determining whether pre-service teachers apply this knowledge in their classrooms after they graduate. My focus is on the preparedness of pre-service teachers to integrate technology in selected Kenyan teachers' training colleges. Results from this study may contribute to lessening the dearth of empirical research in this crucial area.

1.1 Background

Moursund and Bielefeldt (1999) suggest that research has not correlated formal coursework on technology integration with pre-service teachers' technology application and integration in classrooms. Another study by Wright and Wilson (2005) proposed that prospective educators should have enough technical skills, be able to understand the advantages of using technology in the classroom and be willing to use technology to improve instruction for students.

Tondeur et al. (2012) synthesized 23 international qualitative research studies indexed in the Web of Science citation database to study technology integration in schools. They found that teacher education programs have struggled with selecting and implementing the most effective strategies on how to prepare pre-service teachers to integrate technology in their future lessons. Tondeur et al.'s survey found that many programs have attempted to develop pre-service teachers' technology skills through an introductory educational technology course. Tondeur et al. argued that the technology course in pre-service teacher training often does not model well the ICT-based teaching practices for the trainees. Thus, student teaching experiences are highly variable in their use of ICT, and students are often left to their own devices to figure out how to use ICT to teach their content effectively.

Furthermore, there is often the expectation of school administrators and officials that newly hired teachers be conversant with the integration of technology. Magliaro and Ezeife (2007) note that school leaders and administrators look to new teachers to fill the gap between the technology available in schools and its effective integration into the curriculum.

1.1.1 Inclusion of Technology Integration in Training

The inclusion of specific courses in teacher training and professional development is essential in increasing the teachers' skills in manipulating and using educational technology. Magliaro and Ezeife (2007) note that teachers' professional development is a critical factor in the successful integration of technology into classroom teaching. Successful technology integration into classrooms requires teachers to get training on how to master this task. Buabeng-Andoh (2012) has suggested that training in technology usually leads to the successful integration of technology in classrooms. Doering, Hughes, and Huffman (2003) note that because teachers are anxious about technology use, teachers are often reluctant to consider the worth of acquiring technical knowledge, and thus are unable to integrate technology within their curriculum.

In Chapter 2 of this study, I further discuss additional factors that influence teacher adoption of technology. Some of these factors include:

- The argument that new teachers often adopt technology practices that they learned in their first schools
- The view that new teachers build-up a small set of 'teaching scripts' that work for them, which evolve over their teaching profession, and they are reluctant to abandon these personal scripts as they advance in the profession
- The fact that the use of ICT is often poorly taught in teachers' colleges – it does not follow any structure and is not taught in the context of teaching scripts that are subject-specific (consistent with TPACK)
- Teachers' fear of technology failing to work at critical moments in class and causing the teachers to lose control of the class
- Teachers' perception of the usefulness and ease of use of technology, among others

1.1.2 Technology Integration in Kenyan Pre-Service Colleges

Over the last decade, there has been an increase in the use of computers in Kenyan schools. Many of these computers have been donations from both foreign and local well-wishers (Menjo & Boit, 2010). In a study of computer use in schools in a part of western Kenya, Menjo & Boit suggested that female teachers especially need more training using computers so that they can become comfortable using computers. Menjo and Boit found that there were relationships between what faculty taught teachers in ICT training and the extent of the use of ICT for instructional purposes by teachers. However, research by Kiptalam and Rodrigues (2010) notes that the most common use of computers in teaching by Kenyan teachers was for preparing papers and teaching material while the second most common use of the computers was collecting electronic handouts and reference material by teachers. Kiptalam and Rodrigues also found that most Kenyan teachers did not have ICT training at their training colleges, with 55% of the respondents indicating that they got into the teaching profession with no computer-use experience at all.

Most training in ICT for Kenyan pre-service teachers is on the use of word processors, spreadsheets, email, and internet use. In a survey of the use of computers in schools in rural Kenya, researchers Ogembo, Ngugi, and Pelowski (2012) found that 79% of the usage of computers in these schools is for record-keeping and administrative tasks. Ogembo, Ngugi, and Pelowski also found that 71% of the time, teachers use computers for computer literacy programs, 34% of the time for email communication, and 34% of the time for data processing (for example, preparing exams, attendance, sports record-keeping). Unsurprisingly, Ogembo, Ngugi, and Pelowski found that computers are only used 29% of the time for teaching, for classroom use by students. These percentages of use indicate that the teachers make multiple uses of computers, and these uses are not mutually exclusive. Thus, a teacher can use a computer for an administrative task and later use it for literacy.

Additionally, Ng'eno, Githua, and Changeiywo (2013) note that the current curriculum for Kenyan teacher training merely deals with 'teaching about computers.' Kenyan teacher training curriculum does not deal with how teachers can use computers to transform the teaching and learning process. Further, according to Gakuu and Kidombo (2012), teachers lack the expertise and time to prepare teaching material that integrates technology because of a full curriculum. Gakuu and Kidombo note that teachers feel that efforts to integrate technology into their lesson plans are an added workload that has neither any exclusive personal rewards nor is it mandated by the school curriculum. Further, Kenyan teachers also deal with a limited number of computers, frequent power blackouts, and computer virus attacks (subscription to anti-virus software are additional expenses). Kenyan teachers also face a lack of reference materials and resources that respond to the use of educational technology that targets the local learning environment. Significantly, Gakuu and Kidombo report that experienced teachers exhibit technophobia (further discussed in Chapter 2) mainly because their training did not include ICT integration as part of the curriculum. Mathipa and Mukhari (2014) also record this non-use of ICT by this experienced generation of teachers. They note that even some more practiced teachers exhibit anxiety in using technology to teach and that they are unable to reconcile the use of ICT and subject content.

1.1.3 Using the TPACK Framework

One way to measure how teachers can integrate technology can into pre-service teacher training is by using the Technology, Pedagogy, and Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). Although the TPACK framework is not without limitations or critics, researchers can functionally use it to provide some measure of teacher technology integration. I expound on these limitations in Chapter 2. Mishra and Koehler (2006) used Shulman's (1986) model for pedagogical content knowledge to build the TPACK framework. Mishra and Koehler added 'technological knowledge' to Shulman's content knowledge (CK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK) to form TPACK. TPACK thus incorporates technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). TPACK provides an intuitive understanding of teaching content with appropriate pedagogical methods and technologies (Schmidt et al., 2009).

Schmidt et al. (2009) define the seven components of TPACK as follows:

1. Technology knowledge (TK): Technology knowledge refers to the knowledge about various technologies, ranging from low-tech technologies such as pencil and paper to digital technologies such as the Internet, digital video, interactive whiteboards, and software programs.

2. Content knowledge (CK): Content knowledge is the “knowledge about actual subject matter that is to be learned or taught” (Mishra & Koehler, 2006, p. 1026). Teachers must know about the content they are going to teach and how the nature of knowledge is different for various content areas.
3. Pedagogical knowledge (PK): Pedagogical knowledge refers to the methods and processes of teaching and includes knowledge in classroom management, assessment, lesson plan development, and student learning.
4. Pedagogical content knowledge (PCK): Pedagogical content knowledge refers to the content knowledge that deals with the teaching process (Shulman, 1986). Pedagogical content knowledge is different for various content areas, as it blends both content and pedagogy, with the goal being to develop better teaching practices in the content areas.
5. Technological content knowledge (TCK): Technological content knowledge refers to the knowledge of how technology can create new representations for specific content. It suggests that teachers understand that, by using a specific technology, they can change the way learners practice and understand concepts in a specific content area.
6. Technological pedagogical knowledge (TPK): Technological pedagogical knowledge refers to the knowledge of how various technologies can be used in teaching and understanding that using technology may change the way teachers teach.
7. Technological pedagogical content knowledge (TPACK): Technological pedagogical content knowledge refers to the knowledge required by teachers for integrating technology into their teaching in any content area. Teachers have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) by teaching content using appropriate pedagogical methods and technologies. (Schmidt et al., 2009, p. 125)

1.1.4 Assessing Teachers’ Understanding of TPACK

Researchers may use the TPACK framework to conceptualize educational technology, not as a vehicle that simply delivers information; rather, those who use this framework should see technology as a facilitator for the acquisition of cognitive tools that amplify learners' higher-order cognitive processing (Kramarski & Michalsky, 2010). TPACK, unlike stand-alone technology courses, may be used to enable teachers to have strong content, pedagogical and technological knowledge, and to seamlessly weave these knowledge bases together (Admiraal et al., 2017). Researchers can use the TPACK framework to provide concurrent and authentic content and pedagogy that enables the integration of technology in lessons.

According to Koehler and Mishra (2005), the TPACK framework focuses on designing and evaluating teacher knowledge of authentic student learning in various content areas. One way to gauge whether effective teaching with technology is taking place is to use TPACK to understand how forms of knowledge interact with each other (Koehler & Mishra, 2008). Thus, effective TPACK enables teachers to:

- Understand how to represent concepts with technology
- Use technologies in constructive ways to teach content
- Understand what makes concepts difficult or easy to learn and how technology can assist students in learning these concepts
- Be knowledgeable on students' prior knowledge and theories
- Know how teachers can use technology to build on existing knowledge and develop new epistemologies (Mishra & Koehler, 2008)

Indeed, Drummond and Sweeney (2017) emphasize that for technology to be seamlessly integrated into a lesson, the most relevant domain of knowledge is the overlap between technological, pedagogical, and content knowledge. Drummond and Sweeney note that it is at this nexus of technology, pedagogy, and content that knowledge on how to integrate technology best, teaching practices, and specific content knowledge resides the most effective learning experience for students.

It is essential to be able to assess approaches for measuring TPACK for teachers to tailor professional development and other training courses that change teachers' knowledge (Schmidt et al., 2009). Several tools for assessing teachers' knowledge of TPACK use survey methods that provide self-assessment questions intended to gauge pre-service teachers' and practicing teachers' levels of TPACK (Schmidt et al.). Making meaningful modifications, improvements, or changes to classroom instructional approaches cannot take place without a thorough understanding of students' fundamental technology skills (Kyei-Blankson, Keengwe, & Blankson, 2009) and understanding the level of TPACK among teachers is a step in this direction. In a review of 303 TPACK research publications and measures between 2006 and June 2010, Koehler, Shin, and Mishra (2012) found a strong indication that the TPACK framework has indeed provided researchers with a set of conceptual tools with which to articulate precise research questions. Koehler, Shin, and Mishra found that the TPACK framework is robust and applicable across multiple contexts and domains.

1.2 Statement of the Problem

The problem for this study is: Educational planners should have some understanding of the integration of technology into classrooms by conducting some evaluation on what the pre-service teachers understand about educational technology. Given similar research using the TPACK framework in Africa in general (Agyei, 2012; Evoh, 2009; Nkula & Krauss, 2014; & Omariba, 2016), this framework may also be well-suited to interrogate the integration of technology for pre-service teachers in the Kenyan context. Can the TPACK framework be effectively used to measure technology integration in Kenya pre-service teachers' colleges?

1.3 Purpose of the Study

The purpose of this study is to examine the extent of educational technology integration among pre-service teachers in selected Kenyan teachers' training colleges as measured by

TPACK. Education policymakers may find this research useful in evaluating pre-service teachers' barriers in using educational technology as indicated by the Technological, Pedagogical, and Content Knowledge (TPACK) framework. I will study these barriers will in the context of a developing country-Kenya, which will enable me to judge how applicable the TPACK framework is to the Kenyan context.

1.4 Research Questions

I have four research questions for this study. Through Question 1, I intend to find out only the presence of the TPACK constructs among these students. For Research Question 2, I planned to establish the various levels of the TPACK subscales of TK, CK, PK, PCK, TPK, and TCK for these respondents. The following are the research questions for this research:

1. To what extent do pre-service teachers in selected Kenyan teachers' training colleges demonstrate knowledge of TPACK necessary for integrating technology in their teaching?
2. To what extent do pre-service teachers in selected Kenyan teachers' colleges demonstrate knowledge of the TPACK domains of technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK)?
3. To what extent do personal experiences with technology impact the use of educational technology by pre-service teachers in selected Kenyan teachers' training colleges?
4. To what extent does the TPACK framework capture the readiness of pre-service teachers to use ICT for classroom instruction?

1.5 Nature of the Study

1.5.1 Study Design

I used a survey in a case study of the two teachers’ colleges to enable me to derive some descriptions of the characteristics of my study population and to answer the research questions. Data from the survey helped me to study how members of a population distribute themselves on one or more variables (Fraenkel, Wallen, & Hyun, 2016). Since I based the results from the study on an analysis of self-reports on the possible integration of educational technology, the survey method is best suited to gather data from a sample of the teachers. Results from the survey also provided data that enabled me to answer the research questions. I derived additional data from three open-ended questions that I included at the end of the questionnaire.

1.5.2 Participants

I distributed the survey instrument to students in pre-service teachers' training colleges in Kenya. As explained later in Chapter 3, I approached these pre-service teacher students at their colleges and requested them to participate in the study. They were a convenience sample that was accessible to my assistants, and I. Most of the pre-service teachers in Kenya have completed high school and are mostly under 30 years old. Estimates from the Kenya Ministry of Education (2017) indicate that these pre-service teachers are evenly distributed between male and female trainees. In 2015 the number of Kenyan pre-primary education teachers rose to 107,187 up from 101,062 in 2013 (Ministry of Education, Republic of Kenya, 2017). However, like most Sub-Saharan Africa countries, Kenya continues to face a shortage of qualified teachers. Furthermore, the government lacks the funds to employ additional teachers who are qualified but cannot find work.

I recruited the participants from students in two Kenya public pre-service teacher training colleges. A minimum of 100 subjects would have been enough for this study (Fraenkel et al., 2016). However, a similar study in central Kenya (Omariba, 2016), determined that a sample of between 20% to 30% of the target population provided an adequate sample. Moreover, power size calculations using online tools from the University of Iowa (Lenth, 2006) determined that with a power value of 0.8 (80%) and a standard deviation of 4 (arrived at from similar studies), the optimum sample size is 324. Consequently, with the previous related studies as a guide (Koh, & Chai, 2011; Omariba, 2016; Saade, Nebebe, & Tan, 2007), and the power calculations above, I found that 300 respondents to be an acceptable target for this study.

1.6 Significance of the Study

About eight years ago, some researchers suggested that beginning teachers do not make extensive use of technology in their lessons (Agyei & Voogt, 2011b; Omariba, 2016). In a study of teachers' use of technology in classrooms in Thailand, Tanak (2018) found that most teachers use technology as a tool for word processing or information retrieval instead of incorporating technology support inquiry that promotes students' deeper conceptual understanding of ideas. However, continued use and experience with technology may serve to increase beginning teachers' commitment to using technology from pre-service education to actual professional practice (Tondeur et al., 2017a). With this present study, I intend to extend the use of the TPACK framework within the international teacher education community by providing information on Kenyan pre-service teachers. Ultimately, this study may advance the practice of teaching pre-service teachers in Kenya how to integrate technology into their classrooms. This evaluation provides policymakers and education officials with data on pre-service teachers' levels of understanding of how to integrate technology in classrooms.

The Kenyan government has invested in educational technologies in schools to be able to improve the quality of teaching and student learning (Ministry of Education, Science, and Technology, Kenya, 2014). The government states that educational technologies are essential for a developing economy such as Kenya's because these technologies may prepare students to function in an integrated, technologically oriented, global economy (Kenya Ministry of Education, 2017). Additionally, the Kenyan government allocated 119 million US dollars to a Digital Literacy Program that would require increased use of technology by teachers (The National Treasury and Planning, 2018). Considering this substantial investment in educational technology resources and the projections by the government of increased use of technology, this study may provide a useful assessment of how faculty integrate technology into teachers' training colleges. This study may also be used as an evaluation document for the current state of the integration of technology in Kenya's teachers' training colleges so that educational officials may improve how teachers learn how to use technology.

1.7 Threats to Validity

1.7.1 Assumptions

One assumption made in this study was that the respondents truthfully answered the questionnaire and did not feel coerced in any way to respond. Another belief is that the responses were typical responses of similar pre-service teachers in Kenya, and I inferred some general conclusions about pre-service teachers. I also assumed in this study that Kenyan pre-service teachers underwent at least a basic course in ICT use. Further, I thought that teacher training faculty teach pre-service teachers in similar ways on how to use technology in classrooms after they graduate.

1.7.2 Limitations

This study was limited by the short time to collect the survey information and by the self-report answers provided by the respondents. Further, I discuss limitations in Chapter 5.

1.7.3 Delimitations

Considering that I did not have the luxury of interpreting data from a longitudinal study due to time constraints, the study is delimited only to the point in time that I gathered the data. Also, I delimited the study to the research questions. I did not seek to make any inferences beyond the research questions in this study. It was also limited to only pre-service teachers in public teachers' training colleges while recognizing that teachers often improve interaction with technology privately once they graduate and can use this knowledge in lessons in the classroom. I further delimited the data to the close-ended Likert-like questions on the survey, which did not give respondents the latitude to provide more personalized responses. Additionally, I also delimited the study to the TPACK framework within which I have confined this study. A more robust understanding of the TPACK constructs are explained in Table 1 (Chai, Koh, & Tsai, 2011).

Table 1

TPACK Constructs Explained

TPACK Knowledge Constructs	Definition	Example
TK (Technological Knowledge)	Knowledge about features, capacities, and applications of technologies	Knowledge about how to use Web 2.0 tools (e.g., Wiki, Blogs, Facebook)
PK (Pedagogical Knowledge)	Knowledge about the students' learning, instructional methods and process, different educational	Knowledge about how to use problem-based learning (PBL) in

TPACK Knowledge Constructs	Definition	Example
	theories, and learning assessment to teach a subject matter	teaching various scientific topics (e.g., lights, electrics)
CK (Content Knowledge)	Knowledge of the subject matter	Knowledge about Science or Math subjects
TPK (Technological Pedagogical Knowledge)	Knowledge of the existence and specifications of various technologies to enable teaching approaches	Knowledge about how to use Wiki as an online tool to enhance collaborative learning
TCK (Technological Content Knowledge)	Knowledge about how to use technology to represent the content in different ways	Knowledge about how to use animations to show the operations of the solar system
PCK (Pedagogical Content Knowledge)	Knowledge of adopting pedagogical strategies to make the subject matter more understandable for the learners	Knowledge about how to use analogical skills to teach math concepts
TPACK (Technological Pedagogical Content Knowledge)	Knowledge of using various technologies to teach and represent the designated subject content	Knowledge about how to use Wiki as a communication tool to enhance collaborative learning in social science

1.8 Definitions of Terms

- *ICT, information and communications technology*: Technologies used for accessing, gathering, manipulating, and presenting or communicating information (Lloyd, 2005).
- *Integration*: The adoption, inclusion, and use of resources, materials, and equipment to aid in the process of teaching and learning (Omariba, 2016)
- *LMS, learning management system*: Computer programs used to manage, search and present various kinds of digital media and electronic text (Harasim, 2017)

TPACK, technological pedagogical and content knowledge: Knowledge required by teachers for integrating technology into their teaching in any content area (Schmidt et al., 2009)

In the next chapter, Chapter 2, I review the literature on the integration of technology using TPACK, while in Chapter 3, I address the methodology used in this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this chapter, I explain the strategy that I used to search the literature for information on the use of educational technology in schools. I provide details on where I sourced the information for the literature review. I discuss the role of teachers in technology-rich learning environments and how teacher trainees use this equipment in their training colleges. In the literature review, I primarily examine the use of educational technology in Africa and Kenya in particular. I also discuss the conceptual framework that I used for this study – the TPACK conceptual framework. My discussion includes a conversation on the use of TPACK in teacher training colleges and the appropriateness of this framework for answering the research questions.

To get an overview of the current state of integration of technology in Kenyan pre-service teachers' colleges, I consulted several sources. These sources included Google Scholar and databases from the University of North Texas (UNT) online library. These databases included Ebsco, ProQuest, Gale, and Springer, among others. I also used research from professional organization sources like the Institute of Electrical and Electronics Engineers (IEEE), International Society for Technology in Education (ISTE), LearnTechLib of the Association for the Advancement of Computing in Education (AACE), among others. Information on educational technology in Africa generally and particularly from Kenya was sourced from several organizations including, Kenya's Ministry of Education, United Nations Education Scientific and Cultural Organization (UNESCO), African government sources, Kenyan university research databases, and some private development organizations. The research terms included searches that included 'technology integration,' 'TPACK,' 'technology and pre-service teachers,' 'TPACK and pre-service teachers', and others. I narrowed down the articles to peer-reviewed studies conducted over the last 15 years that addressed the integration of technology in teaching pre-service teachers. A few studies that were published more than ten years ago were included in the review because these studies provided valuable background information, especially on the TPACK framework. I examined one hundred eighty-two research studies, position papers, and government publications for this review. The corpus of documents also includes publications from international organizations such as the World Bank and the African Union (AU), among others. In choosing the papers, I emphasized research papers that have used the TPACK framework and have targeted the development of TPACK in pre-service teachers' training colleges. The choice of documents also emphasized the reported use of the TPACK framework in African, and especially Kenyan, teachers' training colleges. However, there were only about five publications that directly addressed TPACK in Kenyan pre-service teachers' training colleges.

2.2 Introduction

Educational technology, which includes both hardware and software, is widely being used in many learning environments. For many students, schools have increasingly become places where learners can easily access knowledge through these learning technologies. Results from a study by McKnight et al. (2016), suggested that technology improved access for teachers as well as for students, to current learning resources and materials anytime and anywhere.

McKnight et al. found that technology also improved access for students with exceptional circumstances and needs by affording differentiation and individualization of learning.

According to McKnight et al. (2016), the use of technology by teachers may also:

- Enhance communication and feedback
- Restructure teacher time by decreasing time spent on grading papers, assignments, and assessments, as well as tracking, reporting, and locating late or missing student work
- Authentically extend the purpose and audience for student work when students actively find their information to support the construction of knowledge
- Shift teacher and student roles by enabling student access to numerous resources and perspectives and reducing reliance on the teacher for answers

Some of the potential advantages of technology integration in classrooms include:

- *Engage students and making them creative learners*: Educational technology, when well-integrated, can support meaningful learning and knowledge integration. Educational technology can promote the social construction of knowledge which, the traditional teacher-centered learning environment has difficulty providing (Dori & Belcher, 2005).
- *Focus on individual student strengths and goals*: Because educational technology can identify learning deficits in students, it can target these deficits and improve student learning outcomes.
- *Promote peer collaboration*: educational technology can provide avenues and opportunities for learners to collaborate and with their instructors, and even across borders. Learning technologies offer new opportunities for students to be part of a digital learning community by interacting regularly. In these learning environments, students can adopt

discussions, social interaction, collaboration, peer feedback, and group projects as teaching and learning strategies (Keppell, Au, Ma, & Chan, 2006).

- *Provide students with 21st-century skills*: Educational technology can also foster the teaching of skills that are important for learners' careers. These skills include creativity, critical thinking and problem-solving collaborative skills, IT skills, new forms of literacy, and social, cultural, and metacognitive awareness (Griffin & Care, 2014).

- *Create engaged and progressive teachers*: Educational technology also provides various ways for teachers to create engaging lessons and to present content in non-traditional ways. These include innovative ways to have learners with content and to access and retain knowledge.

Considering that schools in Kenya are investing in educational technology, this investment must provide adequate returns to all the stakeholders, including the communities, the administration, and students, among others. Angeli and Valanides (2005) note that an essential factor that influences beginning teachers' uptake of computers is the amount and adequacy of their pre-service training. Angeli and Valanides state that ICT can only have a positive impact on student learning when teachers know how to use ICT to promote learning. Without comprehensive pedagogical knowledge on how to integrate technology in classrooms, teachers will continue lagging in effectively integrating technology in their classrooms.

2.3 Role of Teachers

The use of educational technology in learning institutions does not eliminate the role of teachers in student learning. Spector notes that in the 1990s, experts predicted that distributed learning and telecollaboration would make classroom teaching and teachers obsolete (Spector, 2001a). He states that this did not happen. Spector notes that experts have realized that the role of the teacher is not likely to be eliminated by technology. Spector finds that the role of teaching in technology-intensive learning environments is more difficult and challenging than teaching in a familiar face to face teaching environments. Spector notes that only a few teachers master the knowledge and skills required to integrate technology into everyday learning and instruction effectively. Considering that teachers will continue to play a vital role in student learning through technology, the researcher intends to understand how the training of teachers influences their interaction with technology.

Although most professions have easily and efficiently adopted technology as part of their everyday work, this is not necessarily the case with teachers. Ertmer and Ottenbreit-Leftwich (2010) note that it is time that we realized that technology is essential to the teaching profession and is not merely a supplemental teaching tool. Ertmer and Ottenbreit-Leftwich state that effective teaching requires effective technology use. For teachers to effectively use technology to facilitate student learning, teachers need additional knowledge and skills. Teachers have conceptualized these skills and knowledge in a variety of ways, including the use of TPACK (Ertmer & Ottenbreit-Leftwich).

One of the arguments for teachers' slow adoption of technology is that teachers are used to practices that teachers learned in their first school and are slow to change to new practices. Mims (2004) notes that in most teacher preparation programs, current instructional practices in teacher education rarely challenge pre-service students' existing beliefs about teaching learning and technology. He notes that beginning teachers' perceptions in their integration of computers with the processes of teaching and learning are naïve and demonstrate very little development. Mims, who studied pre-service teachers at the University of Georgia, found that all participants in the study explained that their previous experience with computer integration as K-12 students influenced their perception of the use of computers. Thus, pre-service teachers often base their perception of educational technology on their own experiences in using these technologies.

Additionally, pre-service teachers also face several obstacles to building sophisticated models for the use of educational technology tools and their affordances (Poitras, Doleck, Huang, Li, & Lajoie, 2017). Indeed, according to Poitras, Doleck, Huang, Li, and Lajoie, several attempts have been made to design instructional scaffolds to support pre-service teachers in developing more sophisticated mental models related to planning lessons. Further, teachers are also known to develop their teaching scripts, which they put to daily use, reducing the demands on their processing capacity in familiar situations (Monteiro, Carrillo, & Aguaded, 2010). Often, it may take long before these teachers alter or abandon these trusted scripts for newer teaching methods that involve technology.

Further, some research suggests that pre-service teachers are often poorly taught how to use and integrate technology in classrooms. For example, in a study of students in a postgraduate degree teaching program at a Norwegian university, Røkenes and Krumsvik (2016) observed that teacher trainees did not get modeling from their instructors on how to integrate technology in their lessons. The lack of modeling often resulted in the teacher trainees developing their teaching scripts. Røkenes and Krumsvik also found that teacher trainees often lack opportunities to experience and critically reflect on the educational value of ICT through hands-on activities such as through collaboration with peers and reflective activities. Thus, they conclude, teacher trainees need not only have access to appropriate educational technology tools but also access to pedagogical support and time to experience how to use ICT in teaching. Angeli and Valanides (2005) reiterate this point when they note that a gap exists between what pre-service teachers learn in their ICT courses and what they teach using ICT in an actual classroom. Angeli and Valanides note that although basic computing skills constitute the foundation of ICT literacy, they are not enough to prepare pre-service teachers on how to teach with ICT adequately.

Besides, technophobia among teachers also impacts whether they use educational technology. Juutinen, Huovinen, and Yalaho (2011) note that because some teachers do not have much experience in using technology, their skills are also low, leading to an unwillingness to learn more about technology. Sometimes these negative feelings towards computers may lead teachers to fear that the technology may fail while they are teaching. Thus, the teachers resort to their true and trusted technology-free methods of which they have greater control than technology-enabled teaching processes. Juutinen, Huovinen, and Yalaho state that some teachers lack confidence in their computer skills, and often, they do not have enough pedagogical skills to teach using computers.

The viewing of teachers' use of technology as a new literacy emphasizes the role of the teacher as a producer, and not the traditional conceptualization of teachers as consumers of technology (Mishra & Koehler, 2008). The teacher can integrate technology when he or she can flexibly navigate the learning landscape of technology, pedagogy, and content and becomes an expert in TPACK.

In a technology-enhanced learning environment, the teacher becomes one of the many resources that the student may access. The teacher should engage students in experiences that challenge their conceptions on existing knowledge, facilitate students to drive lessons, encourage questioning, and promote collaboration, among other activities (Gilakjani, Leong, & Ismail, 2013). Teachers' low-level uses of technology is inadequate in meeting the needs of the 21st century learner and using technology simply to support lecture-based instruction falls far short of professional practice (Ertmer & Ottenbreit-Leftwich, 2010). This low-level use of technology by teachers includes the use of computers for administrative tasks such as typing and printing examinations, maintaining students' enrolment records, including financial records and other administrative functions (Cetin-Berber & Erdem, 2015; Mutuku & Ogutu, 2018).

According to Ertmer and Ottenbreit-Leftwich (2010), teachers also mostly use technology to create power-point presentations, to search for supplemental content information, and to communicate with students and their parents or guardians. However, teachers are unable to integrate this technology in such a way to maximize its use. There is, thus, a need to train teachers on how to use and integrate technology in classrooms. Teachers may be savvy on the use of a variety of educational technology tools. Still, they have little to no knowledge about how to use these tools to facilitate student learning (Ertmer & Ottenbreit-Leftwich). This research intends to focus on the teachers' use of educational technology that encourages students to explore and learn using technology.

2.4 Educational Technology and Pre-Service Teacher Education

Curriculum developers have realized the importance of preparing teachers to use technology. Stobaugh and Tassell (2011) note that in the US, schools of education include technology skills within the methods courses, field experiences, and the content - courses intended to prepare pre-service teachers to master technology standards. Stobaugh and Tassell state that although many pre-service teachers exhibit a generally positive attitude towards technology, they are still ill-prepared to integrate technology in instruction. Wang, Schmidt-Crawford, and Jin (2018) also note that merely having pre-service teachers to complete technology courses may not be enough for the knowledge transfer and application of technology integration to occur in their future classrooms. Researchers Wang, Schmidt-Crawford, and Jin suggest that considering that technology is an essential tool for teachers, teacher training institutions need to address how college faculty prepare pre-service teachers to use and integrate technology into their programs. They also note that teacher preparation programs must work to develop further and incorporate methods that better infuse technology throughout the entire teacher education program.

In Kenya, one of the main failures of the past integration of technology efforts was that the government provided schools with expensive equipment without adequate support for teacher training (Tondeur, Krug, Bill, Smulders, & Zhu, 2015). The Kenyan government tried and failed to implement one laptop per child policy (Malakata, 2015; Obara, 2019), which cost the government over 600 million US dollars. According to Obara (2019), some of the causes of the failure of the project were:

- Weak infrastructure that was unable to support the program
- Budget cuts
- Power outages and inadequate electricity supply
- Suspected procurement irregularities
- Lack of trained teachers

- Theft of hardware
- Reported the misuse of student computers

For such a project to succeed, there needs to be considerable devotion of effort and funding for infrastructure development, teacher training, curriculum development, assessment reform, and formative evaluation (Warschauer & Ames, 2010). Thus, some of the factors that influence the effectiveness of educational technology integration include teacher factors, e-learning policy frameworks, technology support in schools, and high cost of equipment (Awuor & Kaburu, 2014). A study in Kenya by Wanjala, Khaemba, and Mukwa (2011) has also shown that few teachers integrated ICT in their classrooms. Wanjala, Khaemba, and Mukwa found that most Kenyan teachers use trial and error in attempting to integrate ICT integration. Wanjala, Khaemba, and Mukwa also state that the teachers referred to their coursework in training colleges to assist them with ICT integration.

A survey by Muyanga (2010) on the integration of ICT in five schools in eastern Kenya suggested that although the Kenyan Ministry of Education has an elaborate ICT policy for education and training, the teacher-trainees are ill-equipped to integrate technology in their lessons. The mixed-methods study, which surveyed, observed, and interviewed 36 mathematics and science teachers from five schools in the area, suggested that Kenyan college teaching staff did not teach pre-service teachers the skills to integrate technology in their lessons.

Due to various infrastructural problems, most pre-service teachers in Kenyan colleges do not receive adequate or sustained training on how to use technology, let alone how to integrate it in classroom teaching. A study by Kiilu et al. (2018) on the preparedness of Kenyan teachers to adopt educational technology, suggested that most of their study respondents were unaware of any educational technology training policy by the training institution. In a survey of 287 respondents from five teacher training colleges, Kiilu et al. suggested that teachers' training colleges often did not have any strategies to promote the adoption of educational technology for the trainees. Their study, which used semi-structured questionnaire and observation, describes the level of preparedness of Kenyan teachers training colleges to teach trainees how to use technology as low and still in the developmental stage. Other research has cautioned that without corresponding integration of educational technology in the curriculum, student resources, technical support, and teacher incentives, educational technology training cannot succeed (Muriithi, 2005). Findings from a study by Omariba (2016) on the preparedness of teachers' colleges to integrate educational technology in Kenya suggested that:

- The colleges lack expert help in integrating educational technologies.
- The pre-service teacher trainees had little previous exposure to educational technologies.
- The colleges lacked the infrastructure that could support training using technologies.
- The college staff lacked requisite knowledge and training to be able to train the pre-service teachers.
- Educational technologies were used mainly for essential functions like word-processing and not for extensive use for learning and teaching.
- Prior teaching experience influences the integration of educational technology in teaching.

Students and teachers in Kenyan urban centers do not fare much better. In a study using a sample of 12 mathematics teachers, 275 students from 12 public schools, and 12 heads of mathematics departments in Nairobi County schools, Sheila (2012) suggested that school officials were not interested in integrating ICT in the mathematics curriculum. Sheila states that this is because the teachers lacked training opportunities to enable them to incorporate technology in teaching and learning. Additionally, according to Sheila's study, mathematics teachers lack ICT skills and knowledge; they do not have support from school administrators, and there is an inadequate ICT infrastructure for teaching and learning mathematics.

Further, Kihoza, Zlotnikova, Bada, and Kalegele (2016), in a similar study in Tanzania, found that there is a low level of use of educational technology by pre-service teacher trainees. Kihoza, Zlotnikova, Bada, and Kalegele found that in a sample of 206 respondents from Morogoro Teachers' Training College and Mzumbe University (in Tanzania), most teacher trainees suffer from unrealistic and fragmented ICT knowledge transfer. The lack of a harmonized educational technology training program that targets pre-service teacher trainees is part of the cause of poor knowledge transfer.

2.5 Conceptual Framework

As shown in Figure 1, the conceptual framework for this study accounts for independent variables of

- Teaching pre-service teachers how to integrate technology
- National government educational policies on the use of technology in classrooms
- Availability of these technologies as teaching tools in teacher training colleges, play an essential role in influencing the integration of technology in classrooms

The TPACK conceptual framework is also affected by individual teacher attitudes and beliefs towards the integration of technology, the pre-service teachers' prior teaching experience, and their personal use of technology.

As the conceptual framework diagram (Figure 1) shows, the successful intervention through efficient and practical training on how to use technology, and the teachers' exposure to various technologies, can be change agents. Exposure to multiple technologies may lead to increased integration of technology in classrooms, increased preparedness to use technology and increased productivity for both teacher and learners. On a personal level, the pre-service teachers may show improved attitudes towards the use of technology in classrooms and even show an increase in personal use of technologies.

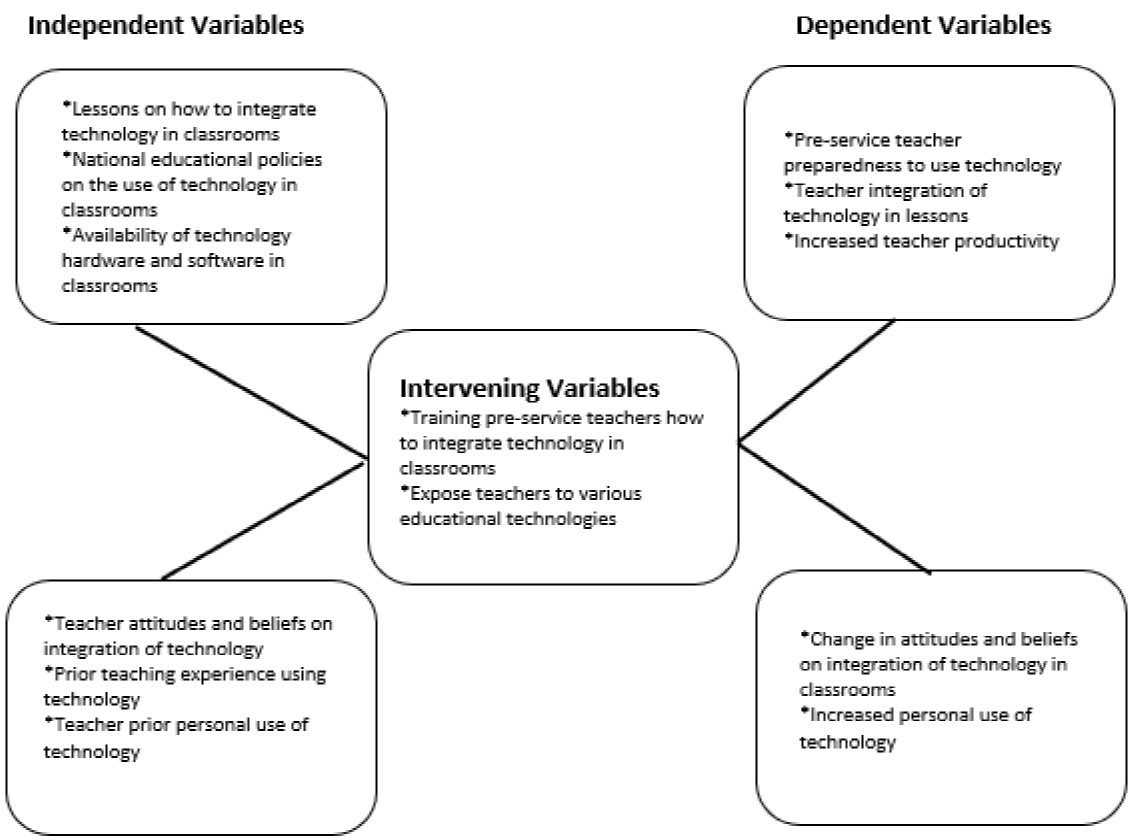

Figure 1. Conceptual framework of the TPACK process.

2.6 Epistemology

The base of this research is the epistemological perspective that knowledge is assumed to be evolving; it is dynamic, and it is shareable. This epistemology is grounded in learning theories, instructional designs, as well as pedagogies of learning in complex dynamic systems.

Spector (2001b) has identified some of these learning theories as a cognitive apprenticeship (Collins, 1991; Collins, Brown, & Newman, 1989), cognitive complexity (Spiro, Coulson, Feltovich, & Anderson, 1988; Spiro, Vispoel, Schmitz, Samarapungavan, & Boerger, 1987), collaborative learning (Salomon, 1988, 1992, 1997), elaboration theory (Reigeluth & Stein, 1983), problem-based learning (Barrows, 1985), and situated learning (Lave, 1988). These learning theories form the underlining epistemology of this study.

Advocates of the epistemology which assume knowledge is always evolving, recognize that learning is often complicated and takes place in ill-structured learning environments. The cognitive apprenticeship, for instance, shows that learning from a master or someone with more experience has been practiced for ages. Pre-service teachers can thus benefit from learning how to use technology from experts in this field. Likewise, they can serve as experts in their classrooms after they graduate, and their students will be their apprentices. According to Spector (2001a), many researchers agree that these epistemologies underline the constructivist nature of learning. Spector notes that learning is a social undertaking that aims at changing the beliefs of learners (Collins, 1991; Hernandez-Serrano, Choi, & Jonassen, 2000; Lave, 1988; Spector & Anderson, 2000). The use of educational technologies by learners may enable the learners to construct new knowledge rather than merely acquiring it through memorization or transmission from experts to the learners (Bates & Poole, 2003). Thus, when college teaching faculty teach pre-service teachers how to integrate technology, this instruction is underlined by tested learning methods.

2.7 TPACK and Pre-Service Teachers

Although there are several other conceptual frameworks which may explain pre-service teachers' abilities to integrate technology, the TPACK framework is well-suited for this task. TPACK is a culmination of various models to understand how teachers may integrate technology into their classrooms. Venkatesh, Morris, Davis, and Davis (2003) have presented eight models that attempt to explain the individual acceptance of information technology. These alternative models, according to Venkatesh et al. are:

- Theory of reasoned action (TRA)
- Technology acceptance model (TAM)
- Motivation model (MM)
- Theory of planned behavior (TPB)
- Combined TAM and TPB (C-TAM-TPB)
- Model of PC utilization (MPCU)
- Innovation diffusion theory (IDT)
- Social cognitive theory (SCT)

Venkatesh et al. (2003) synthesized findings from these models to advance the unified theory of acceptance and use of technology (UTAUT) model, which according to Philips (2014), was unable to predict technology adoption in complex, contradicting and changing environments such as ill-structured learning environments. Ertmer and Ottenbreit-Leftwich (2010) also identified other frameworks that study the use of technology to facilitate student learning as pedagogical technology integration content knowledge (PTICK), and ICT-TPCK. I did not use PTICK (Brantley-Dias, Kinuthia, Shoffner, de Castro, & Rigole, 2007) for this study because PTICK primarily uses the case study design to gather data. Because case studies require additional time and other resources, this method would not have been suitable for my investigation. On the other hand, ICT-TPCK (Angeli & Valanides, 2005), a strand of TPCK, uses a combination of methods for assessment, including ongoing- and progress-oriented assessment procedures, which can be complicated. I preferred the TPACK framework as presented by Schmidt et al. (2009) because Schmidt et al. designed it for elementary school pre-service teachers such as my respondents, and it has already been successfully pilot-tested on 124 pre-service teachers. Additionally, the study by Schmidt et al. indicated that the instrument showed high Cronbach alphas of 0.80 for each of the TPACK constructs, suggesting that the instrument had excellent internal reliability.

I have based this present study on the TPACK framework (version 1.1), as developed by Schmidt et al. (2009), to gauge teachers' understanding of how they integrate technology in their classrooms. According to Koehler and Mishra (2008), the TPCK model builds on Shulman's (1986) description of pedagogical content knowledge to describe how teachers' understanding of technologies and pedagogical content knowledge interact with one another to produce effective teaching with technology. This framework also considers the interactions among these bodies of knowledge. The framework presents these interactions as pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPCK).

Mishra and Koehler (2008) argue that the interactions between and among these TPACK components, play out differently across diverse contexts and account for the wide variations seen in educational technology integration. Mishra and Koehler note that the TPACK framework encompasses understanding the representations of concepts using technologies, pedagogical techniques, knowledge of students' prior content-related understanding, and how the teachers can use these technologies to build understanding to develop new epistemologies or strengthen old ones. Mishra and Koehler note that TPACK is the intersection of the three bodies of content knowledge, pedagogical knowledge, and technological knowledge and how these bodies all interact with each other. The TPACK framework describes the kinds of knowledge that teachers need to teach with technology and the complex ways in which these bodies of knowledge interact with one another (Koehler, Mishra, Akcaoglu, & Rosenberg, 2013). Thus, effective teaching with technology requires TPACK and is also characterized by:

- Understanding how to represent concepts with technologies
- Pedagogical techniques that use technologies in constructive ways to teach content
- Knowledge of what makes concepts difficult or easy to learn and how technology can help students learn
- Knowledge of students' prior knowledge and theories of epistemology
- Knowledge of how teachers can use technologies to build on existing knowledge and to develop new epistemologies or strengthen old ones (Mishra & Koehler, 2008)

In this way, TPACK shows that teachers' thinking concurrently draws upon multiple domains to guide students in understanding any topic (Niess, 2011). Effective teacher educational and professional development needs to craft systematic, long-term educational experiences where the participants can engage fruitfully in all three of these knowledge bases in an integrated manner (Koehler, Mishra, Kereluik, Shin, & Graham, 2014). The TPACK framework proposes that tackling all of the variables at once creates effective teaching because, for the teacher with TPACK, knowledge of technology, pedagogy, and content is synthesized and put to use for the design of learning experiences for the student (Koehler, Mishra, Akcaoglu, & Rosenberg, 2013).

Unfortunately, many teachers are not prepared to teach using technology (Niess, 2011).

Niess notes that although society charges teachers with preparing students with 21^{st}-century skills, they have not learned their content using these technologies. Niess states that teachers do not have essential learning experiences with these technologies, and they are not prepared to engage in strategic thinking as encouraged by TPACK. Most teachers learn in traditional technology-poor learning environments, and they are unable to develop TPACK thinking because they lack the skills to do so (Niess, 2011).

How do teachers develop TPACK in their practice? Teaching and learning with technology are often complex and ill-structured endeavors. Contexts vary by teacher and by the school; cultural and social setting; student and teacher preferences; prior experiences and attitudes, among many others. Teachers should thus be able to weave through these complicated and irregular landscapes to arrive at curriculum designs that they can use to reach learners effectively. They are always engaged in an active, iterative, and feedback-driven process of problem-finding and creative problem-solving (Koehler & Mishra, 2005). One way that teachers can develop strategies to use TPACK is through self-assessment and reflection on their understanding and thinking about teaching with technology (Roblyer & Doering, 2010). Niess (2011) also reports on studies that propose learning-by-design to learn TPACK, instructional modeling, collaborative lesson studies, focus on action research, case studies, among others. Using the TPACK framework to design a course for pre-service science teachers in Thailand, Tanak (2018), suggested that the TPACK elements of technology, pedagogy, and content can be used in concert to make teachers more effective in integrating technology.

Researchers can assess the extent to which teachers use and understand TPACK using various measures. Koehler et al. (2014) report that some of the instruments for measuring

TPACK include self-report measures, performance assessments, interviews, open-ended questionnaires, and observations. In a review of 303 TPACK-related articles published in journals, conference proceedings, dissertations, and conference presentations, Koehler et al. (2012) found the use of 141 instruments for assessing participants’ understanding of TPACK. The self-report assessment used in this study is a survey instrument developed by Schmidt et al. (2009). I chose to use this instrument because it collects data efficiently, it does not take too much of the respondents’ time, and it provides a suitable assessment of the respondents’ TPACK levels. Additionally, Schmidt et al.'s instrument was developed through content validation by experts and pilot-tested with 124 pre-service teachers (Chai, Koh, & Tsai, 2016). The instrument has high Cronbach alphas of 0.80 for each of the TPACK constructs, indicating excellent internal reliability, and researchers can apply these constructs to a variety of content areas.

Consequently, the choice to use the TPACK framework to interrogate Kenyan pre-service teachers’ integration of educational technology in their lessons, is guided by previous scholarship. Education policymakers may use this study to examine the integration of technology in a developing country’s pre-service teachers’ learning program using scholarly methods and instrumentation. TPACK allows researchers to look at the complex phenomenon of technology integration in ways that are amenable to analysis and development (Koehler, Mishra, & Cain, 2013).

As shown in Figure 2, TPACK has three main components of teachers’ knowledge: content, pedagogy, and technology. The framework emphasizes the interaction between and among these components.

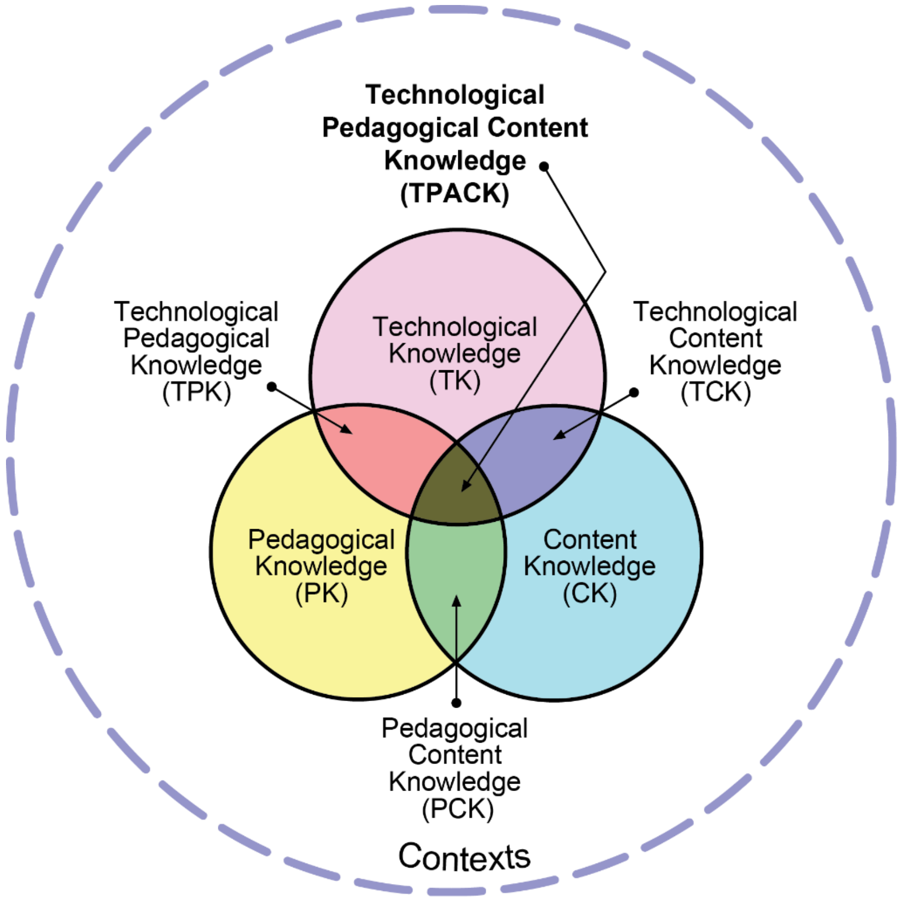

Figure 2. The TPACK framework and its knowledge components (TPACK, 2012).

The base of the framework is the understanding that teaching is a highly complex activity that draws on many kinds of knowledge (Mishra & Koehler, 2006). According to Abbitt (2011), the TPACK framework has been used in multiple teachers' training preparation and professional development programs to investigate specific learning activities. The framework expresses content knowledge (CK) and pedagogical knowledge (PK) as primary areas of teacher knowledge (Abbitt, 2011). Pedagogical content knowledge (PCK) is considered a domain that illustrates the knowledge of pedagogy that targets specific content areas. Unlike Shulman's (1986) model, TPACK includes technological knowledge (TK) as a third major area of knowledge resulting in three additional interactions: technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPCK) (Mishra & Koehler, 2006).

The importance of having teachers trained in integrating technology has been recognized in other countries as well. Tondeur et al. (2015a) note that in several countries, frameworks on ICT competence now target teachers. Tondeur et al. give the example of Norway, where the emphasis is on teacher competence in using ICT in educational practices. Further, they note, education policymakers are applying the International Society for Technology in Education (ISTE) standards and performance indicators as important guidelines for in-service teachers in the US. Additionally, Tondeur et al. report that in the Netherlands, education policymakers have developed a framework that will describe the skills teachers need to integrate ICT so that it makes education more attractive and efficient for teachers.

TPACK, as used in this current study, has value for the pedagogical, content, and knowledge development for pre-service teacher preparation. It will assist in describing pre-service teachers' knowledge about technologies; the manner with which they take the features and advantages of technology into the content; their knowledge about the existence, components, and capabilities of various technologies as teachers use them in teaching; and to illustrate the ideas on how teachers integrate technology into their pedagogy (Lee, & Tsai, 2010). The instrument also includes an assessment of behavioral intent to use technology in learning. In a survey of 558 teachers in elementary schools to high schools in Taiwan, Lee & Tsai used the TPACK framework to develop a derivative survey to evaluate teachers' self-efficacy in the use of web resources. The TPACK framework has also been used by Blackwell, Lauricella, and Wartella (2016) to suggest that attitudes towards the value of technology in learning are critical in understanding how teachers incorporate educational technology in learning environments. In an online survey of 945 educators who work directly with children ages 0 to 8, Blackwell, Lauricella, and Wartella found that shifting teacher attitudes may change how teachers integrate technology and influence the effect of technology on student achievement. Other studies suggest that this dependent variable (the behavioral intent and attitude towards technology) strongly influences educational technology adoption and knowledge of TPACK (Sang, Valcke, van Braak, & Tondeur, 2009; Tondeur, Scherer, Siddiq, & Baran, 2017b). In a study of 22 classroom teachers who were part of a US Department of Education-funded school reform program, Kim, Kim, Lee, Spector, and DeMeester (2013) found that teachers' beliefs about the nature of knowledge and learning, and beliefs about effective ways of teaching were related to their technology integration practices.

Additionally, in an adaptation of Schmidt et al.'s (2009) instrument into the Turkish language to investigate its factor structure through exploratory and confirmatory factor analysis, Kaya and Dag (2013) found that the survey had the goodness of fit indices that indicated it was a good fit. Their survey used responses from 352 elementary pre-service teachers from three universities in Northwestern Turkey. They additionally concluded that the survey was a good fit for use in Turkish culture. Their survey suggested that educationists can successfully develop the TPACK framework in other cultural contexts, such as Kenya's. In Tanzania in a case study involving 206 respondents from Morogoro Teachers' Training College and Mzumbe University (Morogoro campus), Kihoza et al., (2016), also recommended the use of TPACK framework to develop pre-service teachers' understanding of how to integrate technology. These studies suggest that good teaching with technology requires understanding the mutual relationship outlined in TPACK to develop appropriate, context-specific strategies and representations (Tee & Lee, 2011).

In a random sample study of 37 teachers and 34 headteachers in Kenya, researchers Njagi and Oboko (2013) suggested that the capacity of teachers to use educational technology also affects students' ability to use these technologies, which may lead to the enhancement of learners' technology skills. They noted that teachers who use ICTs for peer-led instruction are likely to use these technologies for small-group instruction and learning. Njagi and Oboko recommend that teacher training colleges train teachers in basic as well as advanced use of technology to empower them to integrate technology in teaching. They also suggest that the education officials consider strengthening educational technology infrastructure, support school management in the integration of educational technology; and, develop and implement a framework to monitor and evaluate ICT integration in teaching and learning in elementary schools.

Additionally, in a mixed-methods study involving 39 headteachers, 390 teachers, and two top education officials in western Kenya, researchers Batoya, Wabwoba, and Kilwake (2015) suggested that teacher professional development had a significant influence on how well teachers integrated ICT into classrooms. The study, which used a questionnaire and an interview schedule to gather information from respondents in two schools, also suggested that teachers who successfully integrated technology in classrooms were able to raise the scores of students. Batoya, Wabwoba, and Kilwake also recommended more training for teachers. They note that this training will enable the teachers to understand the importance of technology integration, and they also recommended support of school administration through government education policy on ICT integration. In another study in western Kenya (Kakamega County) which used an exploratory-descriptive survey design, and with a sample of 147 mathematics teachers in 25 selected schools, Sulungai, Toili, and Amadalo (2011), suggested that mathematics teachers in the region do not have the requisite computer skills to use educational technology in mathematics instruction. Sulungai, Toili, and Amadalo noted that although teachers in the area have a positive attitude towards the use of educational technology, they still lack skills to integrate this technology into their lessons successfully. The researchers also found that teachers routinely lack access to computers in addition to barriers like lack of electricity and poor computer infrastructure.

The situation in western Kenya is not different from the condition in the capital city, Nairobi. In a study of 15 school principals and 15 computer technology teachers, Awuor, and Kaburu (2014), suggested that the integration of ICT into classrooms in Nairobi has been sluggish. Awuor and Kaburu recommended that teachers training colleges not teach teacher-trainees how to use computer hardware but also how they should use this hardware in lessons. Awuor and Kaburu also suggested that education policy officials develop an evaluation of teacher ICT competency and strengthen the framework for educational technology in schools.

2.8 Criticism of TPACK

Although the introduction of TPACK as a framework for articulating and improving teachers' uses of technology for teaching and learning has become popular with some studies, there is growing concern that the theoretical framework from which researchers draw TPACK studies are conceptually flawed (Kopcha, Ottenbreit-Leftwich, Jung, & Baser, 2014). Graham (2011) notes that there is no agreement on how to define the TPACK constructs or to distinguish the TPACK constructs from related constructs. Graham notes that without understanding PCK as proposed by Shulman (1986), researchers cannot productively understand and effectively measure TPACK constructs. Graham also criticizes the TPACK framework for merely representing the interaction between pedagogical, content, and technological knowledge domains and attempting to build on the familiar and heavily researched concept of pedagogical content knowledge introduced by Shulman. Graham also notes that the framework does not have precise definitions that are essential to a coherent theory. Meanwhile, Maor (2013) cautions that the TPACK deficiencies identified by Graham and others require theoretical development for the long-term viability of TPACK research.

Additionally, Abbitt (2011) notes that measuring TPACK using instruments designed for a specific context limits their broad application. On the ability of the questionnaires to measure TPACK, Valtonen et al. (2017) also state that there is a challenge in separating all seven areas of TPACK with empirical data using EFA and CFA. Valtonen et al. (2017) note that some of the TPACK elements do not load separately in analysis and that only two factors (content knowledge and technological knowledge) loaded in alignment with the TPACK framework.

Despite these challenges, TPACK, as measured by Schmidt et al.'s (2009) self-reporting instrument, can credibly measure the perceived knowledge of pre-service teachers in the TPACK domains (Abbitt, 2011). Abbitt also notes that the researchers can use the instrument to reveal the changes in TPACK throughout a teacher preparation program, as some researchers have demonstrated that the instrument is valid and reliable. It provides an efficient tool for research and evaluation relating to TPACK. TPACK also includes information on how teachers' knowledge of technology can support student learning (Brantley-Dias & Ertmer, 2013), and it enables the conceptualization of how technology can improve teaching and learning (Archambault & Barnett, 2010).

In Chapter 3, I discuss how the study was conducted, including the research design, sampling of the study participants, and the survey instrument, among others.

CHAPTER 3

METHODOLOGY

I deployed a validated survey to evaluate the teaching of how to integrate technology in classrooms to pre-service teachers, using the TPACK framework, in selected Kenyan teachers' training colleges. The survey was appropriate for use in this study because it is best suited to provide answers to the research questions, offer anonymity to the respondents, and it draws responses from a broad cross-section of the study population. The survey also provided the respondents with adequate time to respond to the study. I gave the respondents the paper-based questionnaire because many did not have personal access to the internet to get the digital copy.

3.1 Research Questions

1. To what extent do pre-service teachers in selected Kenyan teachers' training colleges demonstrate knowledge of TPACK necessary for integrating technology in their teaching?
2. To what extent do pre-service teachers in selected Kenyan teachers' colleges demonstrate knowledge of the TPACK domains of technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK)?).
3. To what extent do personal experiences with technology impact the use of educational technology by pre-service teachers in selected Kenyan teachers' training colleges?
4. To what extent does the TPACK framework capture the readiness of pre-service teachers to use ICT for classroom instruction?

3.2 Premise

The extent to which pre-service teachers integrate technology in their lessons is dependent on the degree to which the teachers learn how to integrate technology while enrolled in their teacher training colleges. The premise is that if teachers learn how to integrate technology in classrooms while they are in pre-service teacher training colleges, the teachers will be able to incorporate technology in their lessons.

3.3 Research Design

I used Eregi and Kaimosi TTCs as case studies to understand the TPACK levels of the pre-service teachers. According to Fraenkel et al. (2015), much can be learned from studying cases and patterns from cases can be applied to a larger section of the population. Insights gained from a case study can lead to information to be applied to the larger population. Gerring (2006) notes that we can gain better understanding of the whole by focusing on a key part.

I used a survey instrument to collect data on pre-service teachers from the selected Kenyan teachers’ training colleges. I used the survey to collect information from a sample drawn from a predetermined population. The respondents were a convenience sample of pre-service teachers from which I made inferences about the pre-service teacher population in Kenya. I distributed the survey to teacher-trainees in two pre-service teachers' colleges in Kenya, which I selected because my assistants and I could easily access these colleges. I used the survey results were used to provide a snap-shot view of the pre-service teachers' TPACK levels at a point in time.

A survey, which allows some descriptions of characteristics of a study population, was used to answer the research questions. Data from the survey may help study how members of a population distribute themselves on one or more variables (Fraenkel et al., 2016). The survey method is best suited to gather data from a sample of the teachers because the analysis of the teachers' self-reports may provide a study on the possible integration of educational technology. Results from the survey also provided me with data that answered the research questions. I derived additional data from three open-ended questions included at the end of the questionnaire.

Although I did not use this survey to identify causal results for the state of pre-service teachers' understanding of TPACK, it provided rich information about this population, which may form a basis for official action or further research. This TPACK survey included information on behavioral intent to use educational technology, which is a good proxy for the actual use of this technology.

3.4 Population and Setting

I distributed the survey instrument to students in two pre-service teachers' training colleges in Kenya – St. Augustine Eregi and Kaimosi Teachers' Training Colleges (TTC). I approached the pre-service teacher students at their colleges and requested them to participate in the study. Most pre-service teachers in Kenya have completed high school and are mostly under 30 years old. Estimates from the Kenya Ministry of Education (2017) indicate that there is an even distribution of pre-service teachers between male and female trainees. In 2015 the number of Kenyan pre-primary education teachers rose to 107,187 up from 101,062 in 2013 (Kenya Ministry of Education, 2017). However, like most Sub-Saharan Africa countries, Kenya continues to face a shortage of qualified teachers. The fact that the government lacks the funds to employ additional qualified teachers who have no jobs compounds the shortage of teachers in schools.

According to Kenya's Ministry of Education, Science, and Technology (2014), there are

22 public primary teacher training colleges with an enrolment of 17,999 students who are undertaking two-year training programs for a teacher's certificate. Also, there are over 88 private teacher training colleges offering the same certifications. Two public and 12 private diploma-issuing colleges, 36 public universities, and some private universities train secondary (high) school teachers. Religious missionaries established both colleges in the early 1900s. Kaimosi Friends TTC was founded by the Religious Society of Friends (Quakers) missionaries in 1902 (“Welcome to Kaimosi TTC," n.d.). St. Augustine Eregi TTC was founded in 1949 by the Catholic Mill Hill Fathers to train teachers (“St. Augustine Eregi TTC”, n.d.). Each year, these two colleges train about 1,000 pre-service teachers who learn languages, religious studies, basic mathematics, child development, human and children's rights, psychology, ICT, and educational administration. At the end of the course, the pre-service teachers are examined by the Kenya National Examinations Council before graduating.

Because I used the survey results to make inferences on a section of the population, a minimum of 100 subjects would have been enough (Fraenkel et al., 2016). However, a similar study in central Kenya (Omariba, 2016), determined that a sample of between 20% to 30% of the target population provided an adequate sample. Additionally, power size calculations, using online tools from the University of Iowa (Lenth, 2006), determined that with a power value of 0.8 (80%) and a standard deviation of 4 (arrived at from similar studies), the optimum sample size is 324. Consequently, with the previous similar studies as a guide (Koh, & Chai, 2011; Omariba, 2016; Saade et al., 2007), and the power calculations above, 300 respondents were deemed an acceptable target sample for this study. A slight oversampling of the respondents compensated for the respondents who did not complete the surveys.

G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) calculations computed with a priori power analysis, with an effect size of 0.5 and the power of 95%, suggested a total sample size of 54 respondents (Figure 3.) would be adequate. However, using power size calculations from online tools at the University of Iowa (Lenth, 2006) I determined that with a power value of 0.96 (96%) and alpha of 0.05 (arrived at from similar studies), the optimum sample number of respondents for this study is 296 (Figure 4). Thus, using previous similar studies as a guide (Koh, & Chai, 2011; Omariba, 2016; Saade et al., 2007), and these power calculations, 300 respondents, was an acceptable target sample size for this study. An oversampling of the respondents by about 20 more respondents compensated for non-response and incomplete responses to the survey. The informed consent documents which were signed by respondents are in Appendix A.

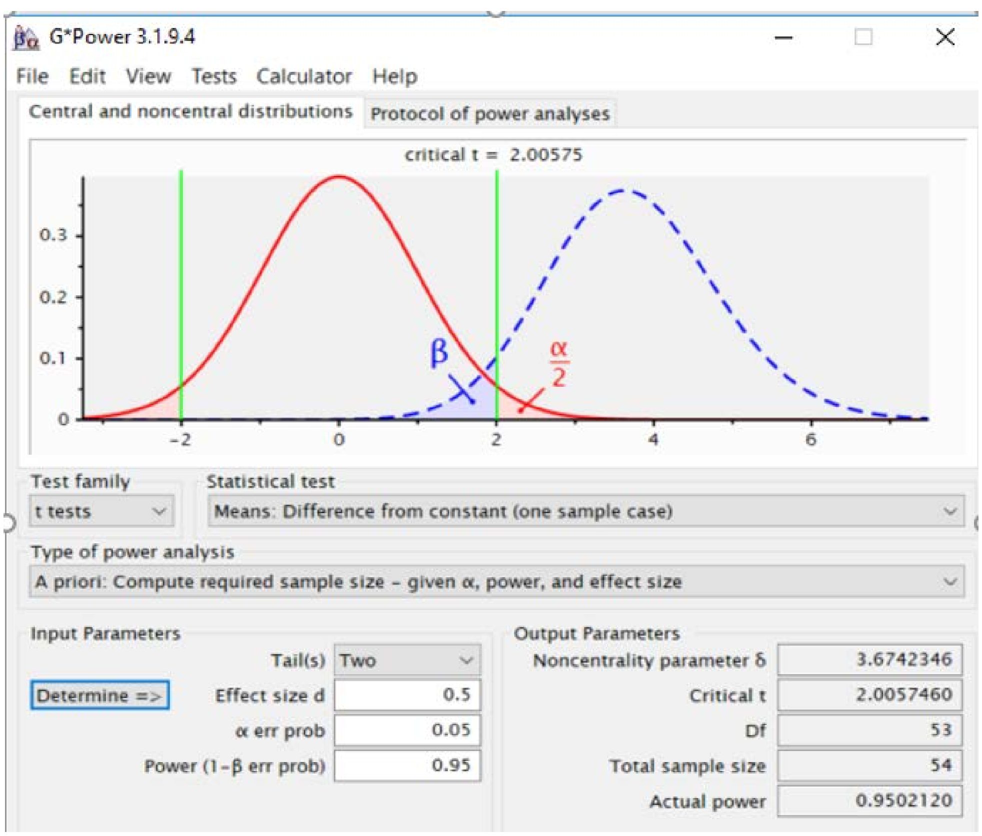

Figure 3. G* power calculations for sample size.

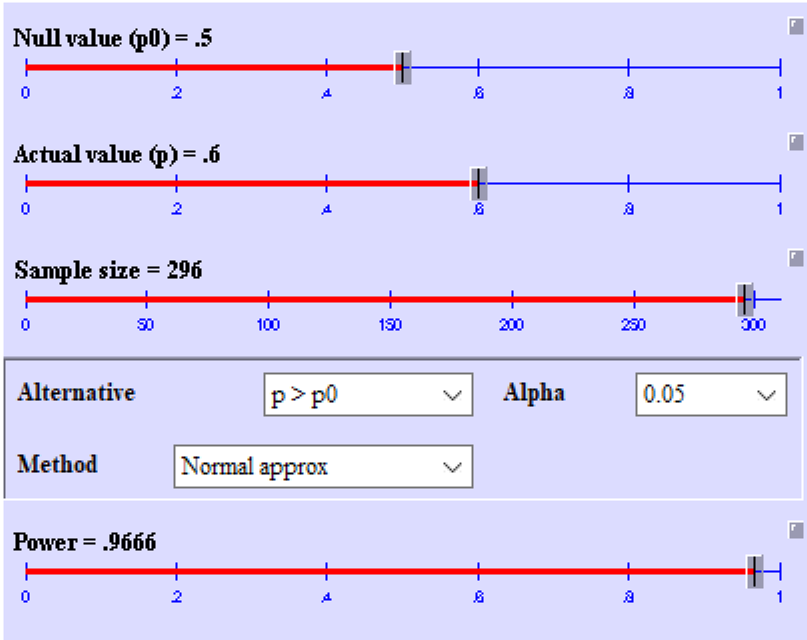

Figure 4. Sample size calculator from the University of Iowa.

To gather the data, I obtained permission from the University of North Texas IRB, which granted conditional approval, contingent on my acquiring permission from the Kenyan government and the principals of both Kaimosi and St. Augustine's Eregi teachers' training colleges. However, by the time I was granted the conditional approval on October 3, 2019, the teachers' training colleges were completing their annual exams and getting ready to leave for the long end of year break. These colleges generally follow the regular school year, which starts in January with breaks in April and August and the long break from November to January.

Besides, I sought permission from the Kenyan National Commission for Science, Technology, & Innovation, which grants permits for all research in the country. The Kenyan authorities permitted me to research the pre-service teachers on November 7, 2019. At that time, the teachers' colleges had already closed for the end of year break and to allow the faculty to assist in administering national examinations for elementary and high schools held every November. The students at the teachers' colleges were thus away from their campuses for the rest of that year. I had to wait until the re-opening of the colleges in January 2020 to get permission from the principals to conduct the research.

Meanwhile, I deposited a copy of the research permit with the county education officials and government administrators in Vihiga and Kakamega counties, both in western Kenya - the locations of the two colleges. My research assistant and I visited the colleges in the early weeks of January 2020, and I eventually got permission to distribute the survey on January 10th, 2020, when studies resumed at the colleges. Copies of these permissions are in Appendices I and J. With these permissions in hand, through my dissertation supervisor - Dr. Tandra Tyler-Wood, I resubmitted a request for final approval from the UNT IRB. The UNT IRB approved my application on January 16, 2020 (IRB # 19-418).

3.5 About the Study Sites

Kaimosi TTC is a rural college located next to a lush tropical forest. At the time of our visit, the college had 1020 students (620 female and 400 male) and 110 faculty and other support staff. The college offers 2-year certificates for primary (elementary) school teachers and another 2-year certificate for teachers of Early Childhood Development and Education (ECDE). The study program clusters include arts and informational technology and science. The average class size for the arts stream is 50 students and 30 for the science stream. Students are required to participate in a 3-week teaching practicum every semester. All the college students are residents at the colleges’ hostels.

Additionally, students receive a two-hour lesson on ICT every week. Because of these ICT lessons, there are about 50 working desktop computers at the college. There is free Wi-Fi for the students, although access to some sites is limited.

On the other hand, St. Augustine's Eregi TTC has 1100 students (700 female and 400 male), although, in previous years, the college has accommodated about 3000 students. For the year 2019-2020, following the restructuring of the educational system in Kenya, there was no new intake of students at the college. The government intends to convert the now primary (elementary) teacher training college into a high school teacher training facility, which will issue higher diplomas to students. Apart from this, the student population at Eregi TTC is similar to Kaimosi in most ways.

3.6 Instrument

I used a survey instrument to assess pre-service teachers' technological pedagogical knowledge, known as the Survey of Preservice Teachers' Knowledge of Teaching and Technology by Schmidt et al. (2009). I used this instrument to measure the teachers' deep knowledge about the processes and practices or methods of teaching and learning (Koehler & Mishra, 2009). The argument is that teachers with deep technological and pedagogical knowledge understand how students construct knowledge and acquire skills and how the teachers develop learning habits and positive dispositions toward learning.

The original survey instrument has 75 items that gauge pre-service teachers' self-assessments of the seven TPACK domains. However, the shorter version, which has 45 items, was used in this research. I deployed the shorter version of the instrument so as not to discourage respondents from answering lengthy questions. The shorter version is also validated (Schmidt et al., 2009).

The instrument also features items that request demographic information from the students. The authors of the instrument, Schmidt et al. (2009), note that the instrument creates a robust survey that targets pre-service teachers and thoroughly examines their knowledge of each of the seven TPACK domains.

I used the TPACK framework developed by Koehler and Mishra (2009) to determine the extent to which pre-service teachers in selected colleges in Kenya can integrate TPACK. The TPACK framework builds on Shulman's (1986) descriptions of pedagogical content knowledge (PCK) to describe how teachers' understanding of educational technologies and PCK interact to produce effective teaching with technology (pg. 62).

I obtained permission to use the instrument from the lead author of the instrument. Studies that have validated the instrument include a study by Sahin (2011), who found that the instrument successfully measured the items for each variable. Sahin examined TPACK using exploratory factor analysis, which verified the survey items for each subscale in the instrument. Additionally, Albion, Jamieson-Proctor, and Finger (2010) have also suggested that this survey instrument is reliable, and researchers can use it with confidence in contexts where the subjects represented in the content scales are appropriate.

Schmidt et al. (2009) have shown the instrument to have internal consistency reliability (coefficient alpha) ranging from 0.78 to 0.93 for the seven TPACK subscales. The alpha coefficient ranges in value from 0 to 1 and is used to describe the reliability of factors extracted from questionnaires or scales. The higher the alpha score, the more reliable the generated scale (Santos, 1999). Different reports show acceptable values of alpha ranging from 0.7. to 0.95 (Tavakol & Dennick, 2011). Koehler et al. (2014) note that this instrument has been successfully used to measure significant growth in seven TPACK areas, with the largest growth in TK, TCK, and TPACK.

The subscales for these instruments are:

1. Technology knowledge (TK),
2. Content knowledge (CK),
3. Pedagogy knowledge (PK),
4. Pedagogical content knowledge (PCK),
5. Technological pedagogical knowledge (TPK),
6. Technological content knowledge (TCK), and
7. Technological pedagogical content knowledge (TPACK)

The shorter version of the instrument, which is also validated (Schmidt et al., 2009), was used to capture measurements in these domains:

- 8 Technological Knowledge items
- 17 Content Knowledge items
- 10 Pedagogical Knowledge items
- 8 Pedagogical Content Knowledge items
- 8 Technological Content Knowledge items
- 15 Technological Pedagogical Knowledge items
- 9 TPACK items

The instrument ranks these items on a Likert scale as *strongly disagree* (1), *disagree* (2), *neither agree nor disagree* (3), *agree* (4), and *strongly agree* (5).

Schmidt et al.'s (2009) examination of the relationship between TPACK subscales found the coefficients varying from 0.02 to 0.71 (TPK and TPACK). Schmidt et al. found that TPACK significantly correlated with eight subscales at the 0.001 level and with social studies content knowledge (SSCK) at the 0.05 level. Schmidt et al. also found that the highest correlations were between TPACK and TPK (r= 0.71), TPACK and TCK (r= 0.49), and TPACK and PCK (r=0.49) as shown in Table 2.

Table 2

Correlations among the TPACK Subscales

TPACK Subscale	TK	SSCK	MCK	SCK	LCK	PK	PCK	TPK	TCK	TPACK
Technology Knowledge (TK)	-	0.07	0.41	0.37	0.19	0.21	0.17	0.40	0.54	0.43
Social Studies Content Knowledge (SSCK)		-	0.02	0.35	0.43	0.18	0.35	0.16	0.22	0.18
Math Content Knowledge (MCK)			-	0.39	0.15	0.14	0.25	0.23	0.21	0.26
Science Content Knowledge (SCK)				-	0.33	0.30	0.33	0.26	0.36	0.37
Literacy Content Knowledge (LCK)					-	0.42	0.32	0.35	0.23	0.53
Pedagogical Knowledge (PK)						-	0.56	0.51	0.23	0.53
Pedagogical Content Knowledge (PCK)							-	0.32	0.20	0.49
Technological Pedagogical Knowledge (TPK)								-	0.46	0.71
Technological Content Knowledge (TCK)									-	0.49
Technological Pedagogical Content Knowledge (TPACK)										-
Mean	3.67	3.80	3.70	3.65	4.03	3.97	3.63	4.15	3.84	3.97
Standard Deviation	0.55	0.70	0.78	0.73	0.48	0.45	0.65	0.44	0.53	0.52

Source: Schmidt et al., 2009.

The TPACK survey is a validated instrument (Sharma & Sharma, 2018) and was used to fit the local conditions of Kenyan pre-service teachers where the school terms and semesters are different from those in the US. For example, the school semester was modified from the US system (summer, spring, fall, winter) to reflect local school semesters. I modified the school year will likewise from the US system (freshman, sophomore, junior, senior) to local equivalents (first year, second year, third year, fourth year) and others that have similar differences.

In addition to the survey questionnaire, I included three open-ended questions that elicited more in-depth information from individual respondents on teachers' technology integration knowledge. I placed the open-ended questions at the end of the survey. These are the open-ended questions:

1. How do you currently use digital technologies to support your teaching? (Graham et al., 2009).
2. What kind of technical skills that you can use later in your profession are you learning? Describe how you intend to use those skills in your future teaching (Özgűn-Koca, Meagher, & Edwards, 2009).
3. Describe a specific episode where you conclusively demonstrated or modeled combining content, technologies, and teaching approaches in a classroom lesson. Please include in your description what content you taught, what technology you used, and what teaching approach(es) you implemented. If you have not had the opportunity to teach a lesson, please indicate that you have not (Schmidt et al., 2009).

3.6.1 Coding Protocol for Responses to the Open-Ended Questions

I used descriptive coding to catalog and better reveal the epistemologies of integration of educational technology in pre-service teachers' colleges (Saldaña, 2013). According to Saldaña, descriptive coding summarizes in a word or short phrase the essential topic of a passage of qualitative data. Descriptive coding is appropriate for qualitative studies with a variety of data forms, such as interview transcripts.

Therefore, I documented the responses of the respondents and coded using descriptive nouns. To analyze the written responses, I extracted from the responses all similarly coded phrases to provide a re-organized and categorized narrative portrait of the teachers' views on the integration of technology for further analysis (Saldaña, 2013). This re-organization enabled me to group evidence and label ideas so that these ideas accurately reflected the broader perspectives of the pre-service teachers (Creswell & Clark, 2017). I grouped the codes into themes and arranged the themes into larger dimensions or perspectives (Creswell & Clark). I did not limit my codes to a few labels. Still, I allowed the open-ended responses to enable the labels to transcend descriptive details and encourage a focus on patterns among responses that yield codes (Holton, 2007).

However, because I coded the written responses solo, I frequently engaged my research assistants and consulted a few of the respondents during analysis as a form of member checking (Saldaña, 2013). This member-checking assisted me to validate my findings and presented windows of opportunity to clarify emergent ideas and make new insights about the data (Saldaña).

I coded the first open-ended question (*how do you currently use digital technologies to support your preparation in teaching?)* using Graham et al.'s (2009) example of identifying evidence of general versus content-specific uses of technology. I coded for examples of the actual use of technology to prepare for teaching by the pre-service teachers. This data showed how pre-service teachers are using technology and may suggest how these teachers are preparing to use it in classroom instruction after they graduate.

The second open-ended question (*What kind of technical skills that you can use later in your profession are you learning? Describe how you intend to use those skills in* *your future teaching* (Özgűn-Koca et al., 2009*),* was coded for instances of the respondents' a) attitudes towards, b) skill in using, and c) possible future deployment of TK, CK, and PCK. Themes expected here included 'high probability of future use of technology,' 'using technology to understand the content,' and others.

The final open-ended question (*Describe a specific episode where you effectively demonstrated or modeled combining content, technologies, and teaching approaches in a classroom lesson. Please include in your description what content you taught, what technology you used, and what teaching approach(es) you implemented. If you have not had the opportunity to teach a lesson, please indicate that you have not* (Schmidt et al., 2009)) was coded for themes that explore the pre-service teachers' experience using technologies. I used the codes to explore the pre-service teachers' interaction with content and technology and the pedagogy the teachers used to integrate these components. These questions seek to explore technology, pedagogical, and content knowledge integration by the teachers.

3.6.2 Ethical integrity

There was no foreseeable conflict of interest issue anticipated in this study. All the participants were volunteering adults who could withdraw their consent at any time or choose not to participate without experiencing any adverse consequences. I offered the participants an incentive to win a $20 gift card in a drawing for all study participants.

3.7 Procedure

After receiving approval from UNT's IRB, I sought additional approval from Kenya's National Commission for Science, Technology, and Innovation, which oversees all educational research in Kenya. I obtained a research license from Kenya's National Commission for Science, Technology, and Innovation only after UNT issued me with the primary IRB. The commission also required a written introduction from a UNT professor, acknowledging that I am a graduate student. The UNT IRB committee reviewed my application and issued conditional permission to enable me to get permission from officials in Kenya. After I obtained these permissions, I conducted the research process as follows:

1. Using local contacts in Kenya, I recruited two assistants to distribute the survey instrument after getting permission from the officials of the teachers' colleges.
2. I then sought permission from individual pre-service teachers requesting them to complete the survey. I used this study to target only adult pre-service teachers whose participation was voluntary.
3. My assistants and I then collected the completed survey. The surveys were paper-based due to inadequate access to computers or the internet for many of the potential respondents.
4. I completed the data analysis in Texas using SPSS and Excel, and
5. I then prepared the final report.

The UNT IRB was the primary IRB for this project. The IRB assures the privacy, anonymity, and confidentiality of the respondents' information and responses. Additionally, I have completed training on the Responsible Conduct of Research.

I trained the data collectors using the protocol found in Appendix B. The procedure assured the research participants of their privacy and reiterated requirements of the UNT IRB on Informed Consent for Adults. I trained my assistants on-site in Kenya. I recruited my research assistants because they had previous experience conducting similar data collection for me. I privately communicated with potential assistants through telephone and email conversations.

As stated earlier, I used the TPACK survey instrument developed by Schmidt et al. (2009) to gather information from students in the two teachers' colleges. I administered the survey instrument over two weeks, from February 3 to 11, 2020. Later, from February 11 to 18, 2020, we visited St. Augustine’s Eregi Teachers' College to administer the same survey instrument. The students were returning to their colleges after their end of year break. Although the principals wanted the data collection to occur only during learning breaks, this did not give the respondents enough time to complete the surveys. We later requested time before instruction to have the teachers complete the survey. The principals allowed us this time before instruction, and we were able to administer the surveys. At first, there were not too many students in classes because some of them were unable to pay the college tuition fee or had experienced some financial difficulties that delayed their resuming classes.

Altogether, I gathered responses from 315 pre-service students, but seven of the responses were incomplete, and I ended up with 308 valid survey responses. The raw survey responses are stored in Dr. Tandra Tyler-Woods' office at the UNT Denton office. This raw data includes a copy of the spreadsheet with the raw data and copies of the SPSS outputs.

3.8 Data Analysis Plan

3.8.1 Preparation of the Data

After the data were collected, I entered the data in a spreadsheet documenting the participants' responses as indicated on the Likert-like responses ranging from 1-5, where '1' means the respondents *strongly disagree* with the statement and '5' means the respondents *strongly agree*. I recorded the respondents' gender, age range, major, area of specialization (if any), year in college, and experience with technology. These data were necessary for me to evaluate the representativeness of my sample data. None of the respondents' names or other identifying information, appear in the final document. I entered the data and reviewed it to ensure that there were no data entry errors or other unintended entries. If an entry had entirely missing data, I deleted the participant's response and carried out the analysis without this data. To maintain the representativeness of the data, I allowed entries with missing data. I retained this data also to avoid bias in the results or significant loss of data and associated loss of power because of the reduction in sample size (Papageorgiou, Grant, Takkenberg, & Mokhles, 2018).

3.8.2 Planning for Data Analysis

After conducting some preliminary descriptive analysis of the data, I used SPSS to conduct inferential analysis. Following Abbitt’s (2011) example, I completed a multiple regression analysis to determine the degree to which the respondents' perceived knowledge in TPACK may have contributed to their beliefs on technology.

For the data gathered from the questionnaire, I established the level of construct validity by performing a confirmatory factor analysis of the 46 items of the same items in Schmidt et al.’s (2009) study. I also used Pearson's *r* correlation to conduct a correlation analysis of the computed subscale variables. This correlation analysis enabled me to determine any relationships between the 46 items in the survey (Archambault & Barnett).

Following the recommendations of the instrument’s authors, the data analysis plan accepted factors with Eigenvalues greater than 1 to identify several factors and their constitution following the factor analysis (Schmidt et al., 2009). After eliminating problematic items, I analyzed the final data subscales as follows:

- *Technology knowledge (TK)*: What factor(s) account for the most substantial variance and is present in all the items captured in the respondents' self-assessment of their educational technology knowledge?
- *Content knowledge (CK)*: According to Schmidt et al. (2009), this refers to the knowledge teachers must have about the content they are going to teach and how the nature of that knowledge is different for various content areas. In factor analysis, what factors can I extract on the content, and what are the significances as measured by Cronbach's alpha for these items?
- *Pedagogical knowledge (PK)*: These are the methods and processes of teaching and include fundamental knowledge in classroom management, assessment, lesson plan development, and student learning. What did a factor analysis on the seven items representing PK produce? What was the variance and Cronbach's alpha on these items?
- *Pedagogical content knowledge (PCK):* This domain shows the content knowledge that deals with the teaching process. How many factors were produced by a factor analysis of the seven items in the PCK? What were the variances and Cronbach's alpha?
- *Technological content knowledge (TCK)*: According to Schmidt et al. (2009), this fifth domain refers to teachers' understanding of how using a specific technology can change the way learners understand and practice concepts in a content area. How many factors were produced by a factor analysis? What percentage of the variance for which they accounted?
- *Technological pedagogical knowledge (TPK):* TPK is the teachers' knowledge of how teachers can use various technologies in teaching and understanding that using technology may

change the way an individual teaches. How many factors emerged from a factor analysis of this domain? What was the variance of the factors?

- *Technological pedagogical content knowledge (TPACK)*: Finally, TPACK refers to the knowledge teachers require for integrating technology into their teaching. This knowledge estimates teachers' intuitive understanding of the complex interplay between the components of content, pedagogy, and technology (Schmidt et al., 2009). Successful integration of technology requires the teaching of content using appropriate pedagogical methods and technologies. What did a factor analysis of this domain show? What is Cronbach's alpha for these items? I also conducted analyses to find correlations, if any, for the TPACK subscales using Pearson's correlations.

The open-ended research questions responses were indexed to analytical categories and themes to describe and explain any phenomena observed. All the data relevant to each category was identified, examined, and compared with the rest of the data to establish analytical categories. I added categories to reflect as many of the nuances in the data as possible (Pope, Ziebland, & Mays, 2000). Following recommendations by Pope, Ziebland, & Mays, I analyzed the open-ended interview responses using the TPACK framework as follows:

1. *Familiarization*- I immersed myself in reading the transcripts to list significant ideas and recurrent themes.

2. *Identify the presence of the TPACK framework*- I identified all the key issues, concepts, and themes by which the data could be examined and referenced. This identification resulted in the labeling of the data into manageable chunks for subsequent retrieval and exploration.

3. *Indexing*- I applied the TPACK framework to the data by annotating the transcripts to identify technology, pedagogy, and content knowledge by the respondents.

4. *Charting*- I rearranged the data according to the TPACK thematic framework by grouping similarly-themed responses together. This involved abstraction and synthesis of the data, and

5. *Interpretation*- I used the charts to define concepts, map the range and nature of TPACK by creating typologies and finding associations between themes. These themes provided the outline of the findings from the data and the emerging themes.

3.8.3 Analysis for Answering the Research Questions

I conducted data analysis using measures of central tendency such as mean, median, and mode. These measures of central tendency were intended to describe the 'average' member of the respondents and may provide an estimate of the center of the distribution of values. The data were also analyzed using percentages to understand how the data may relate to a larger group of respondents. Data were also be analyzed using frequencies and range. I analyzed the data by examining the dispersion of the data around the central tendency. The analysis considered the range and standard deviation of data to understand dispersion. The analysis also took into account outliers in the dataset. In analyzing the data, I considered explanations of how the data was collected. I reported unanticipated events or anomalous data and provided explanations. I used the following analysis to answer the research questions:

- Question 1 (*To what extent do pre-service teachers in selected Kenyan teachers' training colleges demonstrate knowledge of TPACK necessary for integrating technology in their* *teaching?*): Analysis of the averages or measures of central tendency from the Likert-like responses on the survey that target the total TPACK of the respondents.

- Question 2 (*To what extent do pre-service teachers in selected Kenyan teachers' colleges demonstrate knowledge of the TPACK domains of technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK)?*)): Analysis of the measures of central tendency (mode, median, and mean) of the responses on the five domains of TK, CK, PK, PCK, and TPK.

- Question 3 (*To what extent do personal experiences with technology impact the use of educational technology by pre-service teachers in selected Kenyan teachers' training colleges?*): I analyzed the respondents' own experiences with technology from the coded responses of the open-ended questions at the end of the survey.

- Question 4 (*To what extent does the TPACK framework capture the readiness of pre-service teachers to use ICT for classroom instruction?*): A more in-depth investigation of the factor analysis resulting from Research Question 1 and comparing this analysis with the coded responses from the open-ended questions.

CHAPTER 4

DATA ANALYSIS

4.1 Introduction

This chapter describes my data analysis, which includes an analysis of quantitative data from the questionnaire and qualitative data from the open-ended questions. After conducting some preliminary descriptive analysis of the data, I used SPSS to conduct inferential analysis. Following Abbitt's (2011) example, I conducted a multiple regression analysis to determine the degree to which the respondents' perceived knowledge in TPACK may have contributed to their beliefs on technology.

For the data gathered from the questionnaire, I established the level of construct validity by performing a confirmatory factor analysis of the 46 items of the same items in Schmidt et al.'s (2009) study. I also used Pearson's *r* correlation was to conduct a correlation analysis of the computed subscale variables. This correlation analysis enabled me to determine any relationships between the 46 items in the survey (Archambault & Barnett).

Following the recommendations of the instrument's authors, the data analysis plan accepted factors with Eigenvalues greater than 1 to identify several factors and their constitution following the factor analysis (Schmidt et al., 2009).

4.2 Data Collection

After I obtained permission to conduct the study from the UNT IRB, the Kenyan government, and the principals of Eregi and Kaimosi TTCs, I approached individual students to gather data. At first, the principals of the colleges wanted my assistants and me to gather data only when the students were on break from instruction or after studies. However, this did not give the students enough time to complete the questionnaire. I approached the principals requesting for time either just before classroom instruction or a few minutes before the end of instruction. The principals agreed to allow us sometime just before classroom instruction, and the data collection process went on quite smoothly after that. We explained to each class the purpose of the study and asked for the students' consent before administering the survey questionnaire. We explained to the students some of the questions, especially the open-ended questions at the end of the survey, and we answered general questions from the faculty and the pre-service students alike.

4.2.1 Missing and Incomplete Data

There were some cases of data that were completely missing that I deleted. I removed seven teacher trainees from the list completely because they did not respond. Because I already had 308 respondents, the responses from these seven samples did not critically affect the representativeness of the completed sample. I had 308 respondents without the missing data, which ensured my adherence to statistical power.

Half of the respondents (160 or 52% of the students) responded to all questions. Twenty percent did not respond to at least one question, and 11% did not respond to 2 questions only. The injection of data bias due to missing data could only be minimal since only 5% of the respondents did not complete the questionnaire.

4.2.2 Causes of Missing Values

There were various reasons for the missing data. Some of these reasons are that some questions did not apply to the respondents, some respondents skipped the questions (whether deliberately or not), some respondents may have found some questions sensitive and chose not to answer, among other issues. The question with the most missing data (24) was Question 11 on content knowledge: *I can use a historical way of thinking*. On further inspection of this question, I found that since it occupies only one line on the questionnaire, the line appears like a borderline, and respondents may have thought it was a borderline, not a space to put a checkmark. The second highest unanswered question (18 unanswered) was Question 5 on technology knowledge: *I know about a lot of different technologies*. It is unclear why this question was unanswered. Generally, the questions on the technology knowledge domain (Questions 1 to 6) were the least answered, and this could be attributed to the respondents gaining confidence as they continue answering the questions.

4.3 Representativeness of the Sample

How representative is this sample of 308 respondents? One measure is by noting the characteristics of this population against the general teacher training population in Kenya. All Kenyan government-run teacher training colleges, such as Kaimosi and Eregi, follow the same curriculum. The pre-service teachers are all taught at the same pace and sit the same national assessments at the end of the year. Additionally, with very few exceptions, Kenyan teacher training colleges (including Kaimosi and Eregi) are mostly located in rural areas and have a diversified student body, somewhat like these two colleges.

At first, the respondents stated that they did not have enough time to complete the survey. We then requested the administrators of the colleges for more time for the students to complete the survey, a request which the principals granted. The college administrators set aside some time just before student instruction, and the students were able to complete the survey.

All the respondents voluntarily answered the questionnaire. Most of our face-to-face interaction suggested that the students were eager to give their views and to be part of finding a solution to the issue of integration of technology in classrooms. Most of the students are already used to technology through their smartphones, tablets, and other personal technology and readily responded to our requests for participation. There was sufficient voluntary response rate, and only modest missing data so that an analysis is reasonably acceptable.

4.4 Respondents' Demographics

The study sample had good returns (*n*=308), with 162 respondents were from St. Augustine's Eregi Teachers' Training College and 148 from Kaimosi Teachers' Training College, as shown in Table 3. It was also not surprising that most of the respondents (204) identified as female against 105 male students, as depicted in Table 4. This gender difference is not as remarkable as most of the students in both colleges are female because these being elementary teachers' training colleges, females have higher representation. One student declined to identify his/her gender.

Table 3

Breakdown of Number of Respondents from the Two Colleges

	Frequency	Percent
Eregi TTC	162	52.6
Kaimosi TTC	146	47.4
Total	308	100

Table 4

Breakdown of Respondents by Gender

	Frequency	Percent
Female	202	65.6
Male	105	34.1
Total	307	99.7
Unspecified	1	

The data also shows that there were 132 students aged between 18 and 22 years who completed the questionnaire. As shown in Figure 5, there were almost a similar number (133) of students aged 23 to 26 years enrolled in both colleges, while those aged between 27 and 32 years were 35. Only five students were aged 32 and above, which is not surprising as most students enroll in these teachers' colleges immediately after high school.

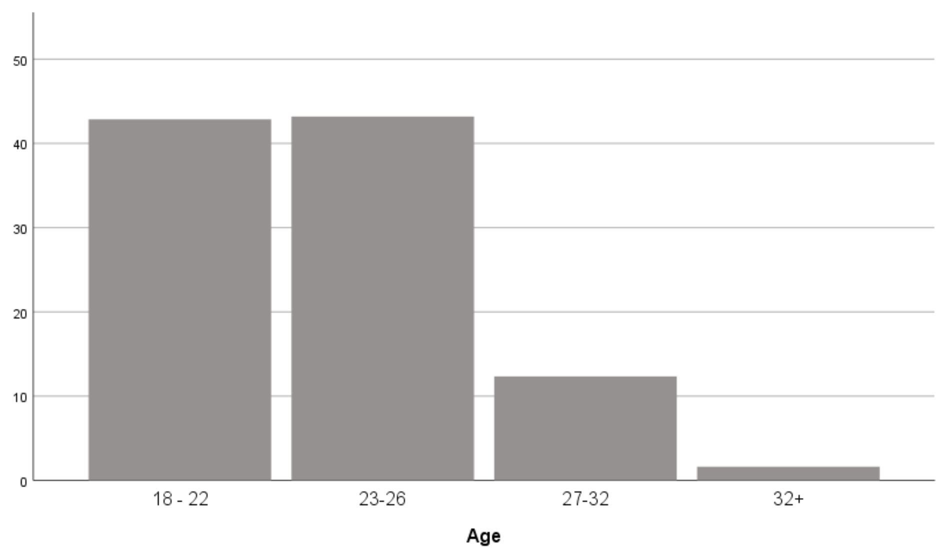

Figure 5. Breakdown of respondents by age.

It was also instructive that 98% of the students (301 students) indicated that they had received training in the use of educational technology from the colleges, as shown in Table 5.

Table 5

Respondents Having Undergone ICT Training in College

	Frequency	Percent
ICT Training	301	97.7
No ICT Training	6	1.9
No Answer	1	
Total	308	

Three hundred two students from both colleges stated that they were in their second year of college, and 301 students indicated that they had had training in the use of ICT in education at their college. Fifty-five percent of the respondents (172 respondents) stated that they have enrolled or have completed their teaching practicum experience, while about 125 respondents had not. Twelve respondents declined to answer this question. So, although there are some missing responses, this dataset is viable in making some inferences on the pre-service teacher trainees in the two colleges.

4.5 Factor Analysis of TPACK Subscales

To verify scale construction and to describe variability among the 46 TPACK items on the questionnaire, I conducted a factor analysis on these items. The determinant for these data was 2.37E-018, which indicated that multicollinearity was not a problem in these data, and the responses correlated well, precluding the need to eliminate any questions at this point.

In testing for sphericity (Table 6), I found the KMO statistic to be 0.882, indicating that a pattern of correlations was relatively compact. So, factor analysis was appropriate and reliable to understand these factors. Since this is greater than the recommended 0.5, it showed that the readings were acceptable and provided me with confidence that factor analysis is appropriate for these data.

Table 6

KMO and Bartlett's Test

Test	Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.88
Bartlett's Test of Sphericity Approx. Chi-Square	5999.76
df	1035
Sig.	0.000

Significance was recorded at $p < 0.001$, confirming that there were some relationships between the variables and that factor analysis is an appropriate method to understand these variables. This analysis confirmed that the correlation matrix of the variables in our data diverged significantly from the identity matrix, indicating that the data reduction was suitable to use to understand the responses.

4.5.1 Factor Extraction

After factor extraction and rotation of the 45 TPACK items, the SPSS extracted nine factors with eigenvalues ranging from 1.029 to 17.034. These are shown in Table 7.

Table 7

Factor Extraction

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% Var	Cum %	Total	% Var	Cum %	
1	17.03	37.03	37.03	17.03	37.03	37.03	10.56
2	3.63	7.90	44.93	3.63	7.90	44.93	6.17
3	3.02	6.57	51.50	3.02	6.57	51.50	5.47

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% Var	Cum %	Total	% Var	Cum %	
4	2.03	4.41	55.92	2.03	4.41	55.92	3.82
5	1.88	4.09	60.01	1.88	4.09	60.01	5.15
6	1.51	3.29	63.31	1.51	3.29	63.31	9.67
7	1.34	2.93	66.24	1.34	2.93	66.24	9.35
8	1.25	2.73	68.97	1.25	2.73	68.97	3.87
9	1.02	2.23	71.21	1.02	2.23	71.21	3.68
10	.93	2.03	73.24				
11	.87	1.89	75.14				
12	.81	1.77	76.92				
13	.74	1.61	78.54				
14	.70	1.53	80.07				
15	.66	1.45	81.52				
16	.62	1.35	82.88				
17	.57	1.24	84.12				
18	.55	1.19	85.32				
19	.53	1.17	86.49				
20	.49	1.06	87.56				
21	.46	1.02	88.58				
22	.44	.97	89.55				
23	.41	.90	90.46				
24	.37	.82	91.28				
25	.36	.78	92.07				
26	.33	.71	92.78				
27	.30	.67	93.45				
28	.30	.65	94.11				
29	.28	.61	94.73				
30	.25	.56	95.30				
31	.22	.49	95.79				

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% Var	Cum %	Total	% Var	Cum %	
32	.20	.45	96.24				
33	.20	.43	96.68				
34	.18	.39	97.07				
35	.16	.35	97.43				
36	.15	.34	97.77				
37	.14	.32	98.10				
38	.13	.28	98.39				
39	.12	.27	98.66				
40	.11	.25	98.91				
41	.11	.24	99.16				
42	.09	.19	99.35				
43	.08	.19	99.55				
44	.07	.16	99.71				
45	.06	.14	99.86				
46	.06	.13	100.00				

Extraction method: principal component analysis.

The scree plot (Figure 6), however, suggested that six factors seemed to be more applicable for this analysis. Even so, the chi-square goodness-of-fit test (Table 8), reinforces the suggestion that, considering that the p-value is less than 0.05, the responses from these pre-service teachers are statistically significant: $\mathcal{X}2$ (45, n=308) = 1253, $p < 0.05$ using six factors.

Table 8

Chi-Square Goodness-of-Fit Results

Chi-Square	df	Sig.
1258.38	657	0.000

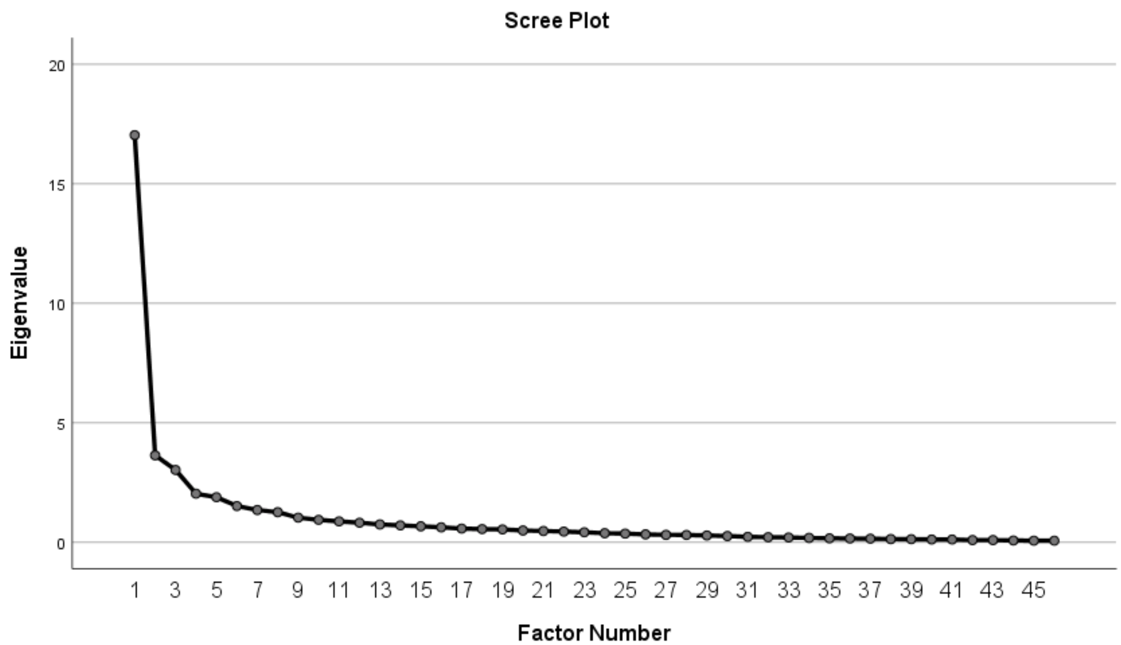

Figure 6. Scree plot showing acceptance of six factors.

4.5.2 Confirmatory Factor Analysis

Schmidt et al. (2009) suggested that there exists a relationship between the constructs of technology knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge, and technological pedagogical knowledge. This relationship helps teachers to develop technological, pedagogy, content knowledge that they require to be effective teachers. To verify that there is a relationship between these variables and that there exists an underlying construct among the variables, I conducted a structural equation modeling using Amos(T) software, which is an extension of SPSS(T) software. The model, as shown in Figure 7, suggests that the latent construct factors load very highly, with most coefficients above 0.7. The first latent construct – Technology Knowledge – showed the least satisfactory indicators as a factor. However, some individual constructs showed loadings of less than 0.6, suggesting that the students needed more exposure on that variable.

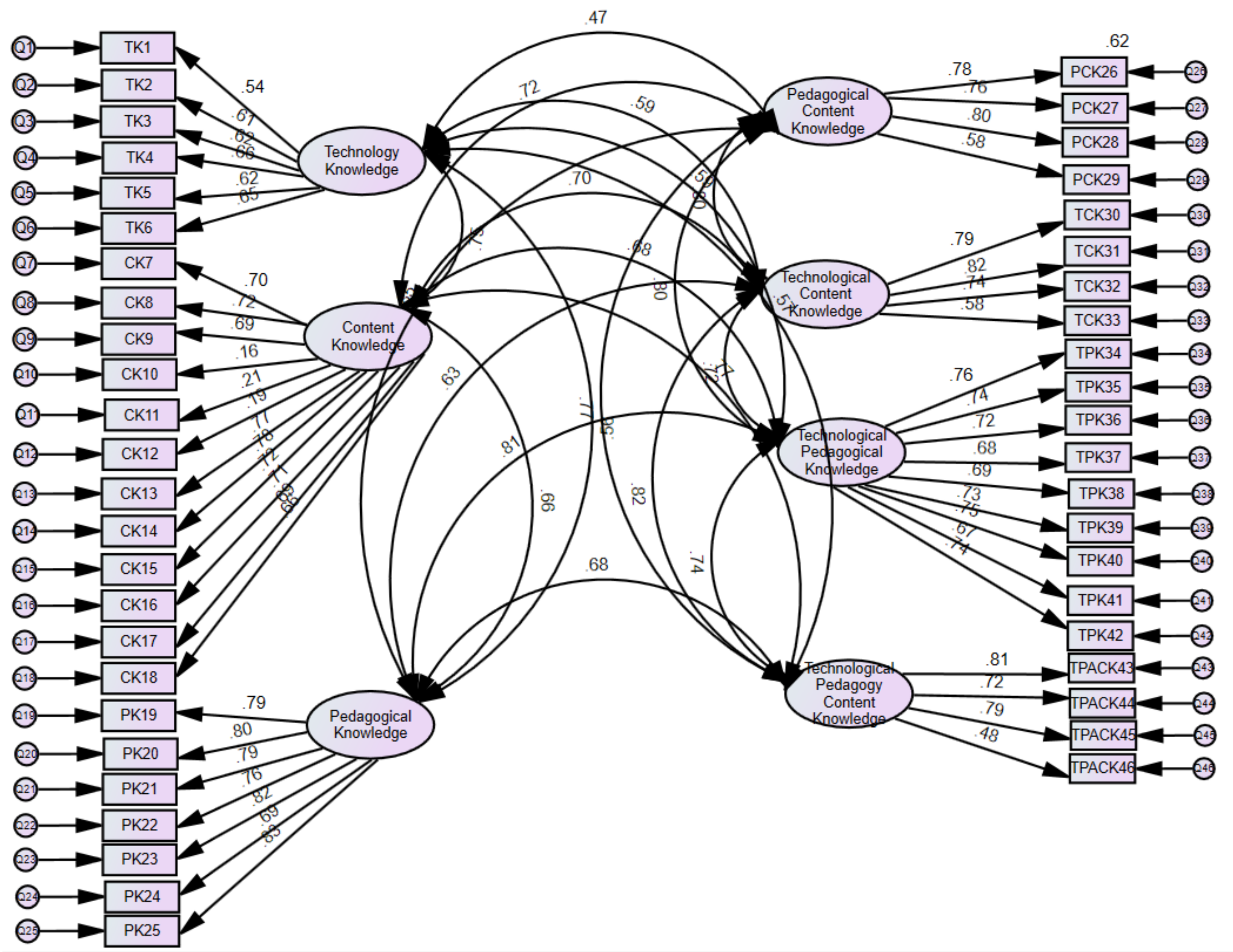

Figure 7. Confirmatory factor analysis using Amos.

Overall, the model indicated that most items did fit the measurement model, indicating an achievement of unidimensionality because of the acceptable factor loadings. If I deleted any items from the model, I would drop items on Content Knowledge (Questions 10 and 11 and Question 46 on the TPACK construct) from the model. These were the questions: Q10 – I have enough knowledge of social studies, Q11 – I can use a historical way of thinking, and Q46 – I can teach lessons that appropriately combine social *studies, technologies, and teaching approaches*. Maybe because the authors of the survey instrument based it on the US education curriculum, the questions in the instrument do not consider that the Kenyan pre-service teachers are required to choose only one of two specializations. These are arts or sciences without any other choice – probably raising confusion in answering these content questions.

In terms of the absolute fit of the model, the Normed Fitness Index (NFI), RFI, Incremental Fitness Index (IFI), Non-Formed Fitness Index – also known as TLI, and the Comparative Fitness Index (CFI) showed modest loadings of 0.7, 0.65, 0.8, 0.7, and 0.8 respectively. These were not superb loadings, and this could be because of the large sample size (*n*=308) for which this model is sensitive. The root mean square error approximation (RMSEA) was an acceptable fit at 0.085 (Teo, Lee, Chai, & Wong, 2009). This sample size is large, and the model is complex, which inevitably inflated the Chi-Square.

Regarding validity, the model suggested good convergent validity when most items in the measurement showed statistical significance with values of 0.5 and higher (as shown in Figure 5). According to Hu and Bentler (1999), for continuous data, a RMSEA < 0.06, TLI > 0.95, CFI > 0.95 suggest superb fit with the model. Regarding construct validity, the model did not suggest superb fitness, but the values were still acceptable at 0.7 and higher for most of the fitness indices. I did not perform discriminant validity since the model only provides a rough idea of its fitness structure, and I ran no additional model without some of the low-scoring items. From this analysis, I found the instrument robust enough for me to proceed with a meaningful analysis of my study sample.

4.6 Research Questions

Considering that the respondents are a reasonably representative sample of the pre-service teachers in these two colleges and that their responses fit the models of typical responses, I proceeded to answer the research questions using the data collected. As a reminder, these were the research questions:

1. To what extent do pre-service teachers in selected Kenyan teachers’ training colleges demonstrate knowledge of TPACK necessary for integrating technology in their teaching?
2. To what extent do pre-service teachers in selected Kenyan teachers’ colleges demonstrate knowledge of the TPACK domains of technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK)?).
3. To what extent do personal experiences with technology impact the use of educational technology by pre-service teachers in selected Kenyan teachers’ training colleges?
4. To what extent does the TPACK framework capture the readiness of pre-service teachers to use ICT for classroom instruction?

In the next section, I use the data and insights from data collection to answer Research Questions 1, 2, and 4. To answer Research Question 4, I completed the coding of responses from 3 open-ended questions. However, I first use the data from the survey to respond to Research Questions 1 and 2.

4.6.1 Research Question 1

To what extent do pre-service teachers in selected Kenyan teachers’ training colleges demonstrate knowledge of TPACK necessary for integrating technology in their teaching?

As stated earlier in Chapter 1, the TPACK framework is one of several ways available to measure how college faculty integrate technology into pre-service teacher training. Therefore, TPACK incorporates teachers' understanding and use of technical knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). TPACK also empowers teachers to have an intuitive approach to teach using appropriate pedagogical methods and technologies (Schmidt et al., 2009). This first research question intended to gauge if pre-service teachers in these two teachers' training colleges have acquired skills to integrate TPACK in their teaching.

I measured TPACK knowledge through responses to Questions 43, 44, 45, and 46 on the questionnaire. According to the calculated frequencies (Table 9) on all the positive answers to these questions (‘agree’ and ‘strongly agree’), 69% of the respondents showed high levels of TPACK to integrate technology. However, when I consulted the rotated component matrix derived from the factor analysis (Table 10), the TPACK factors did not cluster together, suggesting that this variable is not present by itself in this model. These factors coalesced together with technological pedagogical knowledge (TPK), content knowledge (CK), and even stuck together with some PCK variables.

Table 9

Frequencies for TPACK Sub-Scale Responses

Response	N	Percent
Strongly Disagree	61	5%
Disagree	115	9.5%
Neutral	199	16.4%
Agree	**574**	**47.4%**
Strongly Agree	**261**	**21.6%**
Total	1210	100%

Table 10

Rotated Component Matrix

	Component								
	1	2	3	4	5	6	7	8	9
PK20	**.77**		.35						
PK23	**.76**								
PK25	**.76**								

	Component								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
PK21	**.75**								
PK22	**.74**								
PK19	**.69**		.39						
PK24	**.62**								
PCK26	**.60**	.37		.40					
PCK27	**.52**								
TPK42	**.41**							.39	
CK14		**.80**							
CK13		**.76**							
CK15		**.74**							
CK8		**.60**		.43					.37
PCK28	.45	**.48**							
TCK32		**.42**	.36	.38					
TPK35			**.79**						
TPK34			**.78**						
TPK40	.40		**.62**						
TPK39			**.59**						
TPK36			**.58**						
TPACK46			**.41**		.37	.41			
TCK30				**.70**					
TPACK43				**.69**					
TCK31				**.57**					
CK7		.48		**.57**					
CK9		.49		**.54**					
TPACK44				**.53**		.49			
CK12					**.85**				
CK10					**.83**				
CK11					**.73**				
PCK29			.35		**.55**				
TCK33			.45		**.49**				
CK18		.42				**.70**			
CK17						**.70**			
CK16						**.69**			
TPACK45				.42		**.50**			
TK6							**.76**		

	Component								
	1	2	3	4	5	6	7	8	9
TK5							**.69**		
TK4							**.56**		.44
TK1						.38	**.47**		
TK2		.36					**.47**		
TPK38								**.70**	
TPK37								**.59**	
TPK41			.37					**.51**	
TK3					.38				.54

Extraction method: principal component analysis. Rotation method: varimax with kaiser normalization.

Nevertheless, when examined individually, the TPACK items had strong loadings. Reliability analysis on the latent variable of TPACK comprising four items on Questions 43, 44, 45, and 46 showed these items had a Cronbach's alpha with the reliability of α = 0.79. Following DeVellis' (1991) guidelines, this is respectable reliability. Most items on this scale appeared to be worthy of retention (Table 11) except for Question 46 (*I can teach lessons that appropriately combine social studies, technologies, and teaching approaches*), the deletion of which would increase the alpha to α = 0.81.

Table 11

TPACK Items Total Statistics Showing Cronbach's Alpha

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Cronbach's Alpha if Item Deleted
TPACK Q.43	11.14	6.38	0.64	0.71
TPACK Q.44	11.08	6.75	0.65	0.71
TPACK Q.45	11.13	6.63	0.65	0.71
TPACK Q.46	11.23	6.83	0.47	0.81

The failure of the instrument to identify the latent TPACK variable among this population could be because of instrument design problems, construct validity of the instrument may be measuring an altogether different construct. Similar studies have also reported that the TPACK variables do not align as a factor. Shinas, Yilmaz-Ozden, Mouza, Karchmer-Klein, and Glutting (2013) in their study of pre-service teachers in the United States (n= 365), also using Schmidt et al.'s (2009) instrument, found that factors did not load on the variables of PK, PCK, TCK, and TPACK. Shinas et al. found that factors were congruent only on TK and CK variables. Additionally, Koh, Chai, and Tsai's (2010) study of 1,185 pre-service teachers failed to distinguish the TPACK construct. Similarly, Archambault and Crippen (2009) and Koh et al. (2010) also failed to distinguish the TPACK construct as a variable in their studies.

Additionally, I conducted a single-sample t-test to determine if a statistically significant difference existed between the TPACK scores from this group and scores from respondents in similar national studies. A study by Akyuz (2018) of 138 pre-service teachers found that the mean score on their TPACK was 3.8. In another study, Archambault and Crippen (2009) found their respondents mean to be 3.79, while Agyei and Keengwe's (2014) found in a pre-treatment population a TPACK mean of 2.38. Mouza, Karchmer-Klein, Nandakumar, Ozden, and Hu's (2014) study found a mean of 3.5 for TPACK scores in a pre-administration of the survey. Thus, taking an average 3.3 standard mean for this score from these established studies, I computed a single-sample t-test on the TPACK variable of the study population. The results suggested that the students from Eregi and Kaimosi TTCs self-reported TPACK scores were higher (M=3.75, SD=0.70) than similar studies, t(307)= [11.34], p=[0.000].

Therefore, as to Research Question 1 (*To what extent do pre-service teachers in selected Kenyan teachers' training colleges demonstrate knowledge of TPACK necessary for integrating technology in their teaching?)* data from this study suggested that, whereas the teachers rated themselves highly in the individual components of TPACK, the latent TPACK variable for these respondents could not be distinguished.

4.6.2 Research Question 2

Research Question 2: To what extent do pre-service teachers in selected Kenyan teachers' colleges demonstrate knowledge of the TPACK domains of technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK)?

To answer this question, I used the analysis of the measures of central tendency of the responses on the domains of TK, CK, PK, PCK, and TPK. So, to understand the levels of Technology Knowledge, I scored the positive responses to TK Questions 1-6 on the survey. The positive responses are those that the respondents answered agree or strongly agree to demonstrate knowledge of this sub-scale.

As Table 12 shows, 72% of the teachers demonstrated that they either 'agreed' or 'strongly agreed' about their levels of technical knowledge. All the questions in the survey are positive. Calculating the average scores for technology knowledge (TK) among the pre-service teachers, I found the mean score to be quite high at 3.75.

Table 12

Frequencies for Technology Knowledge Frequencies

	n	**%**
Strongly Disagree	64	3.6
Disagree	209	11.9
Neutral	206	11.7
Agree	**897**	**51.1**
Strongly Agree	**381**	**21.7**
Total	1757	100

Indeed, a one-sample *t*-test (Table 13) suggested that these teachers self-evaluated highly on their expertise in technical knowledge. Using a common standard of 3.06 computed from the means of similar pre-tests by Agyei and Keengwe (2014), Agyei and Voogt (2011a), Archambault and Crippen (2009), and Mouza et al. (2014), a one-sample t-test showed that pre-service teachers at Eregi and Kaimosi TTCs self-reported statistically significantly higher TK scores (M=[3.75], SD = [0.7]) than scores from similar studies, t(308) = [17.29], p = [0.000] (Table 13).

Table 13

t-*Test Means for Technology Knowledge (TK)*

	N	Mean	Std. Deviation	Std. Error Mean
Mean for TK	308	3.76	0.71	0.04

For Content Knowledge (CK), the respondents also self-reported, through their responses, high levels of content knowledge. Table 14 shows that 70% of the responses were positive towards their content knowledge levels. I compared these means with pre-test means found in a study by Shinas et al. (2013) of 365 pre-service teachers in the US, using the same survey instrument. Shinas et al. found pre-test means on content knowledge to be 4.1 for mathematics, 3.91 for social studies, 3.79 for science, and 4.23 for literacy. For the same CK means, Mouza et al. (2014) averaged the means to 3.87, while Agyei and Voogt (2011a) found an average of 2.61 mean scores for CK.

Table 14

Content Knowledge Frequencies

	n	Percent
Strongly Disagree	134	3.8
Disagree	398	11.2
Neutral	514	14.5
Agree	**1701**	**48**
Strongly Agree	**800**	**22.6**
Total	3547	100

As shown in Table15, the means of CK for the respondents in Kaimosi and Eregi TTCs, calculated against the average of 3.49 from similar tests, showed that the respondents from Kaimosi and Eregi TTCs scored themselves higher on CK (M=3.74, SD = [0.65]) than respondents from similar studies, t(308) =6.89, p<[0.001].

Table 15

t-*Test Means for Content Knowledge (CK) Scores*

	N	Mean	Std. Deviation	Std. Error Mean
Mean for CK	308	3.74	0.66	0.04

Additionally, for Pedagogical Knowledge (PK), 83% of the respondents entered positive responses to this variable, as shown in Table 16. These responses suggest that the pre-service teachers have high regard for their pedagogical knowledge. Compared to average scores from similar studies 4.24 (Shinas et al., 2013), 3.79 (Mouza et al., 2014), and 2.62 (Agyei & Voogt, 2011a), the respondents from Kaimosi and Eregi TTCs had high mean scores for PK of 4.07. A one-sample *t*-test suggested that respondents from these two colleges self-reported statistically significant higher mean scores for pedagogical knowledge (M = 4.07, SD = [0.79]) than students from similar studies in pre-tests, t(306) = [12.77], p < [0.001] (Table 17).

Table 16

t-*Test Means for Pedagogical Knowledge (PK) Scores*

	N	**Mean**	**Std. Deviation**	**Std. Error Mean**
Mean for PK	308	4.07	0.8	0.04

Table 17

Pedagogical Knowledge Frequencies

	n	**Percent**
Strongly Disagree	67	3.2
Disagree	109	5.2
Neutral	181	8.6
Agree	**966**	**45.8**
Strongly Agree	**785**	**37.2**
Total	2108	100

Similarly, regarding Pedagogical Content Knowledge (PCK) and Technological Content Knowledge (TCK), which I answered through responses to Questions 26 to 33, the data showed high frequencies of positive responses of 75% for PCK (Table 18) and 65% for TCK (Table 19). Similar studies (Agyei & Voogt, 2011b; Akyuz, 2018; Archambault & Crippen, 2009; and Mouza et al., 2014) recorded average pre-test means for the PCK variable at 3.68. A one-sample *t*-test suggested that respondents from Kaimosi and Eregi TTCs were statistically significantly higher with a mean score (M = [3.89], SD = [0.84]) that was higher than scores from similar pre-test studies, t(303) = [4.4], p < [0.001].

Table 18

Pedagogical Content Knowledge Frequencies

	n	Percent
Strongly Disagree	44	3.7
Disagree	99	8.2
Neutral	152	12.7
Agree	**542**	**45.1**
Strongly Agree	**364**	**30.3**
Total	1201	100

As for TCK, similar studies that used the same survey, reported pre-test mean scores on this variable at around 3.36 (Agyei & Voogt, 2011b; Akyuz, 2018; Archambault & Crippen, 2009; and Mouza et al., 2014). Using the same instrument, Lin, Tsai, Chai, and Lee (2013) found that science teachers in Singapore rated all their perceptions on the TPACK scales higher than neutral, ranging from a mean TCK of 5.06. A one-sample *t*-test suggested that the Kaimosi and Eregi respondents' scores were not too far from similar pre-test scores that used this instrument. The Eregi and Kaimosi respondents showed a slightly higher mean score (M = [3.65], SD = [0.85]) than similar respondents, t(305) = [3.10], p = [0.002] (Table 19).

Table 19

Technological Content Knowledge Frequencies

	n	Percent
Strongly Disagree	59	4.9
Disagree	130	10.8
Neutral	230	19.1
Agree	**547**	**45.4**
Strongly Agree	**239**	**19.8**
Total	1205	100

Finally, the frequencies for Technological Pedagogical Knowledge (TPK) were analyzed, and the positive responses to this sub-scale totaled 78%, which is respectable (Table 20). Compared to means from similar studies (Agyei & Voogt, 2011b; Akyuz, 2018; Archambault & Crippen, 2009; and Mouza et al., 2014) where the TPK pre-test means averaged 3.8, the students at Kaimosi and Eregi TTCs scored themselves about the same at 3.9. A one-sample *t*-test showed this similarity in scores (M = [3.9], SD = [0.72]) to similar study respondents, t(305) = [3.0], p = [0.003].

Table 20

Technological Pedagogical Knowledge Frequencies

	n	**Percent**
Strongly Disagree	91	3.3
Disagree	148	5.4
Neutral	360	13.2
Agree	**1399**	**51.4**
Strongly Agree	**723**	**26.6**
Total	2721	100

Therefore, in answer to Research Question 2: To what extent do pre-service teachers in selected Kenyan teachers' colleges demonstrate knowledge of the TPACK domains of technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK)?, these pre-service teachers self-reported relatively robust knowledge in the TPACK sub-scales of TK, CK, PK, PCK, TPK, and TCK.

4.6.3 Research Question 3

Research Question 3: To what extent do personal experiences with technology impact the use of educational technology by pre-service teachers in selected Kenyan teachers' training colleges?

To answer this question, I coded the pre-service teachers' responses to the three open-ended questions at the end of the survey. These were,

1. How do you currently use digital technologies to support your preparation in teaching?
2. What kind of technical skills that you can use later in your profession are you learning?
3. Describe a specific episode where you effectively demonstrated or modeled combining content, technologies, and teaching approaches in a classroom lesson. Please include in your description what content you taught, what technology you used, and what teaching approach(es) you implemented. If you have not had the opportunity to teach a lesson, please indicate that you have not.

To get a broad idea of the themes in the open-ended responses, I read responses from 32 pre-service teachers, where I generated a starting list of instances that demonstrate specific uses of technology with content and pedagogy, as done by Mouza et al. (2014). This analysis was a broad descriptive coding, which, according to Saldaña (2013), summarizes the topic of qualitative data. The topic coding led me to 12 broad themes. These were the use of technology for presentation, research, visualization, resources, administration, exemplars, access to the MS Suite, networking, computer skills, one-on-one teaching. At the same time, some pre-service teachers stated that they have never used technology to teach. Since I was coding solo, for triangulation, I performed member checking (Saldaña, 2013), with six of the respondents and two of my research assistants. As performed by Harris and Hofer (2011), I then reviewed the open-ended responses and recorded evidence of the reported use of technology in the students' written responses. I recorded these responses in Table 21.

Table 21

Evidence of Technology Within the Open-Ended Answers

Type of Usage	Example of Evidence	Frequency
Research	Used a picture from the web to show flooding in a valley	155
One-on-One Learning	Student accessed learning software on individual computer	23
Visualizing	Used a YouTube video to show farming	138
Resources	Used cellphone to download grooming instructions	115
Administrative	Used spreadsheet to prepare students' schedules	116
Computer Operations	Used computer to learn a computer program	31
Exemplars	Used cellphone to download an exemplar poem.	108
Presentation	Used PowerPoint to show student changes in weather	178
Networking	Used email to communicate with student or peer	57
MS Word	Used MS Word software to write an essay	109
Typing	Improved my typing skills on the laptop keyboard	32
Not used technology	I have not used technology to teach	107

To get a better understanding of how the pre-service teachers personally use technology, I recorded their responses in a bar graph in Figure 6. These categories are non-exclusive, and often, the pre-service teachers indicated that they use two or more of these categories. As the data showed, the highest percentage (15%) of the respondents stated that they used technology for presenting information to their classrooms. Most of the pre-service teachers indicated that they used their cellphones to access MS PowerPoint(T) presentation software. 13% of the respondents stated that they used technology to research material for use in their lessons. In comparison, 12% of the respondents said that they used technology so that they could download pictures and other visuals to emphasize some learning objectives in their lessons.

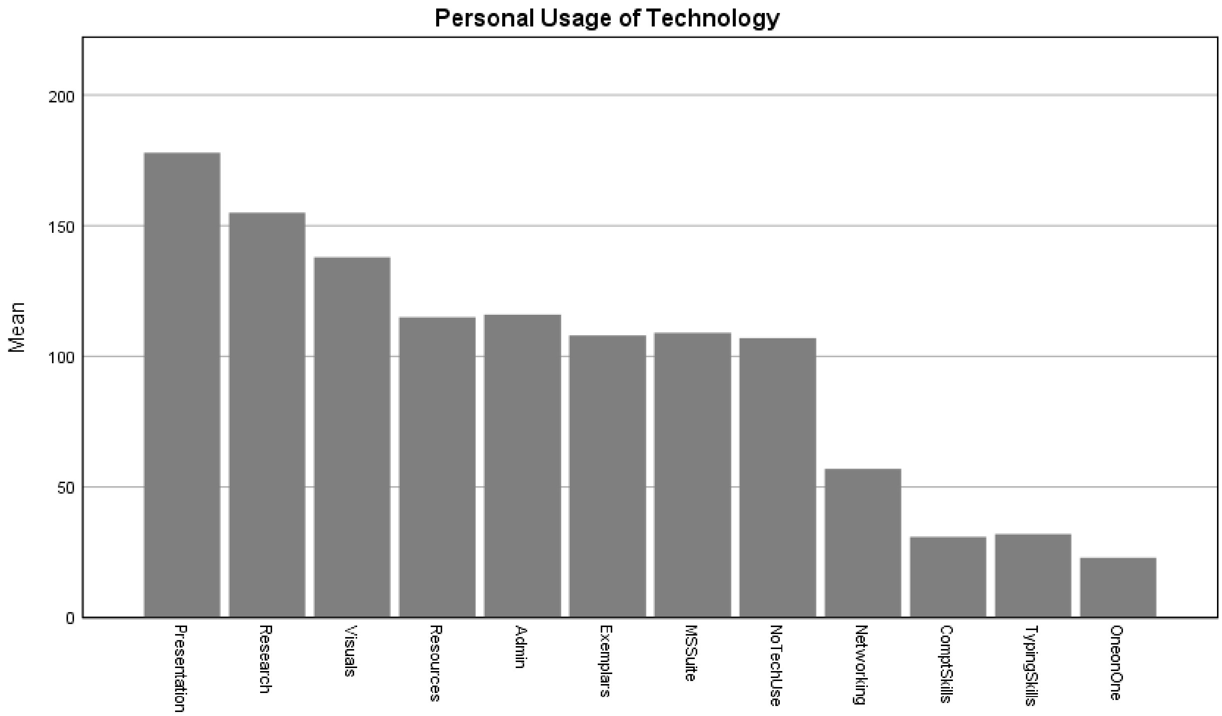

Figure 8. Pre-service teachers' use of technology.

Additionally, 10% of the respondents indicated that they used technology to search for resources to teach their students. Most of the respondents said that they use Google to search for educational material. I coded one use as 'administrative' to encompass how teachers use technology to manage student records. This use includes attendance records, lesson planning, grading, progress reports, tracking learners, creating schedules, setting and storing assessments, storing and managing student demographic data, managing extra-curricular activities like sports, among many others. Those who used computers for 'administrative' purposes were 10% of the group.

Nine percent of the respondents indicated that they used technology to find exemplars and 'realia' online in their lessons. One teacher, for example, reported that she looked up mountain formations to show her students how natural forces shape different mountains. Another indicated that while teaching physical education, she wanted her students to gallop like horses. However, horses being rare in this rural part of Kenya, very few students had ever seen a horse or even knew how a horse galloped. The teacher trainee then pulled up a video of a galloping horse to show the students what that meant. Other teachers indicated that they used it to show examples of calligraphic art, types of stitches, natural disasters, use of solar power, and many others.

Further, at least 9% of the respondents indicated that they used technology to access software for writing like MS Word, tabulating figures, calculating, illustrating, and presentation, among others. Other respondents stated that they used technology for networking (for example, use of email and social media), improving their computer skills, one-on-one learning, and to improve their typing skills. However, about 9% of the respondents indicated that they had never used technology to teach.

From this data and personal interactions with the respondents, it was evident that the most common technology platform that the teachers used was the cellphones. The pre-service teachers said that they use cell phones to access the themes shown in Figure 8. The respondents from both colleges also stated that because they have an ICT class at their colleges, they are more exposed to how the technology works in education.

Therefore, in response to Research Question 3 (*To what extent do personal experiences with technology impact the use of educational technology by pre-service teachers in selected Kenyan teachers' training colleges?),* the data suggests that the pre-service teachers' exposure to technology through their smartphones and at college, influences to a large extent how the teachers interact with this technology. The teachers' personal experiences were through the use of smartphones, which enabled them to access digital resources (for example, the use of Google search, use of email, access to writing software, social networking, and others), which was an essential part of their coded responses.

4.6.4 Research Question 4

Research Question 4: To what extent does the TPACK framework capture the readiness of pre-service teachers to use ICT for classroom instruction?

TPACK, according to Schmidt et al. (2009), is the knowledge teachers require for integrating technology into their teaching, which requires that they have an intuitive understanding of the complex interplay between the underlying concepts of content knowledge, pedagogical knowledge, and technological knowledge. Research Question 4 intends to determine the extent to which the TPACK framework captures these teachers' understanding and readiness to implement TPACK.

To estimate the extent to which this framework captured the pre-service teachers' readiness to implement TPACK, I sought to determine the internal consistency of the instrument used to gather this data. Following Schmidt et al.'s (2009) recommendation that users of the instrument should average the participant's scores for each of the items, I used SPSS to determine reliability. The 10 TPACK subscales for the pre-service teachers returned a robust Cronbach's Alpha $\alpha = 0.882$. As shown in Table 22, the items showed positive correlations with CK (social studies and mathematics) having the highest correlations of 0.988 each.

Table 22

Correlations of the TPACK Sub-Scales

TPACK Domain	Internal Consistency (α)
Technology Knowledge (TK)	0.43
Content Knowledge – Social Studies	0.98
Content Knowledge – Mathematics	0.98
Content Knowledge – Science	0.43
Content Knowledge – Literacy	0.56
Pedagogy Knowledge (PK)	0.69
Pedagogical Content Knowledge (PCK)	0.69
Technological Pedagogical Knowledge (TPK)	0.66
Technological Content Knowledge (TCK)	0.58
Technological Pedagogical Content Knowledge (TPACK)	0.59

Conversely, the TK variable had the weakest correlation in the group with $\alpha = 0.433$. This correlation compared poorly with findings from Schmidt et al. (2009), who found TK $\alpha = 0.86$ (Table 23). All the other sub-scales for the respondents at Eregi and Kaimosi TTCs scored lower than scores found in Schmidt et al.'s study. The only exception was Content Knowledge in social studies and mathematics, which both scored a strong $\alpha = 0.98$.

Table 23

Reliability Scores from Schmidt et al. (2009)

TPACK Domain	Internal Consistency (α)
Technology Knowledge (TK)	0.86
Content Knowledge – Social Studies	0.82
Content Knowledge – Mathematics	0.83
Content Knowledge – Science	0.78

TPACK Domain	Internal Consistency (α)
Content Knowledge – Literacy	0.83
Pedagogy Knowledge (PK)	0.87
Pedagogical Content Knowledge (PCK)	0.87
Technological Pedagogical Knowledge (TPK)	0.93
Technological Content Knowledge (TCK)	0.86
Technological Pedagogical Content Knowledge (TPACK)	0.89

Additionally, compared to similar measures by Abbitt (2011), the reliability of the instrument in measuring the TPACK levels of the pre-service students at Eregi and Kaimosi TTCs came up short. Abbitt recorded high Cronbach's Alpha values for a pre and post-test for pre-service teachers ranging from $\alpha = 0.78$ (for pre-test PK) to strong $\alpha = 0.95$ (for pre-test TPCK). Additionally, in a study of 348 Turkish pre-service teachers, Sahin (2011) also recorded high alpha factors ranging from $\alpha = 0.79$ for TPACK to $\alpha = 0.8$ for PCK.

Further, using the same instrument developed by Schmidt et al. (2009), Chai, Koh and Tsai (2010), also found high pre-test Cronbach alphas (TK = 0.85, pk = 0.91, CK =0.99, and TPACK = 0.96). Similarly, Koh et al. (2010), who also used a modified Schmidt et al.'s (2009) instrument, found high reliability ranging from $\alpha = 0.87$ for TK, up to $\alpha = 0.96$ for TCK. Lin et al. (2013) also confirmed the presence of seven TPACK factors with high alphas ranging from PCK $\alpha = 0.71$ to TCK $\alpha = 0.92$. These alphas are also reflected in studies in Finland by Valtonen, Sointu, Mäkitalo-Siegl, and Kukkonen, (2015). They used the same Schmidt et al. (2009) instrument and recorded high alphas ranging from 0.88 to 0.95.

Therefore, considering that a well-structured scale and its items require an alpha level of 0.7 or higher (Nunnally, 1978), the values detected on the responses from the Kaimosi and

Eregi TTCs do not suggest an excellent combination of observed item responses or a reliable scale for the specific circumstances of these respondents. Apart from TPK, PK, and PCK, which recorded $\alpha = 0.70$, and CK recorded at $\alpha = 0.98$, and the other items were less than robust. I can attribute several reasons for this, and I discuss this in Chapter 5.

Consequently, in response to Research Question 4 (*To what extent does the TPACK framework capture the readiness of pre-service teachers to use ICT for classroom instruction?*), the data suggest that the instrument is inadequate in capturing some of the domains of TPACK framework including TK, TCK, and TPACK. Although there is some extent of readiness to use this knowledge in classrooms by the pre-service teachers, the sub-scale reliability values recorded from the pre-service teachers do not suggest this.

4.6.5 Exploratory Analysis

I further explored the data using an exploratory analysis. I conducted an independent-samples t-test to compare gender differences in TPACK scores in both colleges. I found that there were no significant differences in the TPACK scores for these two groups with Levene's Test for Equality of variances showing no violations in all the sub-scales, $p > 0.05$. Results suggested that both male and female pre-service teachers reported roughly the same levels of agreement or disagreement on the TPACK scales.

This level of agreement was also the case when I explored the differences in scores between different ages of the respondents. There were no significant differences in the TPACK scores for 18-22 and 23 to 26-year-old students. The results suggested that both these age groups showed similar levels of agreement or disagreement on the TPACK scores. However, when I compared the 18-22-year-olds to the 27-32-year-olds, there were slight differences on three scales. For example, on Question 1 on Technology Knowledge (TK1 – I know how to solve my technical problems) there was a significant difference in the scores for 18-22 year-olds (M= 3.86, SD= 1.073) and 27-32 year-olds (M=3.97, SD=0.77) with the conditions; t(77), p=0.53. This difference may suggest that the older students felt more comfortable solving their technical problems than the 18-22-year- old students. I could make the same suggestion to the responses to Questions TK2 (I can learn about technology easily) and TK3 (I keep up with important new technologies).

Furthermore, when I conducted an independent samples t-test to compare the responses on the TPACK scales for students from Eregi TTC with responses from Kaimosi TTC, there were significant differences for scores on the Content Knowledge questions (CK8 to CK15) as shown in Table 24.

Table 24

Independent Samples t-*Test on Content Knowledge Between the Two Colleges*

Scale	f	Sig.	t	df
CK7	20.33	**0.000**	5.59	288.3
CK8	11.43	**0.001**	5.61	261.0
CK9	21.49	**0.000**	4.38	257.0
CK10	10.37	**0.001**	-6.85	256.3
CK11	30.11	**0.000**	-4.36	285.4
CK12	24.04	**0.000**	-5.10	273.8
CK13	8.01	**0.005**	5.77	280.8
CK14	8.47	**0.004**	5.69	272.9
CK15	5.20	0.023	4.32	281.0
CK16	1.22	0.269	2.10	293.4
CK17	2.86	0.094	1.74	290.0
CK16	2.98	0.085	2.16	291.9

An independent-samples *t*-test on the TPACK responses from students at both colleges suggested some significant differences in the scores for Content Knowledge Questions 8, 9, 10, 11, 12, 13, 14, and 15 between the students from these two colleges. CK Questions 8 and 9 were on Content Knowledge of mathematics, Questions 10, 11, and 12 were on social studies, while Questions 13, 14, and 15 were on science. Analysis of the mean scores revealed that of these eight sub-scales, respondents from Eregi TTC scored higher in the four sub-scales of Questions 9, 13, 14, and 15, while respondents from Kaimosi TTC scored higher in Questions 8, 10, 11, and 12.

In another independent-samples *t*-test, I compared the mean responses on the TPACK scores of respondents who indicated that they had had practicum teaching experience, against respondents who said they had not. Pre-service teachers who stated that they had had practicum teaching experience, overwhelmingly exhibited positive responses on the TPACK sub-scales, suggesting that teaching experiences may pre-dispose teachers to a positive experience teaching with technology (Appendix C).

In conclusion, analysis of the data suggested that the teachers reported high levels of TPACK development in all the scales except the latent domain of TPACK for which the instrument could not clarify. Additionally, the open-ended questions suggested that the respondents mostly use personal smartphones to access technology for which they mostly use for presentation, research, getting resources from the internet, and for keeping student records. In the last chapter, Chapter 5, I discuss some of these findings and their possible implications.

CHAPTER 5

DISCUSSIONS AND RECOMMENDATIONS

This study explored the integration of technology for teachers in two of Kenya's pre-service teachers' colleges: St. Augustine Eregi TTC and Kaimosi TTC, both in western Kenya. The study was done through a survey using an instrument by Schmidt et al. (2009), which enabled me to explore the integration of technology through the TPACK framework. The survey collected responses from 308 pre-service teachers. These included responses to 45 Likert-type questions that sought to establish the respondents' self-report on their levels of technical knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge, and lastly technology pedagogical content knowledge.

In this chapter, I discuss my findings to the research questions and give my recommendations. These are the research questions that I sought to answer.

1. To what extent do pre-service teachers in selected Kenyan teachers' training colleges demonstrate knowledge of TPACK necessary for integrating technology in their teaching?

2. To what extent do pre-service teachers in selected Kenyan teachers' colleges demonstrate knowledge of the TPACK domains of technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK)?).

3. To what extent do personal experiences with technology impact the use of educational technology by pre-service teachers in selected Kenyan teachers' training colleges?

4. To what extent does the TPACK framework capture the readiness of pre-service teachers to use ICT for classroom instruction?

5.1 Research Question 1

To what extent do pre-service teachers in selected Kenyan teachers' training colleges demonstrate knowledge of TPACK necessary for integrating technology in their teaching?

Analysis of the data suggested that although the respondents rated themselves highly on some individual subscales of the TPACK variable, the data did not convey a robust extent of the pre-service teachers' demonstration of knowledge of TPACK. The teachers self-reported unusually high content knowledge, especially in mathematics and science, but overall, they did not show a keen awareness of TPACK. Schmidt et al. (2009) state that TPACK provides an intuitive understanding of teaching content with appropriate pedagogical methods and technologies. Therefore, I suggest that although the pre-service teachers at Eregi and Kaimosi TTCs are confident in accessing content using technology, the intuitive understanding of teaching with this technology was not apparent in the study.

There may be various reasons for this weak demonstration of the TPACK variable. It was apparent during the survey process that the pre-service teachers mostly had personal smartphones, which they used to access content in planning lessons. The colleges provided desktop computers housed in a computer laboratory, which meant that the students had limited access to these technologies. I also observed that the pre-service teachers had to buy data 'bundles' out of pocket to use their phones. It was unlikely that they would spend substantial amounts of money accessing learning content for their classrooms.

Additionally, most of the local schools had only limited access to technology. Some schools did not have access to electric power, or the power supply was intermittent at most. The lack of power meant that the pre-service teachers did not have enough practice using technology to develop an intuitive feel and use that undergirds excellent TPACK skills and knowledge.

It could also be that instead of identifying TPACK, the instrument may have measured a different variable apparent in the respondents. The factor loadings suggested that TPACK among the teachers was not a discrete variable – instead, the respondents highly associated it with other variables within the framework. As Valtonen et al. (2015) have pointed out, perhaps TPACK should be considered a combination of separate elements but not a discrete latent variable. Additionally, as Archambault and Crippen (2009) have stated, the inability to differentiate between and among these constructs calls into question whether the domains exist independently or are correlated but distinct from one another (Deng, Chai, So, Qian, & Chen, 2017).

An implication for the indistinct TPACK variable is that the integration of educational technology in Kenyan elementary schools may take longer to be successful. Unless education policymakers take deliberate measures to teach the pre-service teachers how to integrate technology and allow them to interact with this technology at a personal level, it may be difficult for pre-service teachers to develop an intuitive knowledge of the technology. If the pre-service teachers do not learn how to integrate technology, this could result in slower integration of teaching with technology in Kenyan classrooms.

5.2 Research Question 2

To what extent do pre-service teachers in selected Kenyan teachers' colleges demonstrate knowledge of the TPACK domains of technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK)?

Analysis of respondents' data for this question suggested that the pre-service teachers' self-reported high confidence in their levels of the various knowledge in the TPACK framework. In comparison to similar studies elsewhere, as reported in Chapter 4, the pre-service teachers from Eregi and Kaimosi had higher confidence in their skills in the TPACK knowledge levels. The pre-service teachers are confident in the discrete parts of TPACK, especially TK and CK. However, since the survey instrument by Schmidt et al. (2009) is a self-report measure, the pre-service teachers' confidence can only be borne out by a test-retest protocol or another measure that objectively measures their skill – unlike the one-time administration of this survey.

One implication for the teachers' high confidence in the TPACK subscales is that the pre-service teachers demonstrate a possibility of positive attitudes to be able to incorporate technology in schools. Pre-service teachers are exposed to this technology and thus have a great foundation on which their faculty can build on. TPACK is more likely to be adopted by teacher educators who score themselves highly in their TPACK competencies (Voithofer, Nelson, Han, & Caines, 2019).

5.3 Research Question 3

To what extent do personal experiences with technology impact the use of educational technology by pre-service teachers in selected Kenyan teachers' training colleges?

For this question, an analysis of the open-ended questions suggested that the pre-service teachers' personal experiences, to a large extent, influence their use of educational technology. The most personal experience that the respondents had was accessing learning content by using their smartphones and presenting this content to their students. As is shown in Figure 8, the respondents indicated that they also used technology to conduct research, access visual content, teaching resources in addition to using technology for classroom administration. It is because they are confident in accessing and using this technology that I inferred that the pre-service teachers' personal experiences with technology significantly impact their use of educational technology.

As noted in the discussions for Research Question 2, the teachers' personal experiences with technology also prepare them to adapt and integrate technology in their classrooms quickly. Educational planners and the faculty at the colleges can leverage the pre-service teachers' personal experiences with technology to train them to integrate technology.

5.4 Research Question 4

To what extent does the TPACK framework capture the readiness of pre-service teachers to use ICT for classroom instruction?

Data suggested that the TPACK framework was weak in capturing the readiness of the pre-service teachers at Eregi and Kaimosi TTCs to use ICT for classroom instruction. The analysis showed that for these respondents, only CK recorded $\alpha = 0.98$, and TPK, PK, and PCK recorded $\alpha = 0.70$, while the other items recorded weak alphas. There could be two possible reasons for this. One is that the survey instrument captured self-report measures for which respondents may have rated their levels of expertise higher than they were. Another reason that the instrument failed to capture much of the readiness of the pre-service teachers to use ICT for classroom instruction could be that the study required a pre-test, followed by an intervention and re-test protocol, to measure the resultant levels correctly. Compared to other studies that have employed this instrument (Schmidt et al., 2009), the reliability scales for the Eregi and

Kaimosi TTC respondents showed low reliability on most of the subscales.

The implication of this is that there is a need to use a different protocol, including a pre-test, intervention, and post-test, to determine if the outcome is different. There is also a need to continue developing this instrument and to tailor it to fit local circumstances. There is also a need to explore the use of other instruments that may aid in exploring the pre-service teachers' TPACK levels. It is no mean task to measure TPACK because it is a complicated construct, lying at the intersection of multiple constructs, thus requiring sophisticated interrogation that understands the multiple constructs and how they interact with one another (Koehler et al., 2012).

From the exploratory analysis, it was noteworthy that there were significant differences between the scores of the teachers from the two colleges in content knowledge scores. This difference could be because students on one college spent more hours learning content instruction, or there were different instruction styles for content.

5.5 Limitations

Some of the limitations of the study included that the participants are from selected colleges, and these colleges may approach the issue of integration of technology differently. Some colleges may emphasize the integration of technology in their curriculum, while others may not. Another limitation is that pre-service teachers, just like everyone else, do not have the same exposure or similar backgrounds in training and interaction with technology. Additionally, the TPACK survey instrument authored by Schmidt et al. (2009) also limited this study as it did not capture all the aspects of technology integration. Responses to Research Question 4 revealed the extent of the limitation of using the TPACK framework in understanding the teachers' integration of technology.

One of the main limitations was that this survey is a self-report by the respondents on their perceived levels of expertise on the TPACK domains. Respondents to self-reports are susceptible to a certain degree of bias (Archambault & Crippen, 2009) because it is challenging to quantify perceptions of their abilities.

Additionally, because the respondents were a convenience sample, the final data may not reflect the wide geographic distribution of Kenyan pre-service teachers' TPACK readiness. Some teachers' colleges prefer to teach students who will complete tasks that are specific to their local regions. Thus, some may emphasize technology in their curriculum, and others may not.

There was a risk of sampling bias, considering that all the respondents were volunteers. It may be that the study sample did not include contrary views from those who declined or were unable to participate in the study. Additionally, since contact between the respondents and respondents was brief, no meaningful relationships were developed with the respondents before we administered the survey instrument, which may have resulted in responses that were not well-thought-out (Brewer, Torrisi-Steele, & Wang, 2015). Brewer et al. also note that, like most surveys, this research design was not conducive to an in-depth study of the target population and only presented a snapshot of the target population at the time that I administered the survey. Thus, the survey enabled me only to be privy to the changes or trends in the respondents' use of ICT over time.

Finally, this framework can only predict how pre-service teachers may behave after they graduate. It cannot measure all knowledge required for effective technology-enhanced instruction, some of which the teachers will acquire only after graduation and attaining practical experience (Graham, Borup, & Smith, 2012). Archambault and Barnett (2010) have also raised the issue that separating the TPACK domains from each other is difficult. Angeli and Valanides (2005) have also criticized the model for its complexity and impracticability for use in research and teaching. Although some critics have termed TPACK as too vague and too intricate, some even stating that it does not capture the knowledge and expertise teachers possess and use (Brantley-Dias & Ertmer, 2013), this framework remains a useful tool in assessing educational technology integration, especially for pre-service teachers (Schmidt et al., 2009).

5.6 Recommendations and Future Research

One recommendation is that future research uses a pre-test, an intervention, and a post-test research protocol to identify the TPACK levels of the pre-service teachers succinctly. The self-report, such as the one used in this study, may not wholesomely capture the TPACK measures of these student teachers. Additionally, I would also recommend that any future research on pre-service teachers should include other forms of measuring TPACK. These include the use of performance assessments, which will directly examine the respondents' performance on given tasks designed to represent complex, authentic, real-life tasks (Koehler et al., 2012). Other successful ways to measure TPACK that researchers could employ in the future include the use of interviews, observations, open-ended questionnaires, and the measuring of respondents' beliefs and attitudes towards ICT. These may be useful in maintaining the context-sensitivity necessary to examine specific learning experiences in which gain in TPACK are evident (Abbitt, 2011). A combination of some of these methods may lead to results that are more representative of the respondents' TPACK levels.

There is also the need to tweak the survey instrument so that it accounts for local conditions. The content knowledge subscale, for example, could include knowledge and literacy in local languages. In hindsight, and with more resources, perhaps the instrument would have been translated to the local language to provide much clarity with the questions. Additionally, a TPACK-measuring instrument should be updated to take into consideration current technologies, including augmented reality, virtual reality, cloud computing, among others. There is also the need to print the instrument much clearer so that respondents can easily record their responses on the correct lines and checkboxes.

Regarding access to technology by the pre-service teachers from Eregi and Kaimosi TTCs, it is my recommendation that the teacher-trainees have full-time access to computers and other technology. An intuitive approach to teaching with technology, as demanded by TPACK, requires that the teachers have an intrinsic knowledge and understanding about technology that they can only develop if they interact daily with this technology. The hands-on approach needed for successful TPACK integration entails that the teacher is creative, versatile, and knowledgeable in all the TPACK domains. This integration can only occur if the training colleges expose the teacher to these technologies. Furthermore, although there is always a shortage of resources in schools, the teachers' TPACK skills will continuously improve if there is requisite technology in the classrooms that they teach.

5.7 Probable Future Research Questions

1. To what extent do pre-service teachers show improvement in TPACK with technology intervention training?

2. What specific training can pre-service teachers get so that they improve their expertise in TPACK?
3. If the TPACK subscales are not entirely measuring teachers' TPACK, what variable are they indicating for pre-service teacher trainees? and
4. Using measurements other than self-report measurements (for example, performance assessments, observation, interviews, open-ended questionnaires), to what extent can we identify TPACK in pre-service teachers?

5.8 Conclusion

Although I could not clearly distinguish the TPACK levels for the pre-service teachers in Kaimosi and Eregi TTCs in this study, the results of the survey have given a clearer picture of the integration of technology in this group. Through this study, I can suggest that pre-service teachers have high levels of understanding of technology knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological pedagogical knowledge, and technological content knowledge. To a great extent, the pre-service teachers' personal use of technology influences how they integrate technology in classrooms. However, they still require more exposure and training in technology so that they acquire an intuitive approach on how to integrate technology in classrooms. The use of educational technology in elementary schools in Kenya is strategically poised to make an enormous difference in access to formal education by thousands of students across the country. Students who, for many reasons, have never had formal schooling, are primed benefit from technology. The collapse of brick-and-mortar schooling due to the Corona Virus worldwide serves to underline the importance of students and their teachers being able to take advantage of educational technology. Ensuring that teachers know how to deploy this technology to meaningful effect is thus singularly critical.

APPENDIX A

INFORMED CONSENT FORM

UNIVERSITY OF NORTH TEXAS®

Informed Consent for Studies with Adults

TITLE OF RESEARCH STUDY: Evaluation of Kenyan Pre-Service Teachers' Preparedness to Integrate Educational Technology in Classrooms

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You are being asked to participate in a research study. Taking part in this study is voluntary. The investigators will explain the study to you, and they will answer any questions you might have. It is your choice to either participate or not participate in this study. If you agree to participate and then choose to withdraw from the study, that is your right, and your decision will not be held against you.

You are being asked to take part in a research study about the teaching of technology integration for pre-service teachers in Kenyan pre-service teachers' colleges.

Your participation in this research study involves responding to 46 questions on a survey on your knowledge of teaching and the use of technology in teaching. The survey will take about 45 minutes to answer. More details will be provided in the next section.

You might want to participate in this study if you want to share your views on how technology can be integrated into the practice of teaching. However, you might not want to participate in this study if you are unable or unwilling to share your personal views on technology in learning.

You may choose to participate in this research study if you are a pre-service teacher trainee at any teachers' training college in Kenya.

The reasonably foreseeable risks or discomforts to you if you choose to take part is the use of about 45 minutes of your time which you can compare to the possible benefit of contributing information that may assist in preparing Kenyan pre-service teachers to effectively teach using technology. You will be entered in a drawing to win a Kenya Shs. 2000 (US$ 20) gift card to a local supermarket.

DETAILED INFORMATION ABOUT THIS RESEARCH STUDY: The following is more detailed information about this study, in addition to the information listed above.

PURPOSE OF THE STUDY: The purpose of this study is to evaluate pre-service teachers' barriers to using educational technology as indicated by the Technological, Pedagogical, and Content Knowledge (TPACK) framework.

TIME COMMITMENT: Participation in this study is expected to last approximately 40 minutes.

STUDY PROCEDURES: You will be provided a four-page survey in which you will answer Likert-type questions on pre-service teachers' use of educational technology**.** You may also be asked to answer five open-ended questions on this subject. You will answer the questions at your college. The survey will be distributed by an assistant in June, July and August 2019. This will be only a one-time response to the questionnaire. The questions will ask you about your assessment of your:

1. Technology knowledge

2. Content knowledge

3. Pedagogical knowledge

4. Pedagogical content knowledge

5. Technological content knowledge

6. Technological pedagogical knowledge, and

7. Technology pedagogy and content knowledge

Please answer all questions and if you are uncertain, uncomfortable, or neutral about your response, you may always select "Neither Agree nor Disagree".

AUDIO/VIDEO/PHOTOGRAPHY:

☐ **<u>I agree</u>** to be audio recorded/video recorded or photographed during the research study.

☐ **<u>I agree</u>** that the audio recording/ Video recording or photographs can be used in publications or presentations.

☐ **<u>I do not agree</u>** that the audio recording/ Video recording or photographs can be used in publications or presentations.

☐ **<u>I do not agree</u>** to be audio recorded/video recorded or photographed during the research study.

You may participate in the study if you do not agree to be audio recorded/video recorded/photographed.

The recording will be immediately destroyed after transcription.

POSSIBLE BENEFITS: Although you may not directly benefit from this study, the results of this study may contribute to improvement in teaching pre-service teachers how to integrate educational technology in classrooms.

POSSIBLE RISKS/DISCOMFORTS: Apart from taking about 45 minutes of your time, this study does not pose any foreseeable risk or discomfort to you.
If you experience excessive discomfort when completing the research activity, you may choose to stop participating at any time without penalty. The researchers will try to prevent any problem that could happen, but the study may involve risks to the participant, which are currently unforeseeable. UNT does not provide medical services or financial assistance for emotional distress or injuries that might happen from participating in this research. If you need to discuss your discomfort further, please contact a mental health provider, or you may contact the researcher who will refer you to appropriate services. If your need is urgent, helpful resources include any of Kenya's Level 4 hospitals located in the major cities.
Remember that you have the right to withdraw any study procedures at any time without penalty and may do so by informing the research team.
This research study is not expected to pose any additional risks beyond what you would normally experience in your regular everyday life. However, if you do experience any discomfort, please inform the research team or the nearest health facility.

COMPENSATION: All participants will be entered in a drawing to win a Kenya Shs. 2000 (US$ 20) gift card at a local supermarket. There are no alternative activities offered for this study.

CONFIDENTIALITY: Efforts will be made by the research team to keep your personal information private, and disclosure will be limited to people who need to review this information. All paper and electronic data collected from this study will be stored in a secure location on the UNT campus and/or a secure UNT server for at least three (3) years past the end of this research. These records will be secured in a locked cabinet in Dr. Tandra Tyler-Woods'

UNT office. Research records will be labeled with a code and the master key linking names with codes will be maintained in a separate and secure location.
Your participation in this study is anonymous, and the information you provide cannot be linked to your identity.

The results of this study may be published and/or presented without naming you as a participant. The data collected about you for this study may be used for future research studies that are not described in this consent form. If that occurs, an IRB will first evaluate the use of any information that is identifiable to you, and confidentiality protection would be maintained. While absolute confidentiality cannot be guaranteed, the research team will make every effort to protect the confidentiality of your records, as described here and to the extent permitted by law.

CONTACT INFORMATION FOR QUESTIONS ABOUT THE STUDY: If you have any questions about the study you may contact:

1. Tandra Tyler-Wood, Ph.D. (Principal Investigator)
   Professor and Chair, Learning Technologies
   G170 Discovery Park
   3940 North Elm St.
   University of North Texas
   Denton, TX 76207
   Phone: 940-565-2959
   Fax: 940-565-4194
   Email: tandra.tyler-wood@unt.edu

2. Newton Buliva (Student Investigator)
   Student, Learning Technologies Department,
   University of North Texas
   Email: newtonbuliva@my.unt.edu

Any questions you have regarding your rights as a research subject or complaints about the research may be directed to the Office of Research Integrity and Compliance, University of North Texas, at 940-565-4643, or by email at untirb@unt.edu.

CONSENT:

- Your signature below indicates that you have read or have had read to you all the above.

- You confirm that you have been told the possible benefits, risks, and/or discomforts of the study.

- You understand that you do not have to take part in this study and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits.

- You understand your rights as a research participant and you voluntarily consent to participate in this study; you also understand that the study personnel may choose to stop your participation at any time.

- By signing, you are not waiving any of your legal rights.

Please sign below if you are at least 18 years of age and voluntarily agree to participate in this study.

SIGNATURE OF PARTICIPANT **DATE**

***If you agree to participate, please provide a signed copy of this form to the researcher team. They will provide you with a copy to keep for your records.**

APPENDIX B

TRAINING OF DATA COLLECTORS

This training is for data collectors who will assist in passing out and collecting the questionnaire for this study. Some of the training is modeled on the Johns Hopkins School of Public Health's Field Guide to Human Subjects Research Ethics (Johns Hopkins School of Public Health, JHSPH, 2010).

Ethical Interaction with Human Participants

A. Role of the Data Collector

- The data collector is a representative of the research study
- The data collection should make sure that the respondents understand what they are agreeing to do
- The data collector must ensure that the data collected is accurate and protected from loss

B. Respect

Data collectors must show respect for the goals of this study, the individual study participants, the participants' colleges, college leadership, and the community, and the data collected. The respondents are voluntarily participating in the study; they do not have to participate. They have the right to refuse to participate. Some examples of respect include:

- Being polite to participants whether they agree or refuse to participate in the study
- Asking questions in a clear and respectful voice
- Providing accurate and clear answers when participants have questions. If the data collector cannot answer the questions, tell the participants that you will find out and provide an answer later
- Asking the participants if they have any additional questions
- Thanking the participants for completing the questionnaire and for their time

C. Voluntary participation

- No individual is required to participate in this study, participation is voluntary

- There are no consequences for not participating in this study
- There is no remuneration for participating in this study
- The data collector must explain the UNT IRB Informed Consent to the study participants

D. UNT IRB Informed Consent

- Explain what the participants are consenting to
- Explain that they are not required to consent
- They can withdraw consent at any time, without any consequence
- Provide adequate time to consent or to reject participation
- Encourage questions on the UNT IRB Informed Consent

E. Personal privacy

- Understand and respect the privacy of all participants
- Respect institutional customs of the participating colleges
- Participants should be encouraged to complete the questionnaire privately
- Protect all data collected

How to Administer the Questionnaire

1. Go through the questionnaire yourself and complete it. If you encounter any anticipated questions or ambiguities contact us so you can answer the questions of the participants appropriately.
2. Determine the most appropriate time for the respondents to be able to complete the questionnaire.
3. Present the UNT IRB Informed Consent for Adults to each potential respondent to sign and date. Provide the participants with:
    - privacy guarantees
    - assurances that there are no consequences for not participating in the survey

- the information their names will be entered in a drawing to win a US$ 20 gift card to a local supermarket.

4. Briefly explain to the respondents what the questionnaire is about and that completing the questionnaire will take about 30 minutes.
5. Provide a brief explanation about how to complete the Likert-like questions. Inform the participants that they must complete all questions and they must give only one answer for each question
6. Remind participants that this is a self-reported questionnaire and they must give answers that are as truthful as possible.
7. Reiterate to the participants that they must read the questions carefully.
8. Provide enough time and privacy for respondents to complete the questionnaire. Respondents may keep the questionnaire longer for you to pick up later if they cannot complete it in one sitting.
9. Collect the completed questionnaires, place them in a sealed envelope and label the envelope with the name of the college and the date.

APPENDIX C

INDEPENDENT *t*-TEST FROM PRACTICUM EXPERIENCE

	Equal variances assumed	Levene's Test for Equality of Variances			f	Sig. (2-tailed)	*t*-Test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.				Mean Differences	Std. Error Difference	Lower	Upper
TK1	Y	3.036	.083	4.435	278	.000	.500	.113	.278	.723
	N			4.357	239.384	.000	.500	.115	.274	.727
TK2	Y	4.954	.027	3.233	282	.001	.351	.109	.137	.565
	N			3.053	196.582	.003	.351	.115	.124	.578
TK3	Y	.598	.440	.788	278	.431	.093	.117	-.139	.324
	N			.776	234.223	.438	.093	.119	-.142	.327
TK4	Y	3.313	.070	1.819	282	.070	.237	.130	-.019	.493
	N			1.792	234.004	.074	.237	.132	-.024	.497
TK5	Y	.614	.434	.837	277	.403	.113	.135	-.153	.379
	N			.833	235.930	.406	.113	.136	-.154	.381
TK6	Y	12.698	.000	3.661	278	.000	.431	.118	.199	.664
	N			3.588	233.953	.000	.431	.120	.195	.668
CK7	Y	13.039	.000	3.127	287	.002	.399	.128	.148	.651
	N			3.040	231.423	.003	.399	.131	.141	.658
CK8	Y	13.354	.000	4.022	285	.000	.437	.109	.223	.651
	N			3.859	215.576	.000	.437	.113	.214	.660
CK9	Y	34.275	.000	4.500	282	.000	.537	.119	.302	.772
	N			4.255	197.977	.000	.537	.126	.288	.786
CK10	Y	2.162	.143	1.031	280	.304	.144	.140	-.131	.419
	N			1.048	263.443	.296	.144	.137	-.127	.414
CK11	Y	.550	.459	.466	271	.641	.064	.137	-.205	.333
	N			.471	251.953	.638	.064	.135	-.203	.330

	Equal variances assumed	Levene's Test for Equality of Variances			f	Sig. (2-tailed)	*t*-Test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.				Mean Differences	Std. Error Difference	Lower	Upper
CK12	Y	.006	.937	.184	283	.854	.026	.140	-.250	.302
	N			.184	258.008	.854	.026	.140	-.251	.302
CK13	Y	16.631	.000	3.826	285	.000	.456	.119	.221	.691
	N			3.705	224.444	.000	.456	.123	.213	.698
CK14	Y	13.700	.000	3.598	280	.000	.374	.104	.169	.578
	N			3.447	209.348	.001	.374	.108	.160	.587
CK15	Y	2.561	.111	2.812	279	.005	.314	.112	.094	.534
	N			2.785	236.545	.006	.314	.113	.092	.537
CK16	Y	9.253	.003	2.381	285	.018	.299	.126	.052	.547
	N			2.331	237.472	.021	.299	.128	.046	.553
CK17	Y	13.954	.000	2.569	285	.011	.293	.114	.068	.518
	N			2.480	220.290	.014	.293	.118	.060	.526
CK18	Y	4.383	.037	1.243	285	.215	.141	.113	-.082	.364
	N			1.220	237.881	.224	.141	.116	-.087	.369
PK19	Y	.087	.768	2.869	289	.004	.347	.121	.109	.585
	N			2.810	243.079	.005	.347	.123	.104	.590
PK20	Y	.559	.455	.379	.89	.018	.259	.109	.045	.474
	N			2.350	250.348	.020	.259	.110	.042	.477
PK21	Y	.748	.388	3.528	289	.000	.397	.113	.176	.619
	N			3.391	220.644	.001	.397	.117	.166	.628
PK22	Y	.179	.673	2.410	289	.017	.260	.108	.048	.473
	N			2.354	239.639	.019	.260	.111	.042	.478

	Equal variances assumed	Levene's Test for Equality of Variances			f	Sig. (2-tailed)	*t*-Test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.				Mean Differences	Std. Error Difference	Lower	Upper
PK23	Y	.094	.760	2.942	284	.004	.327	.111	.108	.546
	N			2.857	224.298	.005	.327	.115	.101	.553
PK24	Y	8.257	.004	3.013	285	.003	.359	.119	.124	.593
	N			2.929	226.975	.004	.359	.122	.117	.600
PK25	Y	.274	.601	3.421	289	.001	.356	.104	.151	.561
	N			3.310	227.822	.001	.356	.108	.144	.568
PCK26	Y	15.802	.000	3.696	289	.000	.471	.127	.220	.722
	N			3.534	214.519	.001	.471	.133	.208	.734
PCK27	Y	10.901	.001	2.565	289	.011	.281	.110	.065	.497
	N			2.494	232.051	.013	.281	.113	.059	.504
PCK28	Y	6.374	.012	3.408	281	.001	.404	.119	.171	.638
	N			3.298	218.927	.001	.404	.123	.163	.646
PCK29	Y	5.811	.017	3.078	286	.002	.401	.130	.145	.658
	N			3.022	238.598	.003	.401	.133	.140	.663
TCK30	Y	9.732	.002	3.704	286	.000	.467	.126	.219	.715
	N			4.172	251.984	.000	.511	.122	.270	.752
TCK31	Y	8.393	.004	4.219	290	.000	.511	.121	.272	.749
	N			4.172	251.984	.000	.511	.122	.270	.752
TCK32	Y	10.136	.002	3.255	288	.001	.392	.120	.155	.628
	N			3.160	231.300	.002	.392	.124	.147	.636
TCK33	Y	.043	.836	2.921	285	.004	.376	.129	.123	.630
	N			2.936	265.724	.004	.376	.128	.124	.628

	Equal variances assumed	Levene's Test for Equality of Variances			f	Sig. (2-tailed)	*t*-Test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.				Mean Differences	Std. Error Difference	Lower	Upper
TPK34	Y	9.313	.002	2.256	288	.025	.267	.118	.034	.500
	N			2.207	242.533	.028	.267	.121	.029	.506
TPK35	Y	5.664	.018	1.759	289	.080	.199	.113	-.024	.423
	N			1.738	248.678	.083	.199	.115	-.027	.426
TPK36	Y	.229	.632	2.205	288	.028	.250	.113	.027	.472
	N			2.208	270.453	.028	.250	.113	.027	.472
TPK36	Y	2.500	.115	3.420	293	.001	.344	.101	.146	.542
	N			3.293	226.470	.001	.344	.105	.138	.550
TPK37	Y	12.210	.001	4.407	287	.000	.468	.106	.259	.677
	N			4.210	212.645	.000	.468	.111	.249	.687
TPK38	Y	1.396	.238	2.758	287	.006	.306	.111	.088	.524
	N			2.726	251.211	.007	.306	.112	.085	.527
TPK39	Y	4.960	.027	3.067	290	.002	.336	.110	.120	.552
	N			3.037	256.846	.003	.336	.111	.118	.554
TPK40	Y	4.051	.045	1.666	290	.097	.194	.116	-.035	.423
	N			3.677	238.306	.000	.440	.120	.204	.675
TPK42	Y	16.870	.000	4.149	289	.000	.517	.125	.272	.762
	N			4.035	234.724	.000	.517	.128	.264	.769
TPACK43	Y	2.481	.116	2.629	289	.009	.304	.115	.076	.531
	N			2.631	265.826	.009	.304	.115	.076	.531
TPACK44	Y	21.260	.000	3.685	288	.000	.435	.118	.203	.668
	N			3.545	220.365	.000	.435	.123	.193	.677

	Equal variances assumed	Levene's Test for Equality of Variances			f	Sig. (2-tailed)	*t*-Test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.				Mean Differences	Std. Error Difference	Lower	Upper
TPACK45	Y	.185	.668	1.327	288	.185	.186	.140	-.090	.462
	N			1.340	269.304	.181	.186	.139	-.087	.459
TPACK46	Y			4.357	239.384	.000	.500	.115	.274	.727
	N	4.954	.027	3.233	282	.001	.351	.109	.137	.565

APPENDIX D

RECRUITMENT AND THANK YOU MATERIAL

Recruitment Letter

Newton Buliva
Email: Newtonbuliva@my.unt.edu
Phone: [redacted]

Dear Student

I am a graduate student from the University of North Texas. I am conducting a study to evaluate the preparedness of Kenyan pre-service teachers to integrate technology in their classrooms. In this regard, I am requesting that you complete a 47-question survey and three open-ended questions.

Your participation is completely voluntary, and you may stop participating at any time without any consequence on your work in college. I encourage you to answer all the questions completely and as honestly as possible. With your participation, your name will be entered in a drawing to win Kenya Shillings 2000 (US$ 20) gift card to a local grocery store.

If you have any question, you can contact me at my email: newtonbuliva@my.unt.edu or Phone: [redacted]

Thank you for participating

Newton Buliva

Thank You Letter to Respondents

Newton Buliva
Email: Newtonbuliva@my.unt.edu
Phone: [redacted]

Dear student/respondent,
Thro'
The Principals,
St. Augustine Eregi Teachers' Training College,
Kaimosi Teachers' Training College.

I am writing to thank you for participating in my survey. Your responses have been recorded and will inform the outcome of my study. If you have any additional questions please do not hesitate to contact me at my email address newtonbuliva@my.unt.edu

Again, thank you for providing your insight.

Newton Buliva

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