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Turkish Pre-service Secondary Mathematics Teachers: An Examination of TPACK, Affect, and Their Relationship

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TURKISH PRE-SERVICE SECONDARY MATHEMATICS TEACHERS: AN EXAMINATION OF TPACK, AFFECT, AND THEIR RELATIONSHIP

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
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Doctor of Philosophy
Curriculum And Instruction

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by
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Accepted by:
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ABSTRACT

Pre-service teachers' knowledge, beliefs or attitudes gained during their undergraduate education is one of the most influential factors shaping their future teaching in their field. Technological Pedagogical Content Knowledge framework (TPACK; Mishra & Koehler, 2006) identifies the knowledge domains needed by teachers to effectively integrate technology into teaching their field. Due to the fact that pre-service teachers' TPACK domains cannot be directly measured, most of research studies in the literature addressed developing a TPACK survey instrument in order to indirectly measure teachers' TPACK in terms of their perceptions. However, there were rare research studies focusing on development a TPACK survey instrument for pre-service secondary mathematics teachers, especially in Turkey too. Therefore, the main goal of this study is to examine Turkish pre-service secondary mathematics teachers' perceptions regarding TPACK domains, as well as adapting TPACK survey instrument, developed by Zelkowski and his colleagues (2013), into Turkish language and context. Another purpose of this study is to investigate the relationships among TPACK components, and the relationships of pre-service teachers' attitudes towards use of technology in education with their TPACK components. This study also aims to explore the effects of demographics differences (gender and year of enrollment) on their perceptions regarding TPACK domains and attitudes.

Survey, correlational and causal-comparative research designs were used in this study. To adapt the TPACK survey instrument into Turkish, the following processes were used: forward translation, backwards translation, comparison of original TPACK survey with backward translation, expert reviews and cognitive interviews. The data were collected in terms of two studies, the pilot and main studies, during the fall semester of 2016 in Turkey. Two survey instruments, the Turkish TPACK and Attitude scale towards Computer-Aided Education (Arslan, 2006), were used to collect the data. The total of 778 pre-service secondary mathematics teachers participated in this study as volunteer. The pilot study data was used to examine translation of the Turkish TPACK survey instrument and to determine its hypothesized factor structure. The main study data was utilized to validate its factor structure and to conduct further statistical analysis related to the research questions.

The results of factor and reliability analysis showed that the Turkish TPACK survey instrument is valid and reliable for five factors (TK, CK, PK, TPK, and TPACK) including 29 items. The findings of correlations analysis indicated that there were significant positive correlations among five TPACK components with small or moderate effect sizes. In addition, the relationships of pre-service teachers' attitudes with TPACK components were positive and significant, with small or moderate effect sizes. The results of MANOVA displayed that the linear combination of TPACK components differentiated with respect to pre-service teachers' gender and year of enrollment. According to findings of MANOVA, male pre-service teachers had significantly better perceptions about TK and CK than females. Furthermore, fifth grades showed significantly higher perceptions related to CK and TPACK than first and second grades, as well as third grades had greater perceptions on CK than first grades. The findings of ANOVA revealed that there were no statistically differences of pre-service teachers' attitudes towards use of technology with respect to gender, although they had significantly mean differences in regard to year of enrollment. According to the results of ANOVA, five grades had more positive attitudes than first and second grades, as well as third grades had more positive attitudes than first grades. Regarding of finding in this study, future research may focus on which factors influence the development of pre-service teachers' TPACK by means of experimental research studies; and on why male and female pre-service teachers' perceptions in associated with some of TPACK components become different.

DEDICATION

This dissertation is dedicated to my precious family. My warmhearted father and mother, Yusuf Dede and Azize Dede, who have always supported me and showed their love. My sister, Sibel Hatipoğlu, and her lovely husband, Ahmet Hatipoğlu, who have always encouraged me during my doctoral journey. My adorable nephews, Mehmet Ali Hatipoğlu and Ahmet Yusuf Hatipoğlu, who are source of my joy.

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CHAPTER ONE

INTRODUCTION

In previous decades, there have been myriad research studies associated with the knowledge needed for effective teaching. Shulman's (1986) idea of *Pedagogical Content Knowledge* (PCK) has deeply influenced the research studies on teacher knowledge. As other research studies in the field of education, mathematics education researchers are interested in the source of mathematics-specific teaching strategies and the components of knowledge required for high-quality mathematics teaching (e.g., Hill, Rowan, & Ball, 2005; Ball, Thames, & Phelps, 2008).

As the field of research in teacher knowledge had emerged so too has the integration of technology into our daily lives. The rise of technological developments has also affected the processes of mathematics teaching and learning. The development of well-designed digital technologies for mathematics education such as Logo, the Geometer's Sketchpad, and GeoGebra, are examples of technology's potential to benefit the teaching and learning of mathematics. The *National Council of Teachers of Mathematics* (NCTM, 2000) included technology as one of its *six principals for school mathematics*, and suggested, "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (p. 24).

Since technology has impacts on both the content taught and student learning, it has become increasingly germane to empirically examine the knowledge and skills that teachers need to effectively integrate technology into their teaching. Mishra and Koehler

(2006) explained the teacher knowledge required for effectively integration of technology into teaching in terms of their *Technological Pedagogical Content Knowledge* (TPACK) framework. Researchers have claimed the knowledge, skills, and dispositions developed by pre-service teachers during their undergraduate education might be an important indicator of effective technology use in their future teaching (Niess, 2005; Lee & Hollebrand, 2008; Ozgun-Koca, 2009). In consideration of this, the development of a survey instrument to evaluate pre-service mathematics teachers' (PSTs) perceptions regarding TPACK components can be useful and inform the development or refinement of courses intended to develop mathematics teacher candidates' TPACK. Since there currently exists few valid and reliable TPACK survey instruments that specifically address mathematics (e.g., Zelkowski, Gleason, Cox, & Bismarck, 2013), the current study focuses on the adaption of Zelkowski and his colleagues' TPACK survey instrument for Turkish language users and the investigation of Turkish pre-service secondary mathematics teachers' perceptions regarding TPACK. Integration of technology into school mathematics is one of the most significant agenda of Turkish Ministry of National Education (MoNE) since 1980s. MoNE has recently made a great effort to provide technological infrastructure and equipment for each school in Turkey, such as FATIH project. Integration of technology into schools is not one-dimensional, but it also needs teachers who can use technology as a strategic learning tool. With this regard, this study focuses on Turkish pre-service mathematics teachers' perceptions on TPACK domains, which may help Turkish teacher educators to understand and evaluate the efficiency of present courses aimed at development of Turkish pre-service secondary mathematics teachers' TPACK.

Background

Shulman's (1986) attention to the constructs of subject matter knowledge, curricular content knowledge, and pedagogical content knowledge (PCK), began a research movement to investigate the knowledge required for teachers to teach mathematics effectively. According to Shulman, previous research on teaching had focused on teachers' performance related to general pedagogical knowledge without considering the content taught or its relationship with pedagogical knowledge; he called this situation the *"missing paradigm"* (p. 6). Shulman (1986) astutely observed, "no one asked how subject matter was transformed from the knowledge of the teacher into the content of instruction" (p. 6). Shulman (1987) described PCK as being a special amalgam of content and pedagogy, which has a significant role for teaching. Further, Shulman (1987) explained PCK as the following:

> It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to diverse interests and abilities of learners, and presented for instruction. PCK is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue (p. 8).

Shulman's notion of PCK intrigued mathematics education researchers and influenced the field's examination of the type of knowledge bases needed for teaching mathematics.

The researchers studying mathematics education have examined the constructs or domains for mathematical knowledge for teaching (e.g., Hill, Schilling, & Ball, 2004; Hill & Ball, 2004; Hill, Rowan, & Ball, 2005). Ball, Thames, and Phelps (2008) reported their efforts to identify the constructs of mathematical knowledge for teaching (MKT). Ball and her colleagues (2008) also proposed a framework for MKT which expanded on Shulman' idea of PCK. According to the MKT framework, there are two main knowledge domains needed for teaching mathematics, Subject matter knowledge and PCK. Subject matter knowledge includes the sub-domains of common content knowledge (CCK), specialized content knowledge (SCK) and horizon knowledge (HK). PCK is similarly comprised of knowledge of content and students (KCS), knowledge of content and teaching (KCT), and knowledge of content and curriculum (KCC).

Much of the research related to MKT has focused on mathematical knowledge for teaching at the elementary and middle school levels (e.g., Hill, Schilling, & Ball, 2004; Hill, Rowan, & Ball, 2005; Hill, 2007), with, fewer research studies focused on the knowledge needed for teaching high school mathematics (McCrory, Floden, Ferrini-Mundy, Reckase, & Senk, 2012; Herbst & Kosko, 2014). However, these aforementioned research studies have focused on knowledge needed for teaching mathematics without considering technology as an integrated knowledge base for teaching mathematics.

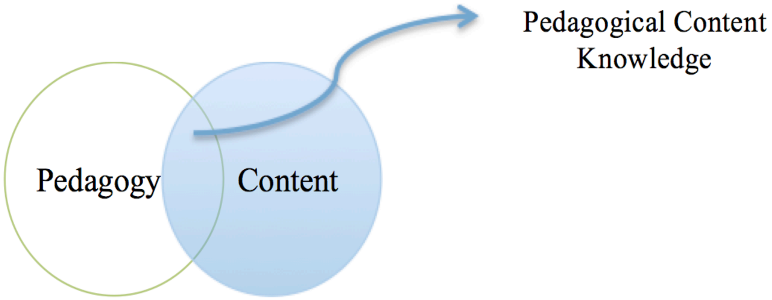
Technological advances since the 1980s have had important impacts on the area of education by affecting teaching, learning and planning processes (Mishra & Koehler, 2006; Erdogan & Sahin, 2010) which merit technology's inclusion as a part of the knowledge bases Shulman had described in his landmark article. For example, the use of technology in education may have important potential for students by supporting them in obtaining the skills required for their future, such as critical thinking and problem solving. The use of technology may also provide students a more comfortable classroom environment to develop mathematical knowledge and imagine abstract and complex mathematical concepts. Through the use of digital technologies designed for mathematics education such as GeoGebra, Cabri 2D, Cabri 3D, the Geometer's Sketchpads, Derive, Maple and Logo, students have the opportunity to learn mathematics more deeply and meaningfully. Kersaint (2007) explained that technology affords students opportunity to develop positive attitudes and self- confidence towards doing mathematics as well as engaging in an active learning environment. According to *the Association of Mathematics Teacher Educators* (AMTE, 2006), technology can provide an opportunity to reach mathematical discoveries, understandings, and connections that may be not easy or possible without using it. For example, the calculation of means, standard deviations, skewness and kurtosis values of large data sets, obtainment of the graphics showing trends or distributions of data sets, and exploring relationships among data patterns by means of technology are easier than tedious calculating by hand. In other words, technology make easy to learning statistics for students while they are discovering data patterns and making connections between variables in data set. In addition, the International Society for Technology in Education (ISTE, 2007) specified standards for students when they engage with educational technologies. According to ISTE, teachers who use technology in their instruction should provide their students' opportunity for the development of skills associated with communication, collaboration, creativity, innovation, critical thinking, problem solving, and decision-making. Furthermore, NCTM (2011) explained their vision for the role of technology in teaching and learning mathematics in the following:

> It is essential that teachers and students have regular access to technologies that support and advance mathematical sense making, reasoning, problem solving, and communication. Effective teachers optimize the potential of technology to develop students' understanding, stimulate their interest, and increase their proficiency in mathematics. When teachers use technology strategically, they can provide greater access to mathematics for all students. (p. 1)

McGhee and Kozma (2001) suggested todays' teachers have new roles in the classroom, in which they will take advantage of innovative technology-supported practices. They have pictured these new roles as an instructional designer, trainer, collaborator, team coordinator, advisor, and assessment specialist. Technology use can support each of these roles as teachers develop project-based learning and inquiry-based learning environments. In other words, the teachers' role in effectively using technology in their instruction is to assist students in the process of building their own knowledge. In this regard, integration of technology into school curriculum and classroom activities, teaching, and learning has an important place in education.

Since the integration of technology in teaching mathematics has significant advantages for student learning, researchers have examined the knowledge and skills teachers need to effectively integrate technology into teaching content (e.g., Pierson, 2001; Margerum-Lays & Marx, 2002; Angeli & Valanides, 2005; Mishra & Koehler, 2006). Koehler and Mishra (2005) stated that merely adding technology into existing teaching and content knowledge is not enough to achieve quality teaching through technology. Koehler, Mishra, and Yahya (2007) posited teaching subject matter through technology effectively not only depends on content, pedagogy, and technology, but also it relies on the relationships among them. In other words, quality teaching in terms of technology integration into subject matter requires an understanding of the complex and mutual relationships among content, pedagogy, and technology so that teachers develop proper content-specific teaching strategies and representations by means of technology. Therefore, Mishra and Koehler (2006) introduced Technological Pedagogical Content Knowledge (TPACK) theoretical framework by integrating technological knowledge into Shulman's original model of PCK (see Figure 1.1).

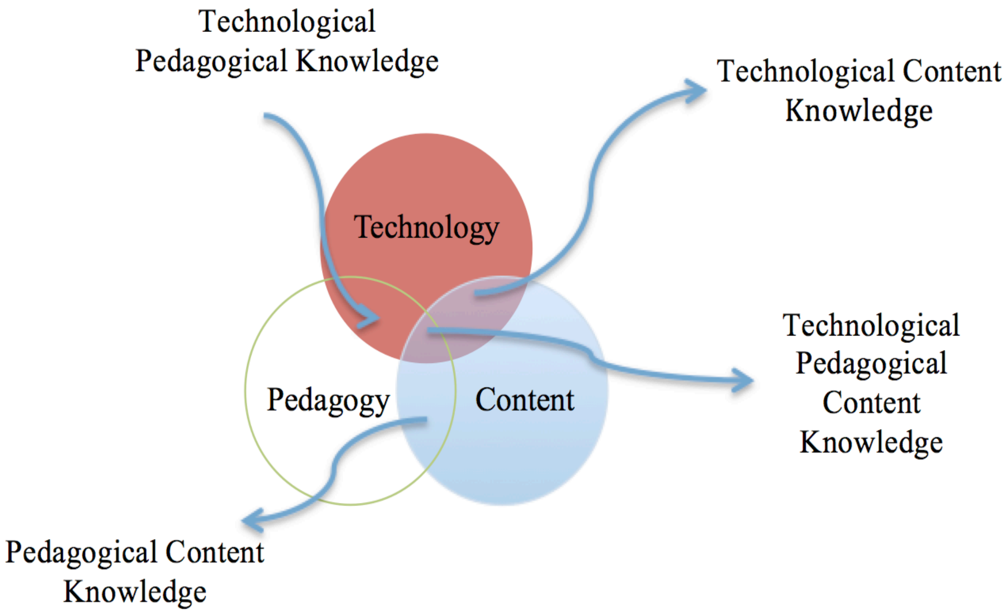
Figure 1.1 *Shulman's PCK* (Mishra & Koehler, 2006, p. 1022)



TPACK framework consists of seven knowledge domains that make up the relationships among Technology, Pedagogy, and Content (see Figure 1.2). The intersection between Technology and Content is called Technological Content

Knowledge (TCK). The intersection of Technology and Pedagogy results in Technological Pedagogical Knowledge (TPK). The intersection of Pedagogy and Content is called Pedagogical Content Knowledge (PCK). The intersection among all three knowledge types called as TPACK. Schmidt, Baran, Thompson, Mishra, Koehler, and Shin explained TPACK as being "an intuitive understanding of teaching content with appropriate pedagogical methods and technologies" (2009, p. 125). In Chapter II, *Review of the Literature,* the definitions of all components of the TPACK framework have been explained in detail.

Figure 1.2. *Technological Pedagogical Content Knowledge (TPACK) Framework (Mishra & Koehler, 2006, p. 1025)*



In addition, researchers have stated pre-service and in-service mathematics teachers' knowledge, experiences, attitudes, and beliefs are one of the most salient factors regarding if and how they will use technology in their instruction (Powers & Blubaugh, 2005; Hew & Brush, 2007; Ozgun-Koca, 2009). Niess (2005) suggested lack of knowledge about how students learn mathematics, how curriculum can be envisioned to advocate students' mathematics learning with technology, and lack of technological knowledge and skills can each be a barrier for technology integration. Furthermore, Koehler, Mishra, Kereluik, Shin, and Graham (2014) reported research studies regarding use of technology with instructional purpose; and stated teachers often lacked the knowledge of how to integrate technology in their teaching and their attempts to use technology tended to be limited. For these reasons, the assessing of pre-service teachers' perceptions, attitudes or beliefs related to their knowledge about how to integrate technology in their instruction may provide significant information regarding their future technology use. Moreover, the evaluation of pre-service teachers' TPACK can be used to inform the design of new courses or adaptation of the existing courses to support development of PSTs' TPACK.

Further, recent research studies have also focused on pre-service teachers' demographic information' effects, such as gender, on their perceptions about TPACK components. Researchers have substantially found male pre-service teachers held more perception on TCK, TPK, TPACK (Erdogan & Sahin, 2010; Canbolat 2011), TK (Erdogan & Sahin, 2010; Koh, Chai, & Tsai, 2010; Canbolat, 2011; Cetin-Berber & Erdem, 2015) and PCK (Erdogan & Sahin, 2010) than those of female pre-service teachers. Considering to these research studies, an investigation of pre-service secondary mathematics teachers' perceived TPACK components with regard to demographic differences might help us to illustrate the current impacts of these differences.

The History of Educational (Information) Technologies in Turkey

In this study, the use of educational (information) technologies within specially classroom settings can be defined as the use of any kinds of well-designed digital or computer-based tools, software, networks, applications, videos or games for the purpose of teaching and learning. In this context, it can be said that the first attempts for incorporating computer technologies into Turkish Education System were started by the Ministry of National Education (MoNE) in the 1980s. In 1984, MoNE conducted a pilot study as a part of the Computer-Based Education (CBE) project and at the first stage provided 1100 computers to 121 secondary schools. In addition, between 1985 and 1988, an in-service teacher-training program was organized for 475 teachers on use of computer and Basic programming languages and provided 2400 more computers to secondary and vocational schools. In 1989, MoNE provided training for 750 teachers through a partnership with 24 universities (Akkoyunlu & Imer, 1998; Akkoyunlu, 2002). However, the results of the pilot study demonstrated computers were mostly used to educate students about the computer instead of integrating it into teaching. Therefore, MoNE contracted with 9 computer companies through a project supported by The World Bank in order to train in-service teachers and to develop courseware for different subjects between 1989 and 1991 (Akkoyunlu & Orhan, 2001). In addition, a total of 8279 computers were distributed to elementary, middle, and high schools by the end of 1992 (Akkoyunlu & Imer, 1998).

In 1992, the General Directorate of Innovation and Educational Technologies (YEGITEK in Turkish) was established as a unit of MoNE. YEGITEK has been responsible for providing information technologies to all schools, establishing of Internet infrastructure, providing in-service teacher training programs for technology-based education, and supplying instructional materials based on information and communication technologies for formal and non-formal education. YEGITEK developed courseware to be used for mathematics, chemistry, and physics lessons in 1993. Following, YEGITEK and the Scientific and Technological Research Council of Turkey (TUBITAK in Turkish) by working together improved courseware for Turkish language, geography, history, and science lessons in 1996 (Akkoyunlu & Orhan, 2001).

With the extension of the period of compulsory education from 5 years to 8 years in 1998, MoNE began another project that was called “Globalization in Education 2000”. The World Bank also supported this project. The purpose of this project was to keep up with new technological developments and standards in education, and to utilize educational technologies in each level of the Turkish Education System. In accordance with this project, new technology classrooms were constituted in 2451 primary and secondary schools located in 80 cities and 921 towns in Turkey. These technology classrooms were equipment with computers, scanners, printers, educational software and videocassettes for different subjects, computer software, videocassette recorder, overhead projectors, and TVs (Akkoyunlu & Orhan, 2001). In addition, new arrangements were made within the education faculties in Turkey. Computer (or information) technologies, and Instructional Technologies and Material Development courses became compulsory for all pre-service teachers. Computer and Instructional Technologies department was established within the education faculties in 1997 in order to train computer teachers.

Furthermore, the Basic Education I-II projects were carried out between 1998 and 2007. In terms of these projects, providing to computer hardware and software to schools, making curriculum development studies, and training in-service teachers were continued. In addition, an agreement between MoNE and the Turk Telecom was made in 2003 to provide internet connection for all schools in Turkey. As a result of this agreement 100% of middle and secondary level schools, and 96% of primary level schools received internet connectivity as of 2012 (Ekici & Yilmaz, 2013).

In 2010, MoNE began one of the most extensive and largest budged project intended for education in modern Turkey history, which called as FATIH in Turkish. The main objectives of the FATIH project are to provide equal opportunity in education for each student and to form new modern classrooms so that teachers can effectively utilize information technology tools within teaching and learning process. The project seeks to supply: smart boards, high speed and secure Internet infrastructure, projectors, and interactive classroom management system for each of 570,000 classrooms in 42,000 schools across Turkey. In addition, it supplied tablet PC, educational software, e-instructional materials consonant with the current curriculum, e-teacher guide textbook, and learning management system for each teacher. It also provided Tablet PC, e-books, and e-textbooks for each student (MoNE, 2017). Interactive management classroom systems give teachers opportunities for orienting to smart board and students' tablet on their tablet, sharing with documents with students, creating quizzes or exams to be administered using tablets, and following students' learning instantly. The learning management system is software that allows one or more teachers to be able to teach lessons in a synchronous or nonsynchronous way.

The Fatih project is still ongoing. Within the context of this project, YEGITEK also established education information network (EBA in Turkish) in 2015, which is an online-social education platform. Through EBA, students can watch e-lessons, play educational games, access individual learning materials, download educational apps, and make connections with their friends. In addition, teachers can share instructional materials with each other, and connect with their students in terms of this platform. MoNE continues to make efforts to support effectively utilized education technologies in classroom environment so that Turkish students can be prepared to the future's information society.

Statement of the Problem

I examined research studies whose aim was to develop a survey instrument for assessing teachers' perceptions of TPACK domain and determined many suffered from a fatal flaw. For instance, some survey instruments faced problems associated with a lack of construct validity (e.g., Archambault & Crippen, 2009; Graham et al., 2009; Landry, 2010), others had conducted a pilot study with small sample size (e.g., Graham et al., 2009; Landry, 2010), some had not implemented a pilot study at all (e.g., Kaya & Dag, 2013), and others were not representative of the population (e.g., Karadeniz & Vatanartiran, 2013). In addition, most of these research studies have focused on the evaluation of pre-service elementary teachers' perceived TPACK in terms of developing a TPACK survey instrument. For example, Schmidt et al. (2009) developed a valid and reliable survey instrument to measure elementary or early childhood education pre-service teachers' self-assessment regarding TPACK. They suggested the next logical step in the process would be to design an instrument to measure secondary mathematics teachers' self-assessment (or other secondary content areas) in terms of TPACK domains.

Another issue I found was research studies conducted to develop a TPACK survey instrument for pre-service secondary teachers utilized more general statements without specializing or focusing on a specific content area (e.g., Koh, Chai, & Tsait, 2010; Sahin, 2011), even though TPACK is highly specific to content. I was successful in identifying research studies in the literature that focused on creating a valid and reliable TPACK survey instrument specifically for secondary mathematics teachers (e.g., Landry, 2010; Zelkowski et al., 2013). These did not however, necessarily pertain to Turkish secondary mathematics teachers.

Research studies related to investigation of pre-service secondary mathematics teachers' perceptions about TPACK within the context of secondary mathematics in Turkey are minimal. Although there exist research studies which created a TPACK survey instrument for measuring teachers' perceptions or adapted existing TPACK survey instruments to a Turkish language and context (e.g., Timur & Tasar, 2011; Sahin, 2011), there are no research studies in Turkey focused on developing or adapting a TPACK survey instrument specialized in secondary mathematics. In addition, most research studies aimed to adapting a TPACK survey instrument did not examine the compatibility of the factor structure of the original scale with its translated version by conducting measurement invariance analysis (e.g., Kaya & Dag, 2013; Timur & Tasar, 2011; Karadeniz & Vatanartiran, 2013).

Further, TPACK research studies outside of the USA have examined the group differences such as gender on teachers' perceived TPACK. While some researchers reported male teachers' perceptions about TPACK domains are stronger than female teachers (e.g., Erdogan & Sahin, 2010; Canbolat, 2011), others concluded that those of female teachers are stronger than male teachers (e.g., Jang et al., 2012; Altun, 2013). Therefore, the present study examines Turkish pre-service secondary mathematics teachers' perceived TPACK in terms of adapting Zelkowski and his colleagues TPACK survey instrument. The present study also analyzes the effects of group differences on Turkish mathematics teacher candidates' perceptions about TPACK.

Purpose of the Study

The primary purpose of this research study is to investigate Turkish pre-service secondary mathematics teachers' perceptions regarding the TPACK domains related to secondary mathematics. For this purpose, I have used Zelkowski and his colleagues' (2013) survey instrument designed in order to measure pre-service secondary mathematics teachers' self-efficacy about the TPACK domains. I have adapted and modified the TPACK survey instrument into a Turkish language and context. Therefore, this adapted TPACK survey instrument will be used to assess Turkish pre-service secondary mathematics teachers' perceived TPACK.

A second purpose of this study is to examine if there are discrepancies stemming from demographic information, such as gender and year of enrollment in the program of secondary mathematics education, among pre-service secondary mathematics teachers' perceptions about TPACK and its components. In addition to this, the study explores the impacts of the demographic information on pre-service mathematics teachers' attitudes towards Computer- Aided Education. Finally, this study also examines the relationship between pre-service secondary mathematics teachers' attitudes towards Computer-Aided Education and their perceptions about TPACK components.

Significance of the Study

Pre-service teachers' knowledge, skills, and disposition gained during their teacher preparation program may have a significant impact on use of technology in mathematics teaching in effective way. Lee and Hollebrands (2008) stated that teachers' decisions related to utilization of technology tools in instruction, which are obtained through knowledge gained during their teacher preparation program, influence if technology would improve or prevent to students' learning. In addition, AMTE (2006) highlighted that "mathematics teacher preparation programs must ensure that all mathematics teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology in the context of teaching and learning mathematics" (p. 1). In other words, field experience, mathematics method courses, and technology-based mathematics courses should be designed in order to support the development of pre-service teachers' TPACK knowledge. For this reason, I believe that the results of the study are important for the Turkish teacher preparation program, and my results will inform our understanding of pre-service secondary mathematics teachers' perceptions about TPACK domains and their affect toward use of technology. This study also is significant because it has adapted and validated a mathematics subject specific measure of TPACK in Turkish. By means of this, the TPACK survey instrument is now available for use nationwide to assess TPACK for Turkish secondary mathematics teachers. Therefore, this study may contribute to evaluation of the present courses related integration of technology into secondary mathematics teaching and be designed to new courses for development of TPACK knowledge domains. Moreover, the results of this study may provide important information that contributes to theoretical knowledge related to TPACK for secondary mathematics.

In recent years, Turkish Ministry of National Education (MoNE) has started a project entitled as *Movement of Enhancing Opportunities and Improving Technology*, which is known as FATIH in Turkish. In this regard, MoNE is aimed to provide interactive white board (IWB) for each class, Internet network infrastructure for all schools from primary level to high school level and tablets for each student in order to integrate technology into teaching and learning environment for enhancing students' learning. However, just adding technology into existing education system cannot ensure that the integration of technology into teaching and learning process. Use of technology in instruction will be most beneficial when teachers possess both the knowledge and disposition to effectively leverage technology in their practice. Because of this, pre-service secondary mathematics teachers' perceptions about TPACK and disposition toward use of technology in terms of findings of this study may be significant indicator for the success of FATIH project.

Research Questions

In this study aims to answer the following questions:

1) What are Turkish pre-service secondary mathematics teachers' perceived technological pedagogical content knowledge as it specifically pertains to secondary mathematics?
2) What are the relationships among the components of TPACK pertaining to secondary mathematics as measured by Pearson correlations?
3) Is there a significant relationship between Turkish pre-service secondary mathematics teachers' attitudes towards use of technology and their perceptions of the TPACK domains?
4) Is there a significant mean difference in Turkish pre-service secondary mathematics teachers' perceptions of TPACK domains with respect to the following factors:
    a. Gender
    b. Year of enrollment in the program of secondary mathematics education
5) Is there a significant mean difference in Turkish pre-service secondary mathematics teachers' attitudes towards use of technology with respect to the following factors:

a. Gender

b. Year of enrollment in the program of secondary mathematics education

Definitions of Terms

Content knowledge **(CK)** is associated with the knowledge about subject matter that teachers are responsible for teaching (Mishra & Koehler, 2006). In this study, it is associated with knowledge of mathematics skills, concepts, facts, and procedures that includes high school or more advance level mathematics. It also consists of common content knowledge (CCK) and specialized content knowledge (SCK) (Ball, Thames, & Phelps, 2008)

Pedagogical Knowledge **(PK)** incudes general pedagogical knowledge about learning theories related to student learning, teaching methods and strategies, classroom management, assessment; and development and implementation of lesson plan (Mishra & Koehler, 2006).

Technology Knowledge **(TK)** refers to the knowledge including all instructional materials ranging from standard technologies such as chalk and blackboard from more advanced technologies such as dynamic geometry software GeoCebra (Mishra & Koehler, 2006).

Pedagogical Content Knowledge **(PCK)** includes “knowing what teaching approaches fit the content”(secondary mathematics) and “ knowing how elements of the content can be arranged for better teaching” (Mishra & Koehler, 2006, p. 1027). In this study, it is also related to knowledge of high school students' mathematical thinking and learning, and knowledge of teaching strategies to present better to secondary mathematics topics such as derivative, integral, trigonometry, functions, and equations.

Technological Content Knowledge **(TCK)** includes knowing what the kinds of new representations technology might create or provide for specific content (Schmidt et al., 2009). In this study, it is related to knowledge of technologies that might use for secondary mathematics, such as Cabri, GeoCebra, Logo, and Derive.

Technological Pedagogical Knowledge **(TPK)** includes "the knowledge of how various technology can be used in teaching, and to understanding that using technology may change the way teachers teach" (Schmidt et al., 2009, p. 125).

Technological Pedagogical Content Knowledge **(TPACK)** is related to "the knowledge required for teachers integrating technology into teaching in any content area" "(Schmidt et al., 2009, p. 125). In this study, it refers to knowledge of integrated relationship among secondary mathematics, pedagogy, and technology.

CHAPTER TWO

REVIEW OF THE LITERATURE

This chapter begins with a section on Teacher Knowledge, which highlights the research occurring from the introduction of Shulman’s prominent idea of *Pedagogical Content Knowledge* (PCK, 1986; 1987) to the emergence of *Technological Pedagogical Content Knowledge* framework (Mishra & Koehler, 2006). Within this section, I address other frameworks, definitions, and concepts related to PCK (e.g., Grossman, 1990; Cochran, 1991). I focus on how Shulman’s approach affected the research studies related to what knowledge teachers need for teaching mathematics (e.g., Ball, Thames, & Phelps, 2008) and what knowledge teachers needs to effectively integrate technology into teaching their subject matter (e.g., Angeli & Valanides, 2005; Niess, 2005; Mishra & Koehler, 2006). I then present the current TPACK framework and its components in the light of secondary mathematics in which I set my research study.

To further frame my study, I present research studies whose goals were to develop survey instruments related to the assessment of teachers’ perceptions of the TPACK domains as well as factors that may be effective in enhancing teachers’ TPACK. Following this, I present and discuss Turkish research studies associated with TPACK and finally, discuss the effects of demographic differences on teachers’ perceived TPACK domains in the light of the related literature.

Teacher Knowledge

Pedagogical Content Knowledge. Shulman's (1986) research study, *Those Who Understand: Knowledge Growth in Teaching,* drew attention to the importance of the interplay between pedagogy and subject matter (content) for teacher competence and brought a fresh perspective to the study of teacher knowledge in the education field. Shulman (1986) highlighted two research paradigms related to teacher competence in the educational research field, which created sharp distinction between pedagogy and subject matter. The common consensus among state superintendents, educational leaders, stakeholders, and politicians in the USA prior to the 1980s was that the subject matter was an indispensible knowledge base for teachers and was enough to create better teachers. Therefore, pedagogical knowledge was relegated to the background. Researchers in the 1980s examined teachers' general pedagogical knowledge for teacher effectiveness without considering subject matter and its effects on pedagogy. Shulman qualified this situation as a "missing paradigm" and he began to ponder on the sources of teacher knowledge and what kind of knowledge was required for teaching (p. 6, 1986).

In addition to pedagogy and subject matter, Shulman (1986) introduced his idea of pedagogical content knowledge (PCK) as a part of content knowledge (CK) in addition to subject matter knowledge and curricular knowledge. Moreover, Shulman (1987) described that the interactions between pedagogical knowledge (PK) and CK produce a unique knowledge for teaching, which is PCK. Although PCK lies at the intersection of PK and CK, its properties make it unique and differentiates it to some extent from both PK and CK. Shulman (1986) described PCK' these features in the following:

> …pedagogical knowledge, which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching. I still speak of content knowledge here, but of the particular form of content knowledge that embodies the aspects of content most germane to its teachability….the most powerful analogies, illustrations, examples and demonstrations-in a word, the ways of the representing and formulating the subject that make it comprehensible to others….includes an understanding of what makes the learning of the specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to learning. (p. 9)

When considering Shulman's explanation of PCK in the above quotation, PCK is described as content-specific pedagogical knowledge needed for teachers in order to learn how to teach their subject matter. In addition, PCK involves a reorganizing or adjusting of subject matter knowledge by taking into account of learners' needs, and common misconceptions and conceptions among learners regarding content. In other words, PCK is a special amalgam of PK and CK, which comes to existence through the transformation of subject mater into pedagogical knowledge for the purpose of teaching (Shulman, 1986; 1987).

Following Shulman's work, Grossman (1990) also examined the source and the nature of pedagogical content knowledge for teaching. In her study, Grossman (1990) illustrated a model for teacher knowledge in which subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge, and knowledge of context were seen as facets of teachers' professional knowledge (p. 5). According to Grossman (1990), PCK consisted of four different components: a) knowledge and beliefs regarding the goals of teaching subject matter, b) knowledge of students, c) curricular knowledge, and d) knowledge of instructional strategies and representations for teaching subject matter (pp. 8-9). Grossman's (1990) first component of PCK, knowledge and beliefs, refers to teachers’ understandings and beliefs with regard to the underlying reasons why a specific topic in the content should be taught. These beliefs are shaped, attributed to, and formed by means of both previous observations and undergraduate education associated with teaching subject matter. The second component of PCK is related to teachers’ understanding of students’ pre-conceptions and misconceptions, the subjects they find interesting, and which subjects they can find confusing. The third component, curricular knowledge concerns the knowledge of the curriculum materials available for teaching a specific topic and this topic’s relationships with the other concepts in the curriculum. The final component pertains to the knowledge of “rich repertories of metaphors, experiments, or explanations that are particularly effective for teaching a particular topic” (Grossman, 1990, p. 9).

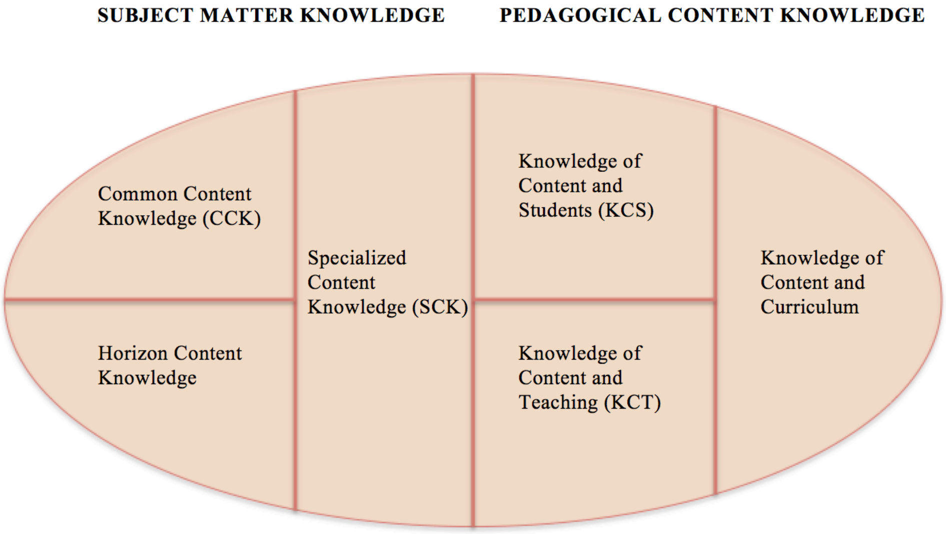
Cochran (1991) also studied the nature of PCK, and suggested another theoretical framework with regard to the constructs of PCK. In her study, PCK is depicted as the knowledge that meets the necessary qualifications in order to become a teacher rather than a subject area expert. According to Cochran (1991), PCK is extremely particular to the concepts being taught; therefore, it requires a greater understanding than CK alone. Like Shulman’s PCK framework, Cochran’s framework described PCK as a special amalgam of four knowledge domains: a) content (subject area) knowledge, b) pedagogical knowledge, c) knowledge of students, and d) knowledge of the environmental context. In her model, knowledge of students refers to understanding of students’ prior knowledge related to content, their motivation toward learning content, and their background information. Knowledge of the environmental context refers to knowledge associated with school settings, district context, and community context. Cochran (1991) explained that while the integration of these four distinct knowledge domains constitute PCK, they cannot be considered separately from each other due to their highly interrelated nature.

Following Shulman (1986), Grossman (1990), and Cochran's (1991) pioneering notions of PCK, researchers from different education fields including science and mathematics conducted subject specific research studies on PCK. Researchers have investigated the factors affecting its development, and its sources for in-service and pre-service teachers (e.g., Ball, 1990; Van Driel, Verloop, & de Vos, 1998; Ball & Bass, 2000; Kinach, 2002; Ball, 2003; Nilsson, 2008); while others have developed refined theoretical frameworks for PCK (e.g., Niess, 2005; Mishra & Koehler, 2006; Ball, Thames, & Phelps, 2008; McCrory, Floden, Ferrini-Mundy, Reckase, & Senk, 2012).

Mathematical Knowledge for Teaching. Shulman (1986) and others worked to explicate the knowledge and skills needed for the work of teaching, especially concerning PCK and how it differentiates from CK and PK. However, they provided general frames and definitions for PCK without considering specific subject matter. There was thus a need for an investigation of mathematics teachers' PCK. Hill, Schilling, and Ball (2004) discussed their empirical efforts to develop measures of teacher's knowledge for teaching elementary mathematics. They found knowledge needed for teaching elementary mathematics consisted of a multidimensional structure such as knowledge of content, and knowledge of student and content. In addition, their statistical analysis showed that knowledge of content apparently became distinct as common knowledge of content and specialized knowledge of content. Ball, Hill, and Bass (2005) explained that mathematical knowledge for teaching demands additional insight and understanding that would go beyond knowing simple mathematical procedures and algorithm. Ball and her colleagues (2005) also stated that mathematical content knowledge for teaching stemmed from two significant domains: "common" knowledge of mathematics that a well trained-adult need know and mathematical knowledge that is "specialized" to teaching profession (p. 43). Ball, Thames, and Phelps (2008) were interested in the domains of mathematical knowledge required for teaching. For that purpose, Ball and her colleagues (2008) conducted an empirical research study with mathematics teachers; and examined the problems arising in teaching mathematics. In light of their analysis, they built a framework they described as mathematical knowledge for teaching (MKT), which draws on Shulman's PCK. In other words, Ball and her colleagues utilized Shulman's PCK to identify and define the domains of mathematical knowledge for teaching, and to reframe the subject matter knowledge and the PCK in terms of the role of mathematics content in teaching.

According to this framework, MKT is first separated into two sub-groups: Subject matter knowledge and PCK (see Figure 2.1). Subject matter knowledge consists of three sub-domains: a) common content knowledge, b) specialized content knowledge, and c) horizon knowledge. Ball and her colleagues (2008) defined common content knowledge (CCK) as " mathematical knowledge and skill used in settings other than teaching" (p. 399). On the contrary, special content knowledge (SCK) is "a mathematical knowledge not typically needed for purposes other than teaching" (Ball et al., 2008, p. 400). Horizon knowledge is defined as being aware of relationships between one mathematics topic and the other mathematics topics in the curriculum. PCK is also comprised of three sub-domains, which are knowledge of content and students (KCS), knowledge of content and teaching (KCT), and knowledge of content and curriculum (KCC). Hill, Ball, and Schilling (2007) described KCS as “content knowledge intertwined with knowledge how students think about, know or learn this particular subject” (p. 375). In other words, it is associated with how students think mathematically, and what their misconceptions and concepts are. KCT is associated with design of instruction, and selection of proper examples and representations (Hill et al., 2007). KCC is related to what curriculum programs, materials or resources are available to teach a specific subject and support students’ learning (Shulman, 1987).

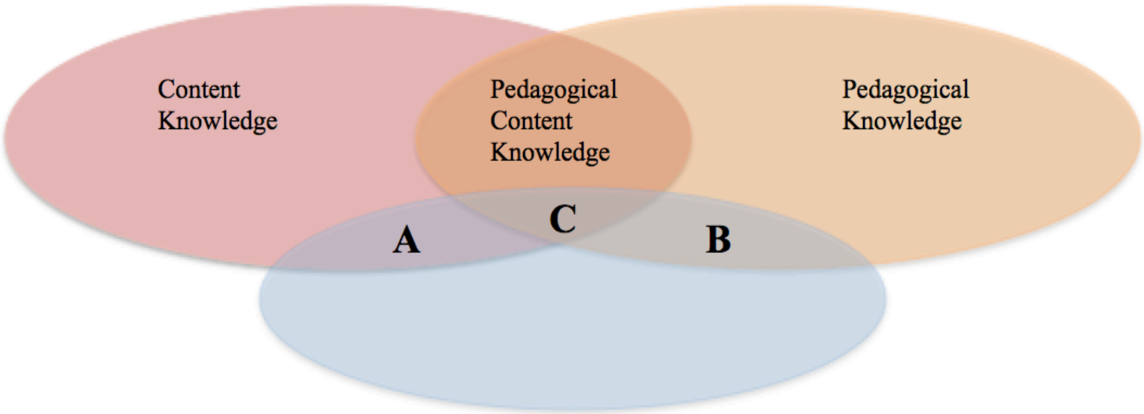
Figure 2.1 *Mathematical Knowledge for Teaching (MKT)* (Ball et al., 2008, p. 403)



The Integration of Technological Knowledge and PCK. With the emergence of instructional technologies such as graphic calculators, Cabri, GeoGebra, and the Geometer's Sketchpad, many researchers have examined the factors affecting the integration of technology into processes of teaching and learning, as well as the kind of knowledge and skills teachers need in order to use technology effectively in teaching their subject matter. Pierson (2001) posited teaching subject matter with technology requires more comprehensive understanding of content, pedagogy, and technology than having general technological competency alone. Similarly, Koehler and Mishra (2005) also stated the inclusion of technology in the educational process does not assure the use of technology as integral to the teaching process.

Pierson (2001) suggested a model (see Figure 2.2), which included technological knowledge as another component of Shulman's (1986) construct of PCK. According to Pierson (2001), technological knowledge involves both basic technological skills and an understanding in which teachers can utilize the characteristics of particular types of technologies within a teaching and learning context. For example, if a teacher knows the features of the dynamic geometry software such as Cabri, he may take advantage of it in his teaching so that his students can discover the relationships between the sine and cosine functions on the unit circle. In this proposed model, the intersection of pedagogical knowledge, technological knowledge, and content knowledge (section C) refers to effective technology integration. Pierson (2001) also identified section A as knowledge of content-based technology resources. Section B represents knowledge of pedagogical methods used to regulate and manage teaching and learning in terms of technology.

Figure 2.2 *Pierson's Model related to Possible Relationship among PK, CK, and TK* (Pierson, 2001, p. 427)



Margerum-Lays and Marx (2002) proposed an extension of Shulman's PCK model by considering the construct of teachers' knowledge of educational technology. They explained the construct of educational technology in terms of content knowledge, pedagogical knowledge, and PCK. Content knowledge of educational technology is related to knowing about the features, capacities, and existence of diverse technologies that would be able to use in teaching and learning settings. For example, a mathematics teacher' having knowledge of which technologies are available for teaching and learning three-dimensional geometric objects and about how to use these technologies. Pedagogical knowledge of educational technology refers to general pedagogical strategies that can be applied while using technology. In addition, Margerum-Lays and

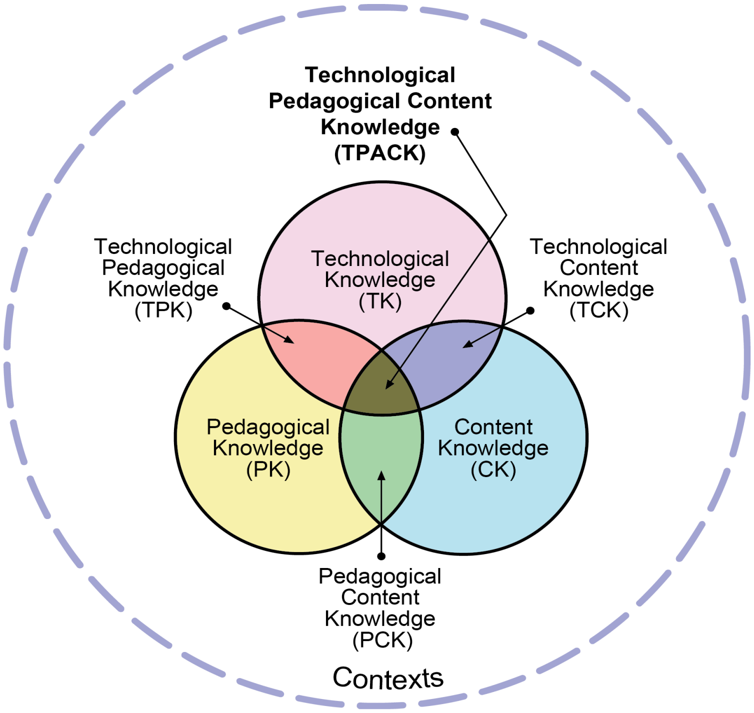
Marx (2002) described PCK of educational technology as knowledge which is particular to effective use of educational technologies and which stems from experiences obtained from using technology in teaching and learning settings, such as: knowing the time needed for teaching with a particular technology, considering students' potential problems with the particular technology, and adjusting instruction and learning tasks in harmony with the relevant technological tool's capacity.

Angeli and Valanides (2005) developed information and communication related pedagogical content knowledge (ICT-related PCK) by extending Cochran's (1991) and Shulman's (1986) conceptualizations of PCK. According to Angeli and Valanides (2005), ICT-related PCK represents teachers' integrated understanding about content knowledge, pedagogical knowledge, knowledge of students, knowledge of environmental context, and ICT knowledge. They explained ICT knowledge as understanding of how to use a technological tool and to leverage its affordances in order to teach a particular topic with a particular technology. According to Angeli and Valanides (2005), ICT-related PCK includes an understanding of which topics will be more comprehensible for students and of how their teaching will be more effective in the presence of use of ICT, the transformation of content into appropriate representations which cannot be obtained with traditional teaching methods, and the awareness of teaching strategies made possible in terms of ICT use, such as interactive learning and authentic learning.

Niess (2005) extended the four components of Grossman's PCK to depict technology-enhanced PCK (TPCK). Niess defined TPCK for teachers as an "overarching conception of their subject matter with respect to technology and what it means to teach with technology" (p. 510, 2005). In addition, Niess (2005) stated TPCK arises from the combination of subject matter knowledge, knowledge of teaching and learning, and knowledge of technology. Margerum-Lays and Marx (2002), Angeli and Valinades (2005), and Niess' (2005) work on the integration of technological knowledge and PCK led to the development of a new construct, technological pedagogical content knowledge.

Technological Pedagogical Content Knowledge. Margerum-Lays and Marx (2002), Angeli and Valinades (2005), and Niess (2005) all developed their theoretical models by integrating technological knowledge within Shulman's or Cochran's conceptions of PCK. The framework presented by Mishra and Koehler (2006) however, treated technological knowledge as separate knowledge from PCK; and therefore, its interplay with the other teacher knowledge domains produced new knowledge domains. Their framework evolved from a series of empirical research studies (Peruski & Mishra, 2004; Koehler & Mishra, 2005; Koehler, Mishra, & Yahya, 2007). Therefore, Mishra and Koehler (2006) presented their technological pedagogical content knowledge framework (TPACK) by building on the construct of Shulman' PCK. TPACK framework includes the interaction among technological knowledge, pedagogical knowledge and content knowledge, which produces the types of flexible and effective teacher knowledge required for successfully integrating technology into teaching subject matter (Koehler & Mishra, 2009; Harris, Mishra, & Koehler, 2009). In other words, learning general technological skills are not enough to know how to use technology for delivering content. In order to synthesize content-based teaching strategies and representations in terms of technology, which can lead to effective teaching, teachers need to comprehend the complex and dynamic relationships among all these three knowledge bases (Mishra & Koehler, 2006). As teachers' develop these types of flexible knowledge, they are better able to make instructional decisions about integrating technology as learning tools (Niess, 2011). The TPACK framework involves three main components, content, pedagogy, and technology, and four components constructed by the various intersections among them (see Figure 2.3): Pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK). I next describe these knowledge domains, as well as situating CK, TK, TCK, and TPACK in the context of secondary mathematics.

Figure 2.3 *TPACK Framework Image* (source: http:// tpack.org)



Technological Knowledge (TK) includes an overarching understanding about different technologies ranging from simple technologies, such as chalk and blackboard to more advanced technologies, such as interactive whiteboards (Schmidt et al., 2009). In addition, it refers to knowledge of the types of technologies available for teaching and learning secondary mathematics. According to Zelkowski and his colleagues, there are two categories for technologies that are specifically utilized in teaching secondary mathematics (Zelkowski et al., 2013). The first category includes computer algebra systems (CAS), dynamic mathematical software such as GeoCebra, Cabri and Geometer's Sketchpad, online apps, and graphing handheld devices. The second category consists of technological tools such as calculation devices, spreadsheets, and interactive whiteboards. *Pedagogical Knowledge* (PK) includes general teaching and learning approaches, methods, and techniques as well as classroom management, assessment of student learning, and educational purposes and values (Koehler et al., 2007). *Content Knowledge* (CK) includes general knowledge about subject matter that should be learned and taught (Mishra & Koehler, 2006). For secondary mathematics, this knowledge is compromised of the mathematical skills, concepts, facts, and procedures that are specific to particular topics in the secondary mathematics, such as trigonometry, functions, derivative, and integral. Considering Ball and her colleagues' MKT framework, CK can define as knowledge that involves both common content knowledge and specialized content knowledge (2008).

Technological Pedagogical Knowledge (TPK) is the intersection of TK and PK, and is related to knowledge of how use of a particular technology can influence and support instructional approaches, methods, and strategies. For example, understanding that a technological tool such as wikispaces and edmodo can be used to foster collaborative learning. TPK also includes a deeper understanding of the manner in which the use of a particular technology either can support or constrain the development of appropriate pedagogical designs and strategies (Harris et al., 2009; Koehler & Mishra, 2009). *Technological Content Knowledge* (TCK) is the intersection of technology and content, and includes an understanding of how technology and content reciprocally can affect each other (Koehler et al., 2007). Zelkowski and his colleagues (2013) have stated this also includes knowledge of how the inclusion of technology in secondary mathematics classrooms can significantly influence students' learning of mathematics. For instance, understanding dynamical mathematics software, graphic handhelds or data collection devices can provide students with new perspectives and techniques to explore mathematical concepts, relationships and real world phenomena that would not be possible, or be tedious, without technology (Zelkowski et al., 2013).

Pedagogical Content Knowledge (PCK) is the amalgam of PK and CK; and involves knowledge of pedagogical strategies or approaches that are content appropriate and knowledge of how to present the content effectively (Mishra & Koehler, 2006). In other words, it includes content-specific teaching processes. In this sense, their characterization of PCK seems very similar to Shulman's notion of PCK. Finally, the intersection of TK, CK, and PK results in what Mishra and Kohler have entitled *Technological Pedagogical Content Knowledge (TPACK)*. This knowledge consists of the understanding of: how to represent the content through technology; pedagogical strategies, techniques or methods that make it possible to effectively teach the content through use of technology; what technology choices might support or constrain the learning of content; knowledge of students' pre-conceptions and misconceptions; and how technology can strengthen students' existing knowledge or can help them to create new knowledge (Koehler et al., 2007). In addition, Zelkowski et al. (2013) pointed out that TPACK in secondary mathematics refers to knowledge of how technology can influence teaching and learning mathematics as well as the required understanding to make critical classroom decisions related to mathematics-specific pedagogy with the proper technology.

TPACK is a complex concert of knowledge of pedagogy, content, and technology. Therefore, it requires more comprehensive and distinctive knowledge than a disciplinary expert, such as a mathematician, or a technology expert, or a pedagogical expert (Koehler et al., 2007). TPACK, much like PCK, is also highly content specific. In other words, TPACK needed for mathematics teachers would be very different from that needed for other teaching fields such as literacy teachers. Niess (2005; 2006) has dealt with teacher knowledge of incorporating technology into teaching mathematics; and has extended the four components of Grossman's PCK for explaining to TPACK needed for mathematics teachers. According to Niess (2006), mathematics teachers should have knowledge of the following:

- An inclusive comprehension of why integration of technology into particular areas of mathematics instruction has importance for students' learning.

- How to use instructional strategies and representations in an appropriate way while teaching particular mathematics topics with technology.
- Knowledge of what students' learning, understanding, and thinking might be while trying to teach a particular mathematics topic with the proper technological tool(s).
- Knowledge regarding which curriculum and curriculum materials are suitable for teaching and learning mathematics with technology.

In addition, the Association of Mathematics Teacher Educators (AMTE) technology committee first proposed the *Mathematics Teacher TPACK Standards* in order to offer guidelines and set goals about how to prepare mathematics teachers effectively integrate technology in their instruction in January 2008 (Niess, Ronau, Shafer, Driskell, Harper, Johnston, Browning, Ozgun-Koca, & Kersaint, 2009). These standards were comprised of four themes in accordance with Niess' proposed four components mentioned above mathematics. Next, the AMTE technology committee, in which Niess and his colleagues had taken part, reviewed the mathematics teacher TPACK standards. Through their consideration of the *National Educational Technology Standards for Teachers* (NETS-T; ISTE, 2008), AMTE (2009) further revised the mathematics teacher TPACK standards and published its principal components of TPACK for mathematics teaching: a) Knowledge of the design and development of technology-enhanced mathematics learning environments and experiences, b) The ability to facilitate mathematics instruction with technology as an integral tool, c) To assess and evaluate technology-enriched mathematics teaching and learning, and d) To engage in ongoing professional development to enhance TPACK.

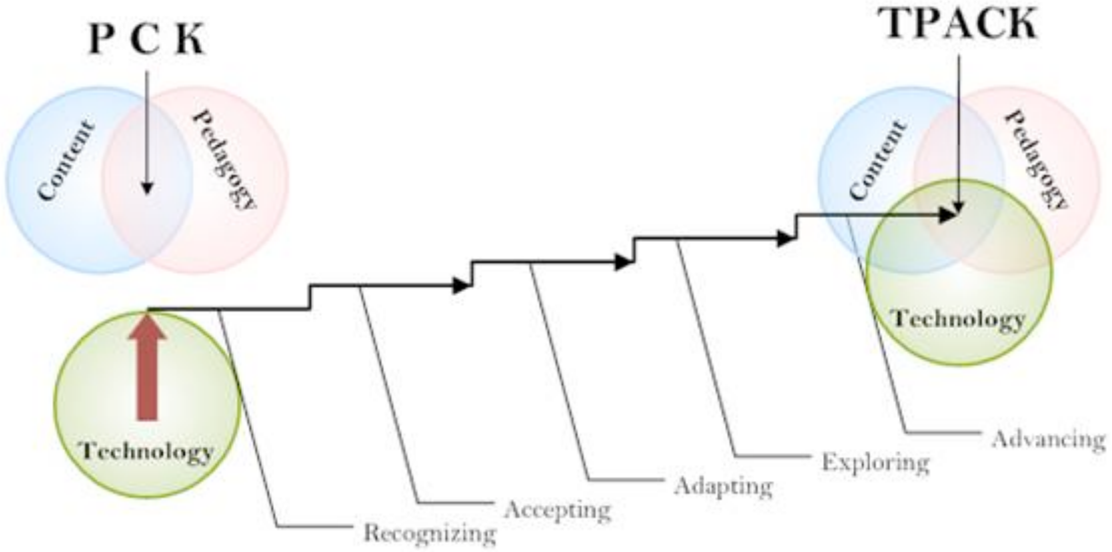
Niess et al. (2009) admonished the mathematics teacher TPACK standards for not providing a means to evaluate mathematics teachers' levels of technology integration in spite of their call for technology to be integrated into the mathematics teaching and learning processes. In response Niess and her colleagues (2009) proposed a five-stage development for levels of mathematics teachers' technology integration (see Figure 2.4), which built on Rogers' innovation-decision process model (Roger, 1995). The five stages are as follows:

- Recognizing (knowledge): Teachers at this level have not developed an understanding of how to integrate technology into teaching and learning mathematics. They can use technology in their lesson as a reinforcement tool and recognize its potential for presenting mathematics content.
- Accepting (persuasion): Teachers at this level have developed an opinion, either for or against, integration of a proper technology into teaching and learning mathematics.
- Adopting (decision): Teachers at this level can use their experiences with a particular technology to make appropriate decisions about it for teaching and learning mathematics.
- Exploring (implementation): Teachers at this level use technology as a learning tool for students' exploration of mathematical concepts and the development of

higher-order skills. In other words, they can actively integrate a suitable technology into teaching and learning mathematics.

- Advancing (confirmation): Teachers at this level can assess the consequences of their decisions concerning possible use of an appropriate technology for teaching and learning a particular mathematics topic.

Figure 2.4 *The Five-Level Model for Development of TPACK* (Niess et al., 2009, p. 10)



My research study will utilize the TPACK framework (Mishra & Koehler, 2006) as a theoretical framework. In the above section, I have defined TK, CK, TCK, and TPACK within the secondary mathematics context. The definitions of PK and TPK will be used as explained in the relevant literature. In respect to PCK, it has been defined as knowledge of proper pedagogical approaches or strategies to present secondary mathematics topics, knowledge of selection of appropriate examples and representations for teaching secondary mathematics topics, and knowledge of high school students' mathematical thinking and learning to adjust teaching strategies according to their needs.

TPACK Research Studies

In this section, I present the research studies related to the development or adaption of survey instruments in order to assess in-service and/or pre-service teachers' TPACK. These survey instruments are related to measuring of teachers' perceptions about TPACK, and therefore, these instruments do not directly measure this knowledge.

Research Studies related to In-service Teachers' TPACK. Several research studies aimed to develop a survey instrument for assessing in-service teachers' perceptions of TPACK (Mishra & Koehler, 2006); and faced construct validity issues due to small sample sizes. To check construct validity of a survey instrument, researchers need to conduct factor analysis in their research studies. Gorsuch (1983), Klein (1994), and Fabrigar and his colleagues (Fabrigar, Wegener, MacCallum, & Strahan, 1999) recommended that sample size needed for conducting factor analysis should be at least 100. In addition, Klien (1994) stated samples consisting of less than 100 participants could be the cause of inaccurate results in terms of factor analysis. Landry (2010), for example, worked to develop a survey instrument related to middle school mathematics teachers' knowledge and beliefs in respect to their use of technology in classroom instruction. She used a survey developed by Schmidt et al. (2009), and modified it to measure middle school mathematics teachers' TPACK. The study included three phases: 1) the administration of the existing survey to 21 middle school mathematics teachers

(Schmidt et al., 2009), 2) semi-structured online interviews with 8 middle school mathematics teachers, and 3) the creation and validation processes for Mathematical TPACK or M-TPACK survey. Analysis of the first and second phase data resulted in the development of the M-TPACK survey, which was administered to 28 middle school mathematics teachers to check its reliability. After obtaining Cronbach's alpha coefficients to evaluate the reliability and internal consistency of the M-TPACK subscales, the researcher found that all the six subscales were reliable and valid except for TPK subscale. However, the researcher was unable to check the construct validity of the M-TPACK survey by implementing exploratory factor analysis due to her small sample size.

Similarly, Graham, Burgoyne, Cantrell, Smith, St Clair, and Harris (2009) also had an inadequate sample size to check the construct validity for their survey instrument. The survey instrument was named "TPACK confidence" as the survey asked participants to rate their confidence in completing the tasks stated in the survey items using a 6-point Likert scale, ranging from "not confident" to "completely confident". The researchers used four constructs of the TPACK framework (Mishra & Koehler, 2006) to develop a survey instrument for measuring in-service science teachers' TPACK confidence. They expressed that these four constructs were considered in the technology circle (see Figure 2.3): 1) TK, 2) TCK, 3) TPK, and 4) TPACK. The researchers considered TPACK as an extension of PCK, TPK as extension of PK, and TCK as an extension of CK; and therefore, justified their exclusion of PCK, PK, and CK in their survey. The TPACK confidence survey included 31 Likert-scale items and two open-ended questions.

Although Graham et al. (2009) were able to establish reliability of the TPACK confidence survey for all constructs; they could not establish its validity by conducting explanatory factor analysis due to the insufficient sample size. The TPACK confidence survey was administered to 15 elementary science teachers during a professional development course as a pre-and post-assessment .The result of the study demonstrated the participants' confidence levels increased for all constructs with the greatest increase made in TK confidence level and the smallest increase in TCK.

Archambault and Crippen (2009) examined in-service K-12 online teachers' perceptions of TPACK using a 24 item, 5-point Likert scale, survey instrument based on their previous research (Archambault & Crippen, 2006) and the TPACK framework (Mishra & Koehler, 2005). 596 participants, who taught online within K-12 distance education, representing 25 different states in the USA participated in this study. The Cronbach's alpha reliability coefficients, which determine the level of internal consistency for each construct, were found to be within acceptable levels, ranging from .699 to. 888. The results demonstrated K-12 online teachers perceived themselves to be more competent within the domains of PK, CK, and PCK while perceiving themselves to be less competent within TK, TPK, TCK, and TPACK knowledge domains. Considering the correlation among all six TPACK knowledge domains, the results revealed a high positive relationship between PK and CK, and low positive correlations between TK and PK as well as TK and CK.

Another research study conducted by Alshehri (2012) investigated the relationship between Saudi Arabian in-service mathematics teachers' perceived TPACK knowledge and their teaching effectiveness as perceived by their school principal. The researcher also examined the effects of mathematics teaching anxiety, technology integration anxiety, and demographic data (e.g., teaching experiences, education levels and age) on teacher effectiveness. Two different survey instruments were adapted and used in this study: The teachers' survey (Hervey, 2011) and the teachers' effectiveness survey (Brennen, 2011; as cited Alshehri, 2012). The participant sample consisted of 214 male middle school mathematics teachers, 133 male high school mathematics teachers, and 109 principals. The results of the study revealed no significant relationships between mathematics teachers' effectiveness, as rated by the principals, and teachers' perceived TPACK domains. Moreover, the researcher concluded mathematics teachers' effectiveness does not significantly correlate with demographic information, mathematics teaching anxiety or the anxiety related to integration of technology in their instruction. Alshehri (2012) also found the mathematics teachers believed their in-service training and professional development workshops were not adequate to prepare them to teach mathematics with technology in comparison to courses taken in their university education.

Lee and Tsai (2010) developed a web-based TPACK instrument including 30 items, named TPACK-w, in order to explore Taiwanese in-service teachers' self-efficacy with regard to TPACK-w and evaluate their attitudes towards web-based instruction. 558 in-service teachers from elementary school to high school level participated in this study. The explanatory factor analysis produced 5 factors: Web-general, Web-communicative, Web Content Knowledge (WCK), Web Pedagogical Content Knowledge (WPCK), and attitude. Furthermore, the Web Pedagogical Knowledge (WPK) construct, which was included in the initial survey, had disappeared. The results revealed the participants demonstrated a lack of web-based pedagogical knowledge since the pre-service teachers could not differentiate between WPK and WPCK. In addition, the participants demonstrated a positive attitude towards web-based instruction. The researchers determined older and more experienced teachers displayed lower self–efficacy in terms of TPACK-w due to the lack of experiences related to use of web technologies in comparison to younger and more novice teachers. In other words, there was a negative correlation between teaching experiences and self-efficacy with regard to TPACK-w. However, there was a positive relationship between teaching experiences associated with web technologies and self-efficacy about TPACK-w. In other words, the teachers who had more experiences with web-based instruction indicated more self-efficacy with respect to TPACK-w.

In addition to the above TPACK studies, Jang and Tsai (2012) developed an interactive whiteboards (IWBs)-based TPACK instrument for in-service elementary teachers. Their initial survey instrument included one additional component called Context knowledge (CxK) in addition to the seven components of the TPACK framework theorized by Mishra and Koehler (2006). Jang and Tsai explained CxK as “knowledge needed to pay attention to students’ prior knowledge, misconceptions, learning difficulties in a certain subjects, and evaluation of students’ understanding” (p. 331, 2012). As a result of item analysis and explanatory factor analysis, the researchers created a valid and reliable IWB-TPACK survey instrument consisting of four components with 31 total items. The components of the survey were Content Knowledge (CK), Pedagogical Content Knowledge in Context (PCKCx), IWB-based Technological Knowledge (TK), and Technological Pedagogical Content Knowledge in Context (TPCKCx). The results indicated that elementary science teachers had significantly better-perceived knowledge of TK, TPCKCx, and TPACK than those of elementary mathematics teachers. In addition, they found that the teachers with more teaching experience demonstrated better-perceived knowledge of CK, TK, TPCKCx, and TPACK than those who had less.

As a result of the research studies in associated with in-service teachers' TPACK aforementioned above, the researchers mostly have sought to develop a TPACK survey instrument into different contexts such as middle school mathematics, science, and interactive white boards to assess in-service teachers' perceptions (e.g., Graham et al., 2009; Landry, 2010; Jang & Tsai, 2012). However, most of these research studies were confronted with issues such as: lack of checking validity of the related scale (e.g., Archambault & Crippen, 2009; Landry, 2010) or loss of some components of TPACK in the developed scale (e.g., Lee & Tsai, 2010). In addition, the studies indicated that in-service teachers needed more professional development courses to leverage their technology integration although they had enough experiences about how to teach their contents (Graham et al., 2009; Alshehri, 2012).

Research Studies related to Pre-service Teachers' TPACK. The TPACK literature presents a larger focus on pre-service teachers' TPACK as compared with research addressing in-service teachers. Pre-service research studies have addressed the development of the instruments for measuring teachers' TPACK (e.g., Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009; Sahin, 2011), the effects of technology-based method courses (e.g., Ozgun-Koca, Meagher, & Edwards, 2010; Haciomeroglu, Bu, Schoen, & Hohenwarter, 2011), and student teaching experiences (e.g., Meagher, Ozgun-Koca, & Edwards, 2011) on the development of teachers' TPACK.

Several studies aimed to develop a survey to measure pre-service teachers' TPACK. For example, Schmidt et al. (2009) developed a survey instrument specifically to measure pre-service elementary and early childhood teachers' TPACK. As these teachers are mainly generalists, the survey's content areas addressed mathematics, literacy, science, and social studies rather than focusing one content area. The survey consisting of 75 items was administered to 124 pre-service teachers. After conducting explanatory factor analysis, the researchers deleted some items that were not located in the related factor or subscale and that seemed as if they belonged to other subscales. In addition, they determined which items reduced the reliability for each constructs through the calculation of the alpha coefficients. In all, they deleted 28 problematic survey items in the survey. Finally, Schmidt et al. (2009) obtained a reliable and valid TPACK survey instrument of 47 items, in which the reliability coefficients for seven constructs were measured between .75 and .92.

Koh, Chai, and Tsai (2010) adapted the TPACK survey developed by Schmidt et al. (2009) to investigate pre-service teachers' TPACK in Singapore. The researchers changed the survey items related to mathematics, social studies, science, and literacy in CK, TCK, PCK, and TPACK subscales of the TPACK survey into a more general form.

For example, the item “I have sufficient knowledge about Mathematics” was altered to “I have sufficient knowledge about my curriculum subject”. The survey was administered to 1185 pre-service teachers. The 1185 teachers consisted of 809 female (68.3%) and 376 male (31.7%), and 545 elementary and 640 secondary pre-service teachers. After conducting an explanatory factor analysis, the researchers found the survey items fell into five different constructs instead of the expected seven. The survey items related to TCK, TPK and TPACK were grouped into one factor, which was renamed Knowledge of Teaching with Technology (KTT). In a similar way, PK and PCK composed another factor, Knowledge of Pedagogy (KP). Two items in TK comprised another factor that is assessed as teachers’ reflection regarding technology integration, Knowledge from Critical Reflection (KCR). The analysis resulted in these five constructs of TK, CK, KTT, KP, and KCR. The reliability coefficients for these constructs ranged between .83 and .96.

Zelkowski and his colleagues (Zelkowski, Gleason, Cox, & Bismarck, 2013) were faced with similar results as Koh et al. (2010) in terms of the “disappearance” of some of the seven subscales of TPACK in their development of a self-efficacy TPACK survey instrument for pre-service secondary mathematics teachers. Zelkowski and his colleagues also began their work using the survey developed by Schmidt et al. (2009). They deleted the items related to science, literacy and social studies; and wrote 22 new mathematics specific items to fill the gaps within the seven knowledge domain constructs. Thus, they initially administered 62 survey items addressing all seven TPACK domains. After conducting statistical analysis including explanatory factor analysis and confirmatory factor analysis, they presented a survey of 22 items as reliable and valid for TK, CK, PK, and TPACK.

Other researchers have taken an interest in the development of TPACK within methods courses and field experiences designed to integrate technology into teaching with subject matter. For example, Niess (2005) designed a course to investigate pre-service mathematics and science major teachers' development of TPACK. This course included the creation of lesson plans with technology and an associated student teaching experience for teaching subject matter with technology. She conducted five case studies; and concluded that pre-service teachers' perspectives related to integration of technology and the nature of the discipline have important effects on the development of TPACK, such as recognizing of how technology can support students' mathematical understanding, thinking and learning in order to discover mathematical relationships by providing dynamic environments them.

Similarly, Ozgun-Koca et al. (2010) examined the development of pre-service secondary mathematics teachers' TPACK during a mathematics teaching methods course focused on PSTs' design and implementation of technology-based teaching materials in their field placements. They used a variety of data collection sources including pre-and post surveys, open-ended questions, the write-ups for the five secondary-level mathematics activities, and field experience reports. The qualitative data were analyzed in terms of TPACK framework (Mishra & Koehler, 2006). The researchers created the codes for determining the possible relationships among TK, CK, and PCK. For example, when a participants talked about what a particular technology means for a specific content, Ozgun-Koca and her colleagues (2010) were coded this as “how technological knowledge influence content knowledge” (p. 13). In addition, the researchers found that not only participant’s TK and PK progressed but the interaction between them, TPK, was also enhanced while they were continuing to develop the activities and the lesson plans throughout the methods course. Ozgun-Koca et al. (2010) also stated that an interesting identity shift emerged, in which the participants’ perspectives changed from learning mathematics with technology to how to teach mathematics with technology through the development of their TPK, TCK, and TPACK. In other words, their identity changed from being a mathematics learner to being a mathematics teacher. The researchers also concluded the participants began to view technology as a tool for developing mathematical concepts instead of as a reinforcement tool.

Haciomeroglu et al. (2011) conducted a research study to explore the growth of pre-service secondary mathematics teachers’ TPACK while designing and implementing lessons with dynamic mathematics software, specifically GeoGebra. They observed that the process of creating GeoGebra worksheets and presenting lessons utilizing it in a collaborative environment contributed to the development of pre-service teachers’ pedagogical, content, technological knowledge, and TPACK. The researchers also stated pre-service teachers developed student-centered pedagogical understandings and began to implement dynamic activities, such as exploring the relationship of mathematical concepts, rather than static activities, such as measuring and drawing of figures.

Ozmantar, Akkoc, Bilgolbali, Demir, and Ergene (2010) also examined pre-service mathematics teachers’ development regarding the use of multiple representations to teach derivative content in technology-based classrooms. For this purpose, they designed two method courses by using the five components of TPACK framework, which are PK, TCK, TPK, PCK, and TPACK. The results revealed the courses could help pre-service teachers develop their knowledge of multiple representations, and prepared them to integrate technology effectively into their mathematics teaching.

Similar to the above studies, Holmes (2009) investigated the lesson activities designed by 13 pre-service secondary mathematics teachers during a method course that highlighted use of interactive white boards (IWB) in teaching mathematics. Holmes (2009) analyzed pre-service teachers' perceptions related to the pedagogical benefits of their IWB lesson activities with respect to the TPACK framework. The results demonstrated pre-service teachers effectively integrated IWB within their lesson activities, which resulted in the development their TPACK. In addition, pre-service teachers identified the primary potential of technology for teaching mathematics as its ability to provide multiple representation and virtual manipulatives, which can contribute to development of students' conceptual understanding.

Another research study conducted by Lee and Hollebrands (2008) developed a module compromising instructional materials and an accompanying video case, which was designed to prepare pre-service teachers for teaching data analysis and probability topics with technology. Lee and Hollebrands (2008) also suggested the module would contribute to the development of pre-service teachers' TPACK. In addition, they asserted pre-service teachers obtained a more detailed picture about what knowledge they would need to teach mathematics by using appropriate technologies. The researchers created the video case in the module to provide pre-service teachers with experiences related to students' learning and thinking with technology. Through the video case, pre-service teachers were provided with an opportunity to analyze students' work while they were engaging with technology. The researchers also stated the video case played an important role for developing pre-service mathematics teachers' TPACK reasoning, such as thinking about how technological representations may support students' mathematical learning and thinking.

In the light of the research studies related to pre-service teachers' TPACK, it can be seen that there were very small number of research studies conducted to develop a survey instrument specialized on pre-service secondary mathematics teachers' perceptions regarding TPACK. Most of researches have focused on develop a survey instrument for pre-service teachers coming from different teaching areas; and therefore, they used general statements for content instead of addressing specific content areas (e.g., Koh, Chai, & Tsai, 2010; Sahin, 2011). In addition, numerous of qualitative research studies that engaged in improvement of pre-service mathematics teachers' TPACK highlighted the effects of the method courses and student teaching experiences oriented technology integration on pre-service teachers' understanding and attitudes (Lee & Hollebrands, 2008; Holmes, 2009; Ozgun-Koca, 2010; Haciomeroglu et al., 2011). Therefore, the adaption the TPACK survey instrument specialized on secondary mathematics (Zelkowski et al., 2013) in Turkish language may help course developer and teacher educators in Turkey to understand influences of the existing courses on development of pre-service secondary mathematics teachers' TPACK.

TPACK Research Studies in Turkey. As my study included the adaptation and validation of a current TPACK instrument for the Turkish language and cultural context, it is relevant to review similar work done in this area. This summary of the literature will outline previous studies conducted in Turkey and allow me to situate the need for my current work. In this section, I also present research conducted in Turkey, which utilized such instruments to measure TPACK in Turkish teachers.

Several research studies have addressed the adaptation of various TPACK surveys for the Turkish language. For instance, Timur and Tasar (2011) adapted an instrument designed to measure TPACK confidence of in-service science teachers (Graham et al., 2009) for the Turkish language and culture. The original instrument included four knowledge domains: TK, TCK, TPK, and TPACK. The survey instrument was translated into Turkish; and was administered to 393 in-service science and technology teachers. The instrument was assessed for reliability and validity through exploratory and confirmatory factor analysis. The result of the study demonstrated the translated TPACK confidence survey was reliable and valid; and therefore, it could be utilized to measure TPACK confidence for teachers in Turkey. Kaya and Dag (2013) adapted Schmidt et al.'s (2009) TPACK survey into Turkish language and context. 352 pre-service elementary teachers (246 female and 106 male) participated in the validity and reliability process for the study. After exploratory factor analysis, Kaya and Dag (2013) concluded that the factor structures of the Turkish version were compatible with the original survey. In addition, the results of confirmatory factor analysis indicated the TPACK survey is proper and fits within the context of Turkish culture. Karadeniz and Vatanartiran (2013) adapted the TPACK survey developed by Koh et al. (2010) for Turkish teachers as well. The survey was administered to 285 (177 female and 108 male) in-service teachers from a variety of subject areas. The original survey included five knowledge domains, TK, CK, KTT, KP, and KCR. The reliability coefficients were found as .74, .87, .92, .89, and .84 respectively. Consequently, Karadeniz and Vatanartiran (2013) stated that the survey is valid and reliable for measuring Turkish in-service secondary teachers' TPACK.

Sahin (2011) sought to develop and create an original TPACK survey instrument in Turkish. The survey instrument was administered to 348 pre-service teachers to check its validity and reliability through explanatory factor analysis. After exploratory factor analysis, Sahin (2011) found that 47 survey items fell into seven subscales comprising the TPACK framework (TK, CK, PK, TCK, TPK, PCK, and TPACK). The results also confirmed the survey to be a reliable and valid measure for each subscale. Sahin's TPACK survey does not address a specific content area and consists of many survey items (15 items) related to technological knowledge, such as "using projector" and "using digital camera" (p. 105, 2011).

Since Sahin's target population was pre-service teachers coming from different departments such as Computer and Instructional technology, elementary, and English, he used a general statement for the survey items related to content. This survey can be useful for exploring departmental differences among Turkish pre-service teachers however, CK, TPK, PCK, TCK, and TPACK are highly specific to content. In other words, the knowledge needs for integrating technology into mathematics teaching may be different from the knowledge needed for integrating technology into English teaching. For this reason, there is a need to develop or adapt a survey instrument designed for Turkish pre-service secondary mathematics teachers' TPACK.

Canbolat (2011) investigated the relationships between Turkish pre-service elementary mathematics teachers' TPACK and their thinking styles. This study included 288 (204 female and 71 male) pre-service both senior and junior mathematics teachers. Two instruments were used to collect data in this study, the TPACK survey developed by Sahin (2011) and the thinking styles inventory compromising of 13 distinct thinking styles (Sternberg & Wagner, 1992). According to his findings, Canbolat (2011) concluded that judicial, liberal, and hierarchic thinking styles have higher correlations with the seven components of TPACK than the remaining 10 thinking styles.

Cetin-Berber and Erdem (2015) examined the contributions of TK, PK, and CK on the development of the TPACK domain for Turkish pre-service elementary teachers in terms of the TPACK survey instrument (Schmidt et al., 2009). After conducting regression analysis, they concluded both CK and PK are significant predictors contributing to pre-service teachers' enhancement of TPACK, but TK was not.

Tokmak, Incikabi, and Ozgelen (2013) analyzed the effects of an *Introduction to Computers* course on pre-service teachers' TPACK domains. The researchers used the TPACK confidence instrument, which was developed by Graham et al. (2009) for in-service science teachers, and was adapted by Timur and Tasar (2011) for the Turkish language and culture. The data were collected from 31 pre-service elementary mathematics teachers, 32 pre-service science teachers, and 38 pre-service literacy teachers studying in a large-public university in Turkey. The findings indicated that post-test results for pre-service mathematics teachers' TPACK self efficacy were an improvement over the pre-test results for all four knowledge domains. They obtained similar results for pre-service science and literacy teachers. In other words, the *Introduction to Computers* course had contributed to the development of all TPACK domains for all pre-service teachers, regardless of content area. Similarly, Horzum (2013) investigated the effects of an *Instructional Technology and Material Development* course on pre-service teachers' enhancements of TPACK domains. The researchers discovered that as a result of experiences within the course, pre-service teachers demonstrated statistically significant increases in the knowledge domains of TK, TCK, TPK, and TPACK.

In addition, research studies related to pre-service teachers' attitudes, perspectives, and self-efficacy towards use of technology in teaching mathematics have also been conducted in Turkey. Ozgun-Koca (2009) explored Turkish pre-service secondary mathematics teachers' views about the use of graphic handheld technologies to deliver mathematics content. After conducting group interviews and a survey including open-ended questions, the researcher concluded teacher candidates perceived the role of graphic calculators as visualization, transformational, computational, and discovery tools. The findings also demonstrated use of graphic calculators have some advantages for students' learning of mathematics such as using ideas in concert, visualizing abstract mathematical concepts, observing a situation through multiple representations, developing higher-order thinking skills, and making mathematics more attractive by motivating students. However, teacher candidates also raised concerns related to students' excessive dependency of calculators as well as classroom management problems. Ipek and her colleagues (İpek, Karasu, Kayahan, Çukurbaşi, & Yeşil, 2014) conducted a similar study; and concluded pre-service mathematics teachers believe use of technology in mathematics education provides visual environments for students, motivates them towards learning, and are useful in saving time while delivering the content.

Pamuk and Peker (2009) analyzed Turkish pre-service science and mathematics teachers' computer self-efficacy and computer attitude. They utilized two survey instruments, the Computer self-efficacy scale (Murpy, Coover, & Owen 1989) and Computer attitude scale (Loyd & Gressard, 1984). The computer attitude instrument was compromised of four subscales: computer anxiety, computer liking, computer confidence, and computer usefulness. The results demonstrated senior pre-service teachers' computer self-efficacy, computer confidence, and computer attitude was higher than those of freshman pre-service teachers. There were no significant differences found within the computer anxiety and computer usefulness subscales. In addition, the findings revealed pre-service teachers who have a computer have better computer self-efficacy, computer confidence, computer attitude, and less computer anxiety than those who do not. Dogan (2012) also studied Turkish pre-service elementary mathematics teachers' points of view regarding the use of technology in mathematics education. The data were collected in terms of one open-ended question, which was "What do you think about using computers in mathematics education? Please, can you explain it in the light of your own experiences?" (Dogan, 2012, p. 333). The researcher concluded that pre-service elementary mathematics teachers tend to have positive perspectives towards technology use. In addition, they believe teaching mathematics by means of technology can help students to learn mathematics more effectively. However, they do not have high confidence in their ability or knowledge for teaching mathematics with technology.

Ipek et al. (2014) investigated the change of mathematics teacher candidates' attitudes and qualifications regarding the application of technological pedagogical content knowledge (TPACK) during a GeoGebra training course. They posited the 9 – hour GeoGebra course changed the teachers candidate' attitudes in a positive manner regarding the application of techno-pedagogical knowledge in their teaching. In addition, the results demonstrated participants who had taken additional computer training displayed a more positive attitude regarding teaching mathematics with technology than those who had not. Similarly, mathematics teacher candidates who displayed more interest in computer use were found to have a more positive attitude about teaching mathematics with technology.

In summary, the research studies conducted in Turkey (Ozgun-Koca, 2009; Canbolat, 2011; Dogan, 2012; Ipek et al., 2014) showed that the roles attributed to technology by pre-service mathematics teachers, their thinking styles, their beliefs about use of technology, and their attitudes towards use of technology in mathematics education may have significant effects on their decisions related to use of technology. Dogan (2012) found that even if pre-service teachers have positive attitude, they feel insecure about use of technology in teaching mathematics. On the other hand, Ipek et al.

(2014) found that pre-service mathematics teachers showed positive attitude towards use of technology in their teaching through a designed course to develop their understanding of TPACK. For this reason, my research study examines the relationship between pre-service teachers' attitudes related to use of technology in mathematics teaching and their perceptions regarding TPACK.

TPACK Demographic Studies. Some TPACK studies conducted with Turkish teachers have investigated the relationship between TPACK and various demographic factors such as, in-service or pre-service teachers, gender, year of study, teaching experience, or area of specialization. In one such example, Erdogan and Sahin (2010) investigated the differences among pre-service mathematics teachers' TPACK domains according to their gender and departmental affiliation (elementary or secondary). They also examined the relationship between pre-service mathematics teachers' TPACK and their academic achievement obtained by means of the GPA scores. The pre-service teachers' perception in TPACK instrument developed by Sahin (2011) was used in this study. The findings showed elementary pre-service mathematics teachers perceived themselves as more sufficiently prepared than secondary pre-service mathematics teachers for all seven TPACK domains. In addition, they presented statistically significant differences between male and female students' perceived TPACK domains, demonstrating male students felt themselves more adequate than female students, in all domains except for pedagogical knowledge (PK) and content knowledge (CK). Finally, their results indicated a positive relationship between the TPACK subscale and pre-service teachers' academic achievements.

Koh et al. (2010), Canbolat (2011), and Cetin-Berber and Erdem (2015) all obtained similar results as Erdogan and Sahin (2010) in respect to male pre-service teachers' TPACK domains. Koh et al. (2010) presented significant differences between gender in terms of TK, CK, and Knowledge of teaching with technology (KTT) for pre-service teachers in Singapore as a result of implementing their TPACK survey instrument. The male pre-service teachers perceived themselves to be more competent than their female counterparts; with the TK domain exhibiting an especially large effect size. Canbolat (2011) also concluded there were significant differences in pre-service elementary mathematics teachers' among some TPACK domains according to gender, year of study, and computer ownership. The researcher presented three main findings: 1) male pre-service teachers' level of perception in TK, TCK, TPK and TPACK were higher than the female participants; 2) senior teacher candidates demonstrated greater levels of PK, CK, TPK, and TPACK than juniors; and 3), pre-service teachers who had their own computer demonstrated more competency than those who did not in terms of levels of TK, TPK, TCK, and TPACK.

Cetin-Berber and Erdem (2015) conducted a TPACK research study with 491 (341 female and 150 male) pre-service elementary teachers in Turkey. Their results showed there was no significant difference among the other TPACK constructs while male pre-service teachers' TK was higher than female teacher candidates. In respect to year of study, their results indicated senior pre-service teachers had higher perception of PK than those of sophomores, and junior pre-service teachers had higher perception of TCK than their sophomore colleagues. In addition, they concluded field experiences have important effects on pre-service elementary teachers' perceptions of TPACK, demonstrating teacher candidates who have had field experiences displayed higher CK, PK, PCK, TCK, and TPACK than those who had not.

Altun (2013), Jang et al. (2012), and Lin et al. (2013) however, obtained different results related to teachers' perceptions of TPACK domains according to gender. Altun (2013) explored Turkish in-service classroom teachers' TPACK as related to demographic variables. Unlike the previous studies mentioned above, Altun (2013) found female in-service teachers had significantly higher scores associated with CK-social studies, CK-literacy, PK, and TCK than their male counterparts. In addition, Jang et al. (2012) used the enhanced interactive whiteboards (IWBs)-based TPACK instrument for in-service elementary teachers with 818 elementary in-service teachers in Taiwan. This study found no significant differences according to gender in the four components of IWB-TPACK (CK, TK, PCKCx, and TPCKCx). Lin et al. (2013) examined 222 pre-and in-service science teachers' perceptions of TPACK in Singapore. The results of this study found female science teachers perceived more self-confidence related to PK than male colleagues while they had lower self-confidence in regard to TK than males.

Given the relevant literature, it can be seen that demographics differences among pre-service teachers can cause the diversities on their perceptions related to TPACK domains. Because of this, my research study also examined the effects of demographic differences among pre-service secondary mathematics teachers on their perceived TPACK and their attitudes.

Summary of the Literature Review

Mishra and Koehler (2006) developed their TPACK framework by including Technological Knowledge construct to Shulman's PCK (1986) framework. TPACK framework explained what kind of knowledge teachers need for effective technology use while they are teaching their subject area. According to this framework, there are three main knowledge domains, TK, CK, and PK. The other four knowledge domains come to the existence through the interactions among these main knowledge domains; and TPACK domain locates in the center of this framework. However, CK in this framework identified in general terms and was not associated with any teaching subject area, such as mathematics, chemistry, and physics. Therefore, CK in this study was associated with secondary mathematics content by considering this study's main goal. And then, the other knowledge domains in the TPACK framework redefined by considering their interactions with secondary mathematics content, Ball and her colleagues' MKT framework (2008), and Zelkowski and his colleagues' definition related to TK, TCK, and TPACK domains with respect to secondary mathematics (2013).

The literature review showed that TPACK research studies substantially focused on four different research interests including situations that were not clarified by TPACK framework. First of all, researchers interested in developing a valid and reliable survey instrument to assess teachers' perceptions related to TPACK domains due to fact that their TPACK knowledge could not be directly measured (e.g., Archambault & Crippen, 2006; Schmidt et al., 2009; Sahin, 2011). However, most of these research studies faced some issues related to small sample size (e.g., Graham et al., 2009; Landry, 2010), which resulted in not checking construct validity of these TPACK survey instruments. The samples used in some research studies also did not represent the populations (e.g., Karadeniz & Vatanartiran, 2013). Further, the research studies in Turkey intended to adapt a TPACK survey instrument in Turkish language and context did not conduct measurement invariance analysis to investigate if the factor structure of TPACK scale was equivalent to throughout Turkey and the county that the survey was developed (e.g., Timur & Tasar, 2011; Kaya & Dag, 2013). During the these adaptation processes, the researchers also did not check content validity of the relevant TPACK survey instruments in terms of expert reviews, as well as did not conduct cognitive interviews to check translation of the instrument by considering pre-service teachers' points of view. In addition, the literature review indicated the research studies focusing on development a TPACK survey instrument related to secondary mathematics content knowledge for pre-service or in-service teachers were minimal, especially in Turkey. Therefore, the methodology of my research was developed to cover the aforementioned gaps in the literature, so that it could reach enough sample size to represent the population, conduct measurement invariance analysis to check factor structure of the TPACK survey instrument across the Turkey and USA samples; and conduct EFA, CFA, and reliability analysis for providing validity and internal consistency of the survey instrument. In addition, my research study followed a systematic approach to translate the TPACK survey instrument in Turkish and check its content validity by performing forward translation, backwards translation, expert reviews, and cognitive interviews processes.

In addition, researchers were interested in factors, which could affect pre-service teachers' TPACK development. The findings of these qualitative research studies displayed that technology-based method courses and student teaching experience developed pre-service teachers' TPACK (e.g., Holmes, 2009; Ozgun-Koca, Meagher, & Edwards, 2010; Haciomeroglu et al., 2011). However, the findings of these studies substantially based on the observations and interviews without conducting statistical analysis by utilizing a TPACK survey instrument. Therefore, the literature review indicated there was in need of a TPACK survey instrument for pre-service secondary mathematics teachers to assess the efficiency of technology-based method courses on pre-service teachers' TPACK development.

Another research interest was associated with the investigation of the relationships among teachers' perceptions regarding TPACK components (e.g., Archambault & Crippen, 2009). However, the literature review indicated these research studies examined the relationships among TPACK components without taking into account the effects of demographic information of pre-service teachers, such as departmental affiliation, gender, and year of enrollment, on these relationships. Because of that, my research study addressed the relationship among pre-service secondary mathematics teachers' perceptions about TPACK components by considering their gender and year of enrollment to fill in the gaps in the literature and extend the prior knowledge.

Lastly, some researchers investigated the impacts of pre-service teachers' demographic information (departmental affiliation, gender, and year of enrollment) on their perceptions about TPACK components. Some of these research studies conducted in Turkey found pre-service teachers' perceptions on some of TPACK components statistically differentiated with respect to departmental affiliation or year of enrollment (e.g., Erdogan & Sahin, 2010; Canbolat, 2011; Cetin-Berber & Erdem, 2015). On the other hand, the findings of some research studies supported male teachers' perception level of some TPACK components were statistically better than female colleagues while the others supported female teachers had better perceptions on some of TPACK components than their male colleagues (e.g., Erdogan & Sahin, 2010; Canbolat, 2011; Altun, 2013). However, the literature review demonstrated that these research studies paid attention to examining if the main effects with respect to departmental affiliation, gender and year of enrollment independent variables were statistically significant regardless of considering the impacts of interactions among them. Considering the relevant literature, it can be said that teachers' demographic differences may influence their perceptions related to TPACK components. Therefore, I was interested in investigating the impacts of demographic information on Turkish pre-service secondary mathematics teachers' perceptions about TPACK components in this study by taking into account the main and interaction effects.

CHAPTER THREE

METHODOLOGY

Introduction

This chapter provides an overview of the research questions, research design, participant selection, instruments, data collection procedures, and data analysis used in this study.

The main aim of this study was to examine Turkish pre-service secondary mathematics teachers' perceptions of their technological pedagogical content knowledge (TPACK) within the six TPACK domains. To accomplish this goal, I first translated and adapted the TPACK survey instrument developed by Zelkowski and his colleagues (2013), hereafter referred to as "the TPACK survey", for use in Turkey. As described in Chapter 2, the TPACK survey consisted of seven sections, and was designed to coincide with TPACK framework (Mishra & Koehler, 2006). A second purpose of this study was to explore possible effects of demographic differences on pre-service secondary mathematics teachers' perceived TPACK domains as well as their attitudes towards use of technology into teaching mathematics. In these respects, the following research questions were addressed:

1) What are Turkish pre-service secondary mathematics teachers' perceived technological pedagogical content knowledge as it specifically pertains to secondary mathematics?

2) What are the relationships among the components of TPACK pertaining to secondary mathematics as measured by Pearson correlations?
3) Is there a significant relationship between Turkish pre-service secondary mathematics teachers' attitudes towards use of technology and their perceptions of the TPACK domains?
4) Is there a significant mean difference in Turkish pre-service secondary mathematics teachers' perceptions of TPACK domains with respect to the following factors:
    a. Gender
    b. Year of enrollment in the program of secondary mathematics education
5) Is there a significant mean difference in Turkish pre-service secondary mathematics teachers' attitudes towards use of technology with respect to the following factors:
    a. Gender
    b. Year of enrollment in the program of secondary mathematics education

Research Design

The structure of my research study includes components of survey, correlational, and causal-comparative research designs. In this section, I outline each of the three components involved within my overall design.

While seeking to the answers above the research questions, this study employed a survey research design, as survey research methodology facilitates obtaining information about a population by asking questions related to its characteristics, such as abilities, beliefs, attitudes, and knowledge (Fraenkel & Wallen, 2006). During the fall semester of 2016, I administered two survey instruments to pre-service secondary mathematics teachers in Turkey. One addressed their perceptions of TPACK domains; the other addressed their attitudes towards the use of technology in mathematics teaching. In addition, my design was cross-sectional (Fraenkel & Wallen, 2006), as I utilized the survey instruments to obtain information about my sample with different characteristics at one specific point in time. Therefore, the approach of this study would be classified as cross-sectional survey research.

This study explored the existing relationships among teacher candidates' perceptions of TPACK components; and the relationship between their attitudes related to delivering mathematics subjects with technology and their perceptions of TPACK constructs. According to Fraenkel and Wallen (2006), a research study is defined as a correlation research design if it investigates the relationships or associations between two or more variables without manipulating dependent variables through experiments or treatments. For this reason, this research study is also considered correlational research.

However, since another purpose of this study is to examine the effects of demographics variables on pre-service secondary mathematics teachers' perceived TPACK and their attitudes towards use of technology in terms of research questions 4 and 5, the study also includes a causal-comparative research component. In other words, this study sought to discover whether the groups formed through the categorical independent variables differentiated on the dependent variables (Gall et al., 2006, p. 306).

Selection of Participants and Sampling Procedures

The target population of this study was pre-service teachers who were enrolled in secondary mathematics education departments of education faculties in Turkey. There are 16 schools of education faculties in Turkey that provide training for secondary mathematics education at the undergraduate level, which includes 14 public and 2 foundation universities. These universities are situated within 11 of 81 provinces and 6 of 7 different geographical regions in Turkey. In the Turkish university, there are 5 academic levels, or grades, that correspond with the number of years of attendance. According to the Student Selection and Placement Center in Turkey, there were a total of 1,322 pre-service secondary mathematics teachers pursuing their education across these five grades enrolled at all universities within the academic year of 2016-2017. The population I drew from in this study consisted of approximately 273 1st grade, 273 2nd grade, 273 3rd grade, and 503 5th grade pre-service secondary mathematics teachers. I expected a very small number of 4th grade students to be available as participants, as pre-service students were not accepted into secondary education programs during the academic year of 2013-2014 due to the decisions of the Council of Higher Education. I did not include any 4th grade students in my population, as I posited any existing 4th grade students would likely be pre-service teachers who were retaking a failed course.

My research study contained two samples, one for the pilot study and one for the main study. First, I selected a representative sample of the available population for a pilot study in order to measure reliability and validity of my survey instruments. The sample for the pilot study utilized cluster sampling to select secondary mathematics education students enrolled at three universities selected from within the 16 Turkish universities. Cohen et al. (2011) suggested using cluster sampling, in which a specific number of groups or schools instead of students are chosen, when the population is large and widespread, or if random selection of participants is impractical. To select the three universities for the pilot sample, I first ranked the 16 universities using information on each university's academic performance (URAP, 2015) in the education field, as determined by Middle East Technical University in Turkey. The 16 universities were separated into two equal groups, one group designated as high academic performance group and one group designated as low academic performance group. I then randomly selected two universities (Karadeniz Technical and Balikesir) from within the high academic performance group, as well as one university (Ataturk) from within the low academic performance group to create the pilot study sample. Finally, since a random selection of pre-service secondary mathematics teachers from within these three universities was impractical, I employed a convenience-sampling method to include all secondary education mathematics students. According to Cohen et al. (2011), convenience sampling can be used to select participants who will be accessible and available at one specific point in time. Therefore, Turkish pre-service secondary mathematics teachers within each academic level in these three universities were available to participate in the pilot study as volunteers. The participants for the main study were also determined using a convenience-sampling method from within the remaining 13 universities. Convenience-sampling method for the main study is consisted of two phases. First, I determined which of the remaining universities would agree to participate in the main study. Second, it was utilized in determining which Turkish pre-service secondary mathematics teachers would volunteer to participate in the main study.

Instruments of the Research Study

One of the main aims of this study was to examine Turkish pre-service secondary mathematics teachers' self-assessments regarding their perceptions of technology, pedagogy, secondary mathematics content, and all possible interactions among them in order to effectively integrate technology into teaching mathematics. Therefore, the survey, which is entitled as "*TPACK Instrument for Secondary Mathematics Pre-service Teachers"*, was used to explore and measure pre- service teachers' perceptions about TPACK domains. The original TPACK survey, as developed by Zelkowski and his colleagues (2013), included two parts. The first part of the TPACK survey contained questions to obtain information concerning participants' backgrounds related to age, gender, ethnicity, field experience, and year of enrollment. The question related to ethnicity was removed for the purposes of this study. The survey items in the second part of the TPACK survey instrument consisted of seven subscales in parallel with the knowledge domains associated with the TPACK framework proposed by Mishra and Koehler (2006): technological knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), technological content knowledge (TCK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK). The initial TPACK survey contained a total of 62 statements aimed to measure pre-service secondary mathematics teachers' perceived TPACK domains. The initial TPACK survey instrument used a 5-point Likert scale, ranging from 'strongly disagree' to 'strongly agree', and was administered to more than 300 pre-service secondary mathematics teachers in the USA. Following exploratory and confirmatory factor analysis, Zelkowski et al. (2013) determined the TPACK survey instrument to be valid and reliable for TK, CK, PK and TPACK subscales, but not for the TPK, TCK and PCK subscales. Additionally, the creators measured the internal consistency reliability of the four subscales and determined the coefficients alpha values as .8889 for TK subscale, .8854 for CK subscale, .8768 for PK subscale, and .8966 for TPACK subscale. From these results, they constructed their final version of TPACK survey instrument with 22 items.

In this study, I utilized the first version of TPACK survey instrument, which included the same 62 items (see Table 1). Although the eliminated survey items did not produce measurable factors for the PCK, TCK and TPK subscales for the U.S. sample, I posited the Turkish sample might produce different results. I began by examining the 22 items in the final version of Zelkowski and his colleagues' TPACK survey to determine if the factor structure of the Turkish TPACK survey was different by means of measurement invariance testing. Measurement invariance analysis was conducted as a separate study with the assistance of my committee member, Dr. Jenny Farmer and is not included in the scope of this study. It was performed after collecting the sample data of the pilot study in Turkey and comparing it to the USA sample data in Zelkowski and his colleagues' research study (Zelkowski et al., 2013). The findings of the measurement invariance testing indicated the factor structure of the TPACK survey with 22 items was not equivalent across Turkey and USA samples. Therefore, I incorporated the removed items (40 items) from the first version of TPACK survey instrument into the adaptation process in order to conduct further statistical analysis such as exploratory factor analysis (EFA); and therefore, to find the underlying factor structure of the Turkish version of TPACK. For this reason, in the pilot study, I utilized all 62 items in the first version of the TPACK survey instead of only the 22 items in final version of Zelkowski and his colleagues' TPACK survey.

Table 3.1 *The Subscales of TPACK Survey Instrument for Pre-service Secondary Mathematics Teachers*

Subscales	Sample Item	Number of Items	Items
Technological Knowledge (TK)	I keep up with important new technologies*.	8	Item 1 to 8
Content Knowledge (CK)	I have a deep and wide understanding of algebra*.	8	Item 9 to 16
Pedagogical Knowledge (PK)	I can adapt my teaching style to different learners*.	8	Item 17 to 24

Table 3.1 (Continued)

Pedagogical Content Knowledge (PCK)	I know different strategies/approaches for teaching algebra concepts.	7	Item 25 to 31
Technological Content Knowledge (TCK)	I know about technologies that I can use for understanding and doing algebra.	7	Item 32 to 38
Technological Pedagogical Knowledge (TPK)	I can choose technologies that enhance the teaching of a lesson.	12	Item 39 to 50
Technological Pedagogical Content Knowledge (TPACK)	I can teach lessons that appropriately combine mathematics, technologies, and teaching approaches*.	12	Item 51 to 62

Note. * represents the sample items for both initial and final version of TPACK survey

I also used another survey instrument to examine Turkish pre-service secondary mathematics teachers' attitudes related to computer-aided education and its relationships with the components of the TPACK framework. This survey instrument was developed by Arslan (2006) and was entitled, "the Attitude Scale for Computer –Aided Education" (see Appendix C). This attitude scale was chosen for this study, as its original language is Turkish and its reliability and construct validity was determined through research studies conducted in Turkey. This instrument contains only one factor with 20 items to measure teacher candidates' attitudes towards computer-aided education. The Cronbach's alpha reliability coefficient for the Attitude scale was found as .93. These 20 items consist of 10 positive and 10 negative items with a 5-point Likert scale (strongly disagree, disagree, neutral, agree and strongly agree). After reversing the score of negative-worded items such as “Computer technologies cannot be used efficiently in education” in the attitude scale, the highest score that might be obtained from this attitude scale was calculated as 100 points while the lowest score is 20 points.

The Adaptation Process of the TPACK Survey Instrument

Since the original language of the TPACK survey instrument is English, it had to be translated and adapted for the Turkish language and context. My procedures for doing so are described in detail in the following sections.

Translation and Back Translation of TPACK Survey. I followed the procedures suggested by Guillemin and her colleagues (1993), and McGorry (2000) in order to adapt the TPACK survey into the Turkish language. To begin, I completed a forward translation of the items in the TPACK survey from English into Turkish. Then, I requested two faculty members working at the department of English Language and Literature in a Turkish public university to review the translated TPACK survey. The experts’ feedbacks pointed out several examples of problematic word selections that were not compatible with the daily spoken Turkish language. As a result of these recommendations, some changes were made for the translated survey and a draft of Turkish version of TPACK survey was obtained (See Appendix A). Next, another faculty member working at the department of translation and interpretation at school of foreign language in the same public university completed a backward translation of the Turkish version of TPACK survey to English without utilizing the original English version of the TPACK survey (see Appendix B). As a result, I obtained two English versions of the TPACK survey, the original TPACK survey and a backwards-translated Turkish version of TPACK into English. Finally, two native English speakers who have PhD degrees and work at Digital Media and Learning Department in a large-state university located in the Southeastern US compared and reviewed the two English versions of TPACK survey to determine any mistranslations, semantic discrepancies, or loss of meaning. In other words, the accuracy of the Turkish version of the TPACK scale was determined by comparing the original English TPACK scale with the backwards translation. In addition, I requested the two native English speakers to specify their confidence levels related to semantic equivalence among the two English version of TPACK in terms of a 5-point Likert scale ranging from very dissatisfied to very satisfied. Then, I coded the 5-point Likert scale with corresponding numerical values, respectively from 1 to 5, and calculated mean score for each survey item. A survey item was considered problematic if its mean score was lower than 4 (satisfied). Through this process, I identified CK16, PK22, TPK39, TPK42 and TPACK51 as survey items with potential problems in regards to semantic equivalence, mistranslation and/or loss of meaning. After the two native speakers explained their thoughts and comments concerning the changes needed in the relevant items in order to obtain the same meaning, the researcher and the backward translator discussed these items by considering the two English versions of the TPACK survey as well as the Turkish version. I made necessary corrections to the problematic items through consults with the backward translator.

Expert Reviews and Cognitive Interviews. Zelkowski and his colleagues (2013) established content validity of the original English version of TPACK survey. However, problems related to content validity may arise as a result of the translation of the survey into Turkish. In order to assess content validity and translation of the Turkish version of TPACK, I conducted expert reviews. In this context, two academic members who are experts in both secondary mathematics education and use of technology in mathematics education reviewed the Turkish version of TPACK scale and the original English TPACK scale. After the expert review was completed, I interviewed the content experts and asked them to verify the translated items represented the original items, and to identify if there were specific items, particular words or phrases which seemed to be problematic in the scale (see Appendix D). As a result of the experts' thoughts and concerns about survey items that could be problematic, I made necessary corrections utilizing their suggestions for making these items more clear and appropriate for pre-service mathematics teachers in Turkey.

I also employed cognitive interviewing to investigate the translation and general effectiveness of the Turkish version of TPACK survey with some participants of the pilot study. According to Beatty and Willis (2007), cognitive interviewing, which emanated at the beginning of the 1980s, is one of the most remarkable methods used to identify and correct problems related to survey questions. Cognitive interviewing is mostly used during the development and design process of a survey instrument, in which survey developers examines each item included on survey. Since the TPACK survey instrument was already developed, I focused on the instrument as a whole and the specific items that might be considered to be problematic as identified in the expert reviews. Cognitive interview questions were developed through feedback by the content experts' identification of potential problematic items as well as those identified in the expert review. I then invited 20 pre-service secondary mathematics teachers who had agreed to participate in the study and were enrolled a technology based-mathematics teaching course at either Karadeniz Technical University or Ataturk University to provide feedback on how well the translated instrument worked through use of a cognitive interview. The recruitment of the participants for the cognitive interviews was continued until saturation occurred at each university. In this way, I individually conducted the cognitive interviews with 10 participants. During the cognitive interviews, each of participants was asked to complete the survey instrument. Upon completion, I interviewed with each of the participants and audio recorded these sessions. After using the cognitive interviews to ensure my edits had corrected the problematic items, I obtained the initial Turkish version of TPACK survey instrument.

Pilot Study

A pilot study was carried out to measure the reliability and construct validity of the Turkish version of the TPACK survey instrument, and to examine the reliability of the Attitude scale. The sample for the pilot study consisted of 217 pre-service secondary mathematics teachers attending Karadeniz Technical, Balikesir and Ataturk universities. As stated previously, the original TPACK survey instrument was designed to evaluate pre-service secondary mathematics teachers' perceived TPACK knowledge, which includes seven dimensions (TK, CK, PK, PCK, TCK, TPK and TPACK) and has total of 62 items. However, utilizing the US sample, the TPACK instrument was determined to be valid and reliable for only four constructs of TPACK (TK, CK, PK and TPACK).

I administered the initial version of TPACK survey, which contained 62 items, to Turkish pre-service secondary mathematics teachers studying at these three universities. After obtaining the data from the Turkish sample for the pilot study based on the initial Turkish version of TPACK, only 22 items' data in the pilot sample corresponding to the items in final version of Zelkowski and his colleagues' TPACK survey was primarily used for measurement invariance analysis. Dr. Farmer and I then conducted measurement invariance testing as a separate study to examine if the factor structure for 22 items in the Turkish version of TPACK was equivalent to those in the final version of original TPACK. In addition, I conducted internal consistency reliability analysis for each subscales as well as the whole scale. As a result of the measurement invariance analysis, the factor structure was found to be different for the two cultures. Therefore, the initial Turkish version of TPACK survey was not finalized with 22 items located in four different constructs.

Consequently, I drew on the data including all 62 items in order to determine the underlying factor structure of Turkish version of TPACK. I conducted EFA with the entire 62-item instrument. Tabachnick and Fidell (2013) stated that one of the aims of EFA is to reduce a large set of observed variables to a smaller number of coherent factors or components by determining the patterns of the correlations among observed variables. Moreover, Pallant (2005) explained that reducing a large number of observed variables to a small number of factors would make further analysis, such multivariate of analysis of variance (MANOVA), more convenient and easier to interpret its results. Therefore, I conducted an EFA to determine how many factors or components of the TPACK framework exist in the Turkish TPACK scale. In addition, I used the EFA to examine the Turkish TPACK scale's construct validity and to determine what the Turkish TPACK instrument is really measuring. After identifying the possible factors or subscales in the Turkish TPACK scale, the items that are not measuring the germane subscale or that are loading to multiple subscales were identified through EFA. The items identified as threatening construct validity were removed from the Turkish TPACK scale.

While obtaining and approving the subscales or factors for the Turkish TPACK scale, reliability analysis was carried out concurrently to calculate the alpha coefficients or Cronbach's alpha values utilizing *the Statistical Package for Social Science* (SPSS) software. The reliability and internal consistency of the Turkish TPACK scale and its subscales were evaluated through Cronbach's alpha coefficients. Buyukozturk (2011) stated the calculation of the alpha coefficients as 0.7 or more is adequate to establish the reliability of a psychological test or survey (p. 171). George and Mallery (2003) also recommended the following rule of thumb in order to assess the alpha coefficients: "> 0.9 Excellent, > 0.8 Good, > 0.7 Acceptable, > 0.6 Questionable, > 0.5 Poor, < 0.5 Unacceptable." (p. 231). Taking this rule of thumb into consideration, I have tried to identify questionable items contributing to a reduction in the reliability of the related subscales. Where necessary, problematic items associated with the internal consistency of the Turkish TPACK scale were eliminated to increase reliability of the survey instrument.

I also conducted a reliability analysis for the Attitude scale in order to check its internal consistency.

Main Study

A main study was conducted to answer the research questions of this study and to check the factor structure of Turkish version of TPACK survey, which emerged by means of EFA. Nine of the remaining 13 universities agreed to participate in the main study. Therefore, the sample for the main study contained pre-service secondary mathematics teachers studying at these universities who volunteered to participate.

After collecting the sample data of the main study, confirmatory factor analysis (CFA) was initially conducted by using the main study data to examine the hypothesized factor structure of the Turkish version of TPACK, which was obtained through the EFA. Brown (2015) stated the intended use of CFA in the later phases of scale development is to verify the underlying structure based on prior empirical (EFA) and theoretical grounds. Following the CFA, I utilized the data obtained from the main study to re-examine the alpha reliability coefficients of the survey instruments. Through the CFA and reliability analysis, the final version of Turkish TPACK survey was determined. Hereafter this final version is referred to as “the Turkish TPACK survey”. Then, the data associated with the items in the Turkish TPACK survey and the data that are associated with the Attitude scale were used to answer the research questions by conducting descriptive and inferential statistical analysis.

Data Collection

The required permissions to carry out this study were obtained from both Institutional Review Board (IRB) of Clemson University, which is responsible for the protection of human subjects participated in research studies conducted under the supervision of Clemson University, and Ministry of National Education in Turkey. After gaining the necessary approvals from IRB of Clemson University and the Ministry of National Education, the researcher sent an email including the permission of the Ministry of National Education to the 16 faculties of education in Turkey in order to inform them of the purposes of this study and to request their participation to this study.

The data collection process consisted of two phases, the pilot study and the main study. For both the pilot and main study, the data was collected through the initial Turkish version of the TPACK survey and the Attitude scale for Computer-Aided Education during the fall semester of 2016. The survey instruments were administered to Turkish pre-service secondary mathematics teachers at the beginning of their courses within their classroom settings. Students required 20 - 25 minutes to complete the survey instruments. Prior to distributing a paper hardcopy of the instruments to the participants, the researcher provided information regarding the purpose of this study, the content of the instruments, the instructions for completing them, and instruction to ensure protection of their confidentiality. Then, the researcher distributed and read an informed consent form to potential participants and following this, asked for volunteers to participate in the main study. The researcher then distributed the TPACK survey instrument and the Attitude scale for Computer-Aided Education instrument to those who volunteered as participants.

The voluntary participants were asked to provide an answer for each item in the survey. The researcher administered the process of the data collection and was present in class to respond to any questions participants had throughout the process. As soon as the survey instruments were returned, the researcher entered each of the participants' data and defined variables in the SPSS software. The SPSS file was used for further statistical analysis on the SPSS, JMP, and Mplus software.

Data Analysis

I began by coding and sorting the raw data in terms of the initial Turkish version of TPACK instrument and the Attitude Scale for Computer-Aided Education. Since each survey item for both survey instruments consisted of 5-point Likert scales ranging from strongly disagree to strongly agree, the related numeric values respectively varies between 1 and 5. The demographic information part of the Turkish TPACK instrument has been coded as 1 or 2 except the age, in years, and grade in college, which have been coded using the values from 1 to 5. Following this process, the quantitative data obtained through the main study were ready to carry out descriptive and inferential statistics analysis utilizing SPSS software.

As previously discussed in the section of the pilot study and the main study, I determined the factor structure of the survey in terms of statistical analysis including EFA, CFA and reliability analysis. With the determination of the factor structure of the Turkish of TPACK survey, the dependent variables for this study were the knowledge types in the Turkish TPACK scale and Attitude. In addition, this research study also included two categorical independent variables; gender with two levels and year in college with four levels.

Descriptive statistics analysis was carried out to determine the characteristics such as mean and standard deviation of the Turkish TPACK scale and Attitude scale. Descriptive statistics was also used to determine whether or not the data met the assumptions required for statistical analysis, and to identify missing values and possible outliers. I calculated the average value of the responses provided by each participant to the survey items for the related components of TPACK. In addition, I assessed the mean value as this participant's perceived score for the relevant components of TPACK. Each participant's attitude score was obtained by a summation of all the survey item scores after reversing negatively keyed items.

In order to answer the first research question, descriptive statistics was again applied. Mean values and standard deviations were calculated to explain the participants' perception levels of TPACK components. For the second research question, correlation analysis was conducted. Pearson product-moment correlation coefficients were calculated to examine the relationships among the components of TPACK regarding secondary mathematics. For the third research question, Pearson product-moment correlation coefficients were used to measure the association between pre-service secondary mathematics teachers' attitudes towards computer-aided education and their perceptions for each component of TPACK.

In order to answer the forth research question, multivariate analysis of variance (MANOVA) was conducted. Tabachnick and Fidell (2013) stated MANOVA is a generalization of analysis of variance (ANOVA) and differs from it, as it includes two or more dependent variables in the same analysis. In addition, MANOVA provides a test to determine significant mean differences among categorical dependent variables (groups) on a linear combination of dependent variables by protecting increase of Type I error that might be through a series of ANOVA analysis (Tabachnick & Fidell, 2013). Therefore, MANOVA was used to test whether there were significant mean differences in pre-service secondary mathematics teachers' perception about TPACK domains in terms of gender, and year of enrolment. While not a focus of the research question, the interaction between gender and year of enrollment was examined in all analyses and found to be non-significant. Therefore, only results pertaining to the main effects (gender and year of enrollment) were reported in Chapter 4.

Since there was one dependent variable and two categorical independent variables associated with the fifth research question, I conducted ANOVA analysis to determine if there were significant mean differences in pre-service secondary mathematics teachers' attitudes in terms of gender, and year of enrolment in order to answer my last research question.

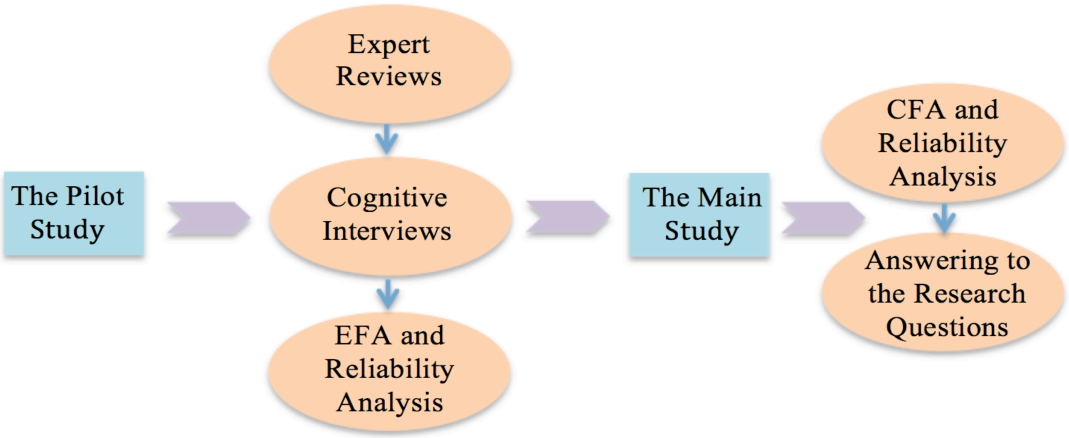
CHAPTER FOUR

DATA ANALYSIS AND RESULTS

Introduction

This chapter presents the result of my data analysis. Analysis began with the pilot study. In the pilot study section, I explain how the initial Turkish TPACK scale was obtained by checking its translation and content validity through expert reviews and cognitive interviews. Additionally, my determination of the hypothesized factor structure of the Turkish TPACK scale is presented by means of Exploratory Factor Analysis (EFA) and reliability analysis. The main study section presents how I obtained the final version of Turkish TPACK scale through Confirmatory Factor Analysis (CFA) and reliability analysis. Finally, I provide data analysis related to each of the research questions and their results (see Figure 4.1).

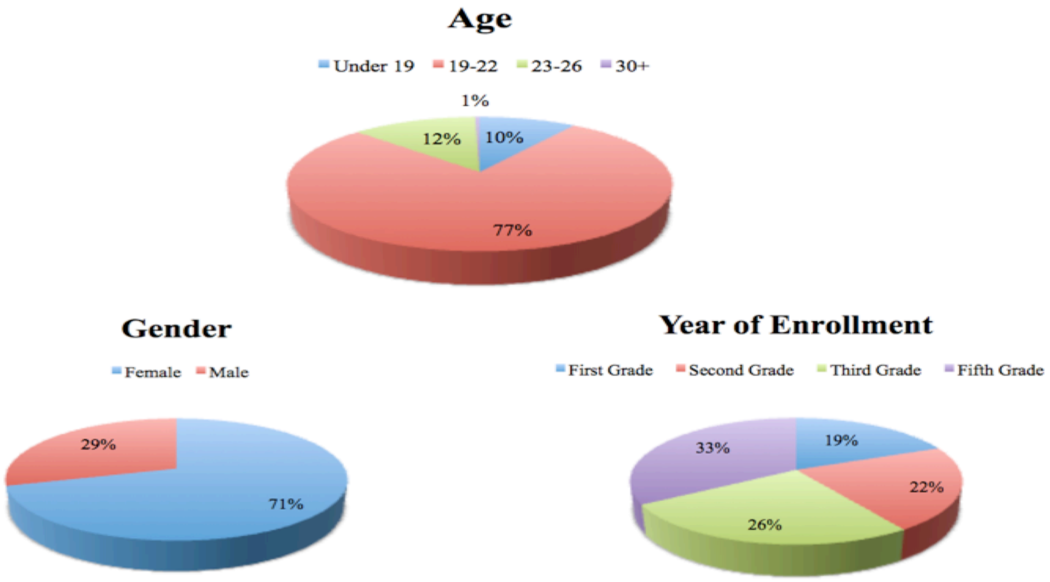
Figure 4.1 *Flowchart for the Data Analysis*



Participant Samples for the Pilot and Main Studies

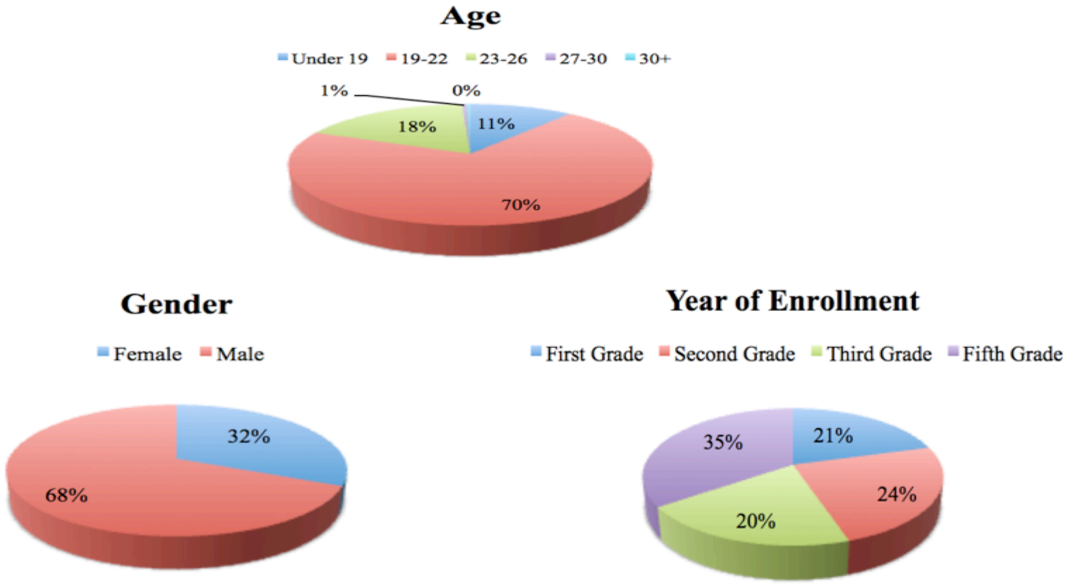
The data for the pilot study was collected from Turkish pre-service secondary mathematics teachers studying at three universities (two of them in the high group, one of them in the low group) during the first half of the fall semester of 2016. A total of 217 pre-service service teachers' responded to the TPACK and Attitude scales. The demographic information of the participants in the pilot study is presented in Figure 4.2.

Figure 4.2 *Demographic Information of the Participants in the Pilot Study*



The main study sample consisted of 561 Turkish pre-service secondary mathematics teachers. During the second half of the fall semester of 2016, the data was collected from students enrolled in nine of the thirteen universities that agreed to participate in this study. These universities were comprised of four universities from the high-level group and five universities from the low- level group. The 561 participants' responses were used for CFA and data analysis associated with the research questions. The demographic information of the participants in the main study is presented in Figure 4.3.

Figure 4.3 *Demographic Information of the Participants in the Main Study*



For the pilot and main study samples, I expected a very few number of fourth grade pre-service secondary mathematics teachers due to the fact that pre-service students were not accepted into secondary education programs in the academic year of 2013-2014 over the decisions of the Council of Higher Education. And, since pre-service teachers retaking a failed fourth grade course also continued to take fifth grade courses, the pre-service teachers in this situation were considered fifth grade students for the study.

The Pilot Study

Expert Reviews. Prior to starting the expert reviews, the researcher and the backwards translator met to discuss possible problematic or troublesome items (CK16, PK22, TPK39, TPK42, and TPACK51) identified in the reviews of the two native English speakers. In considering the native speakers' recommendations and concerns related to semantic equivalence, loss of meaning, and mistranslation, we corrected the potential problems related to PK22, TPK39, TPK42, and TPACK 51. For PK29, TPK39 and TPACK51, the problem was identified as incorrect words with regard to the backward-translated version TPACK into English; an example being the use of "misleading" instead of "misconception". These issues were not caused by the Turkish translation, so we fixed only the backward-translated to English versions of these items. As for TPK42, the problem was related to the Turkish translation of the item, resulting again from unsuitable word choice. In this case, the phrase "seriously think over" in the relevant item was replaced with the phrase " intensely (deeply) think about" (see Appendix E). After discussion, we decided not to change CK16.

Next, two Turkish experts on secondary mathematics education and use of technology in mathematics education reviewed the survey. The purpose of these expert reviews was to check content validity of the scale and its translation to the Turkish language and context in terms of secondary mathematics, technology and pedagogy. As stated in Chapter 3, the experts first reviewed both the original version and the Turkish translated version of the TPACK scale. After they reviewed both versions of the scale, I interviewed them using prepared questions (see Appendix D). As the result of the expert reviews, we identified 17 possible problematic items in the Turkish translated version. While the experts did not identify problems associated with the translation of surveys to Turkish, they provided suggestions to make the items clearer. In this context, the problems were classified as incomprehensibility, improper word selections related to pedagogy and daily spoken Turkish, and an absence of corresponding words in Turkish in the manner they are used in English. In Turkish, since there are no expressions such as "doing algebra, trigonometry, analysis or ratio or proportion", these expressions were replaced with "make calculation or calculate" for all items between and including TCK32 and TCK37. Additionally, use of the expression "in teaching" in TPK45 and TPK46 were replaced with "in my lessons" to be more aligned with regard to their pedagogical use in Turkish and daily spoken Turkish. The items between TPACK57 and TPACK62 were rearranged for clarity by associating with concepts or subjects in secondary mathematics curriculum in Turkey. In addition, the expression of "mingle with" in TK4 item was replaced with the expression "fiddle around/ spend time" in order to make the item simpler and more understandable with respect to daily spoken Turkish (see Appendix F for all corrections).

Cognitive Interviews. Cognitive interviews were held with participants of the pilot study in order to again check the translation of the survey as well as to determine how well the Turkish translation of TPACK scale worked. I was also interested in whether or not the items in the scale made sense and if there were any items that caused confusion or misunderstanding with respect to secondary mathematics, technology and pedagogy terminology (see Appendix G).

As stated in Chapter 3, Turkish pre-service secondary mathematics teachers were invited to participate in the cognitive interview process. The cognitive interviews continued until data saturation was reached. In all, five pre-service teachers (2 females and 3 males) studying at the high-level group university and five pre-service teachers (3 females and 2 males) studying at the low-level group university from the pilot study sample participated in cognitive interviews.

As the result of the cognitive interviews, the pre-service teachers agreed most items in the scale were substantially clear, simple and understandable. They identified misunderstanding and confusion issues associated with TK1, TK4, CK16, TPACK51, and TPACK52 items. For item TK1, many of the pre-service teachers stated that they did not clearly understand the expression “technical problems”. They had difficulties understanding what “technical problems” implied with any kind of technological issues that would arise during teaching. Using the phrase “fiddle with/spend time” instead of “mingle with” was successful in making item TK4 clearer however, the phrase “fiddle with” seemed to imply a negative connotation. Many pre-service teachers explained this verb inferred a meaning as if they were hanging out or wasting time with technology since they had nothing to do. Therefore, they suggested “fiddle with” was not appropriate for the item. This issue was solved with use of the phrase “interested in” instead of “fiddle with” on the recommendations of pre-service teachers in the cognitive interviews. As for item CK16, the use of the expression “in advanced level” after “undergraduate mathematics” implied master-degree level mathematics to the pre-service teachers rather than being at good level for undergraduate mathematics. In Turkish, the meaning of sentence can change according to how it is accentuated. The closest word to the verb in a sentence highlights the meaning of the sentence if there is no punctuation. Thus, they identified an accentuation issue related to CK16. The confusion and misunderstanding related to TPACK51 stemmed from the use of phrase “academic studies”. The pre-service teachers associated this phrase with research studies instead of undergraduate education. For TPACK52, some pre-service teachers expressed that they had confusion about what “for a lesson” implied. For example, they stated it was not clear which lessons such as physics, chemistry, or mathematics they could choose technologies that enhance the mathematics. Considering the pre-service teachers suggestions to fix the problems and consulting again the experts, the necessary corrections were made for these items (see Appendix H). Therefore, the initial Turkish version of TPACK was obtained.

In addition, the cognitive interviews in the pilot study revealed that Turkish pre-service secondary mathematics teachers regarded technology as a teaching tool. According to the pre-service teachers, technology supports conceptual understanding, motivates students learning, makes mathematics lessons more attractive, saves time while delivering content and helps to make abstract mathematical concepts concrete. On the other hand, they raised concerns that using technology in crowded classes might lead to classroom management and time problems. Furthermore, the cognitive interviews provided insight on the kind of technologies or technological tools Turkish pre-service teachers may associate with secondary mathematics areas. The pre-service teachers expressed they could use the Geometer’s Sketchpads, GeoCebra, Cabri 2D, Cabri 3D, and Cinderella geometry software for teaching geometry and trigonometry. For teaching Calculus and Algebra, they suggested using Computer Algebra Systems such as Derive, Octave, Graph Touch, Maxima, and Matlab. Many pre-service teachers however, had difficulty stating the kinds of technologies they might use for teaching proportion and ratio, and probability and statistics.

Exploratory Factor Analysis (EFA). Since one of the aims of the pilot study in this research study was to determine what the underlying factor structure of 62 items on the initial Turkish TPACK survey instrument were, I used EFA to do so. Prior to conducting an EFA, the relevant assumptions in order to perform EFA, which are sample size, normality, missing data, and outliers, were examined. IBM SPSS statistics version 24 software (2016) was used to evaluate the assumptions and to conduct an EFA.

Given the sample size, Comrey and Lee (1992) suggested the following a rule of thumb to evaluate adequateness of sample size for factor analysis: 100 poor, 200 fair, 300 good, 500 very good, and 1000 or more excellent. Gorsuch (1983) argued that the required sample size should be at least 100 to carry out factor analysis. Pallant (2005) further recommended that sample size should be at least 150. Since the sample size of the pilot study consisted of 217 pre-service secondary mathematics teachers, the assumption for sample size was met. In addition, I investigated univariate normality for each of the 62 items by checking minimum, maximum skewness and kurtosis values. While the minimum values for all 62 items were 1 or 2, the maximum values were 5 (see Appendix J). In other words, all responses given by the participants in the plot study were to change from 1 to 5, as expected from a 5 point Likert scale. Therefore, there were no any univariate outliers in the data. All skewness and kurtosis values except for TPK48 and TPK50 items were found in the acceptable range (see Appendix J), between -2 and +2 (George & Mallery, 2010). Therefore, with the exceptions of TPK48 and TPK50, the univariate normality assumption was satisfied. In order to investigate the impacts of the non-normality of TPK 48 and TPK 50 items to EFA, I performed an EFA analysis with or without TPK48 and TPK50 items. I observed the factor structure of the initial Turkish TPACK scale remained the same regardless of whether or not of these items were used in the EFA. Therefore, I decided to keep these items in the scale for further statistical analysis. In addition, I found no any missing values within the pilot sample data. My investigation of the Mahalanobis distance scores indicated 14 participants' Mahalanobis distance scores exceeded the critical value (χ^2 (62) = 102.17, p = .001). As a result, the 14 multivariate outliers were excluded from the pilot sample to examine their effects to EFA and skewness and kurtosis values for each 62 items. Conducting an EFA with or without multivariate outliers indicated there were no any impacts of the multivariate outliers on the factor structure of the scale. I also re-checked skewness and kurtosis values for each of 62 items. However, since I obtained the same kurtosis and skewness problems for TPK48 and TPK50 items and found no any effects on the factor structure, I decided to keep the multivariate outliers in the pilot sample data for further statistical analysis.

Next, I investigated the factorability of the 62 items in the initial Turkish TPACK by considering several criteria. I checked the correlation matrix and found that a reasonable number of correlations (n=750) exceeded .3, supporting the appropriateness of factor analysis (Tabachnick & Fidell, 2013). In addition, all correlation coefficients' values ranged between -.085 and .787 and thus, all absolute values of them were lower than .9. Therefore, there were no multicollinearity or singularity problems since the variables in the correlation matrix were not highly correlated (Tabachnick & Fidell, 2013). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1970, 1974) was .903, above the minimum required value of .6 for good factor analysis (Tabachnick & Fidell, 2013). Bartlett's test of sphericity (Bartlett, 1954) was significant,

χ^2 (1891) = 8933.03, $p < .05$. Given these overall criteria, I concluded conducting an EFA was suitable with all 62 items.

EFA with Principal Axis Factoring (PAF) extraction method was performed, as the primary aim of the pilot study was to determine the hypothesized or underlying factor structure of the initial Turkish TPACK scale (Tabachnick & Fidell, 2013). Since some methodologists suggest the PAF extraction method will provide the best results if the data has normality issues (Costello & Osborne, 2005; Brown, 2015), I decided use of PAF extraction method while conducting an EFA.

Three factor selection procedures dependent on eigenvalues: Kaiser's rule, the scree test (Cattell, 1966), and parallel analysis (Horn, 1965), were utilized to determine the number of factors. Kaiser' rule revealed the presence of 13 factors with eigenvalues exceeding 1, and these explained 68.89% of the variance (see Table 4.1).

Table 4.1 *Total Variance Explained and Initial Eigenvalues based on Principal Axis Factoring.*

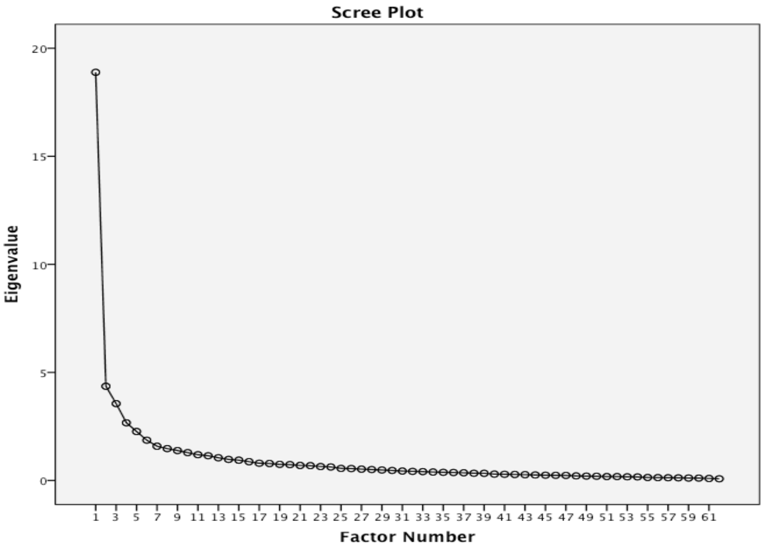
	Initial Eigenvalues			**Extraction Sums of Squared Loadings**		
Factor	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	18.886	30.461	30.461	18.521	29.873	29.873
2	4.359	7.03	37.491	3.979	6.418	36.291
3	3.556	5.736	43.228	3.206	5.171	41.462
4	2.669	4.305	47.532	2.223	3.586	45.047
5	2.265	3.653	51.185	1.867	3.012	48.059
6	1.863	3.004	54.189	1.495	2.411	50.470

Table 4.1 (Continued)

7	1.583	2.553	56.743	1.245	2.009	52.479
8	1.473	2.375	59.118	1.135	1.831	54.310
9	1.383	2.231	61.349	1.072	1.729	56.039
10	1.289	2.079	63.428	.916	1.478	57.517
11	1.191	1.921	65.349	.758	1.223	58.740
12	1.144	1.845	67.194	.712	1.148	59.889
13	1.051	1.694	68.888	.660	1.065	60.953
14	.973	1.569	70.457			

An inspection of the scree test showed there was no clear break (a point of inflexion), but last substantial declines in the magnitude of eigenvalues were seen to very close each other for fourth, fifth and sixth factors (see Figure 4.4).

Figure 4.4 *The Scree Plot*

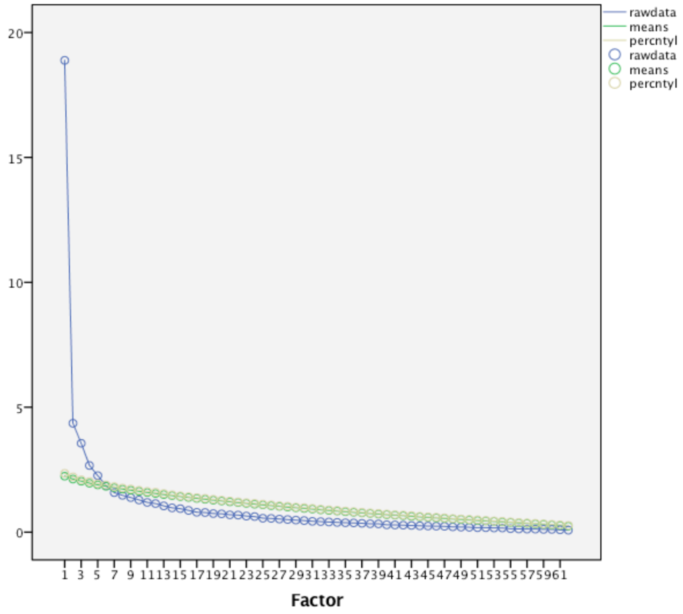


Brown (2105) suggested Kaiser's rule can result in either over-factoring and under-factoring, and the results of the scree test can be unclear because of its somewhat dependence on subjective interpretation. Therefore, I conducted a parallel analysis using SPSS syntax (O'Connor, 2000). Parallel analysis is a method focusing on comparisons of eigenvalues' size in actual data set with those obtained from the randomly generated data set that includes same numbers of observations and variables as the actual data set. (O'Connor, 2000; Pallant, 2005). If an eigenvalue's size in actual data is higher than the relevant eigenvalue' size derived from the random data, then it is considered as a factor or component. For the parallel analysis, I utilized a PAF extraction method and the pilot sample data with a permutation approach since there were normality issues for the two items. The results of the parallel analysis demonstrated the first 5 factors' eigenvalues were greater than the criterion values obtained from the parallel analysis (see Table 4.2 and Figure 4.5). Thus, I retained only 5 components or factors for further investigations.

Table 4.2 *The Parallel Analysis based on PAF by using the Pilot Sample Data with Permutation Approach*

Factor	Actual Eigenvalue	Criterion Value
1	18.886	2.351
2	4.359	2.212
3	3.557	2.096
4	2.669	2.024
5	2.265	1.944
6	1.863	1.893
7	1.584	1.768

Figure 4.5 *The Scree Pilot based on the Parallel Analysis*



According to Brown (2015), an oblique rotation produces more realistic representations related to how factors are correlated with each other and its solutions are more likely to match with CFA than those attained from orthogonal rotation. Tabachnick and Fidell (2013) also stated oblique rotation allows factors or components to correlate with each other while orthogonal rotation assumes factors are not correlated or independent. According to Costello and Osborne (2005), it was expected some correlations among factors or components in social and behavioral sciences research. With these in mind, I used an oblique rotation method with Promax to interpret these 5 factors, utilizing a cutoff point for factor loadings as .3. Following this process, the poorly loaded items with low communalities (below .3) and the items that did not load to any factors, and the items that are cross loading to two or more factors (.3 or higher) were eliminated in the initial Turkish TPACK scale (see Table 4.3).

Table 4.3 *The Items Deleted in the Initial Turkish TPACK Scale after PAF Extraction Method with Promax Rotation*

Not loading to any factors or having low communality (below .3)	Cross-loading	Having low factor loadings (below .5)	To increase of the mean of factor loadings to around .7
TK08	TK06	TK01	CK11
CK12	TCK35	TK07	TCK36
TPK41	TCK37	CK10	TCK38
TPK42	PCK27	PCK25	TPK39
TPK43	TPACK56	PCK26	TPK40
TPK49	TPACK62	PCK28	TPK45
		PCK29	
		PCK30	
		PCK31	
		TCK34	

In addition, an item was deemed as a cross-loading item if the difference between the primary loading and cross loading of the relevant item was lower than .2. Then, the cross-loading items was eliminated within the initial Turkish TPACK scale in order to provide discriminant validity, which is the degree of how much a factor is distinct from the other factors (Hair, Black, Babin, & Anderson, 2010). In other words, discriminant validity refers a factor in a scale should not be highly correlated with other factors in the same scale. Next, I investigated the convergent validity of the scale. Hair et al. (2010) explained convergent validity as the degree of how much the items in a factor share a high proportion of variance in a common way. They suggested all factor loadings should be greater than .5 and as much as possible close to a mean level of .7 for the items' factor loadings within each factor. Therefore, the items that had low factor loadings (below .5) and that reduced the mean of factor loadings for each factor were also eliminated from the scale (see Table 4.3). Before deleting one item from the scale, I considered all of the criteria above (see Table 4.3). After deleting one item from the scale, I re-ran the EFA and checked the remaining items in the scale. First, I eliminated the items that were not loading to any factors or having low communalities (below .3). Then, I deleted the items that had cross-loading and low factor loadings (below .5), respectively. Finally. I eliminated some items from the scale to increase the mean factor loadings around .7 (see table 4.3). Therefore, as a result of this followed process, a total of 28 items were deleted from the scale.

As the result of PAF extraction method with Promax rotation, I identified 5 well-defined factors that consisted of 34 items with good communalities for the initial Turkish TPACK scale. The 5 factors explained a total of 60.174% of the variance. All 34 items had primary factor loadings over .5 and there were no cross-loading items in the scale (see Table 4.4). I investigated the internal consistency of the scale by using Cronbach's alpha reliability analysis. The reliability was found to be .928 indicating excellent internal consistency (George & Mallery, 2003) for all 34 items in the scale. In order to label the factors, I used the TPACK framework (Mishra & Koehler, 2006). The first factor was labeled Technological Pedagogical Content Knowledge (TPACK), since it included a substantial number of items designed to account for the interaction among technology, pedagogy and secondary mathematics knowledge domains. In addition, it contained two items related to TPK and two items related to TCK in the initial version of TPACK scale

(Zelkowski et al., 2013). The first factor consisted of 14 items (see Table 4.4) and explained 31.181% of the variance.

Table 4.4 Factor *Loadings and Communalities based on a PAF Extraction Method with Promax Rotation for 34 items; and Reliability Analysis*

Items	**TPACK**	**PK**	**CK**	**TK**	**TPK**	**Communality**
TPACK57	.84					.56
TPACK55	.82					.65
TPACK58	.80					.51
TPACK54	.70					.45
TPACK60	.66					.47
TPACK61	.65					.57
TCK33	.63					.42
TPACK59	.62					.45
TPK47	.62					.55
TPACK53	.61					.52
TPACK52	.60					.45
TPACK51	.60					.44
TCK32	.57					.49
TPK46	.56					.48
PK20		.84				.69
PK18		.78				.68
PK21		.77				.56
PK17		.77				.57
PK19		.74				.63
PK23		.74				.59
PK24		.69				.57
PK22		.64				.47
CK15			.80			.60
CK16			.77			.60
CK13			.74			.58
CK09			.69			.53
CK14			.66			.53
TK05				.77		.59
TK03				.77		.59
TK04				.70		.50
TK02				.68		.52
TPK44					.72	.49
TPK50					.69	.52

Table 4.4 (Continued)

TPK48					.62	.51
Cronbach 's Alpha	.921	.907	.852	.812	.757	-

Note. Factor loadings < .3 are suppressed and Cronbach's alpha value for the whole scale is .928

In the same way, the second factor was labeled Pedagogical Knowledge (PK) and was comprised of 8 items (see Table 4.4). The second factor explained 9.374% of the variance. Third factor was called Content Knowledge (CK) and included 5 items (see Table 4.4). This factor explained 8.114% of the variance. The fourth factor consisted of 4 items (see Table 4.4) and was labeled Technological Knowledge (TK). The fourth factor explained 5.986% of the variance. Finally, the fifth factor, labeled Technological Pedagogical Knowledge (TPK), contained 3 items (see Table 4.4) and explained 5.519% of the variance. The internal consistencies of the subscales were further examined using Cronbach's alphas. The alpha reliability coefficients were found as .921, .907, .852, .812, and .757, respectively (see Table 4.4). In addition, I determined there were no substantial increases for each of the subscales or the whole scale if we eliminated more items. As a result, no more items were removed from the initial Turkish TPACK scale.

Table 4.5 *Factor Correlation Matrix*

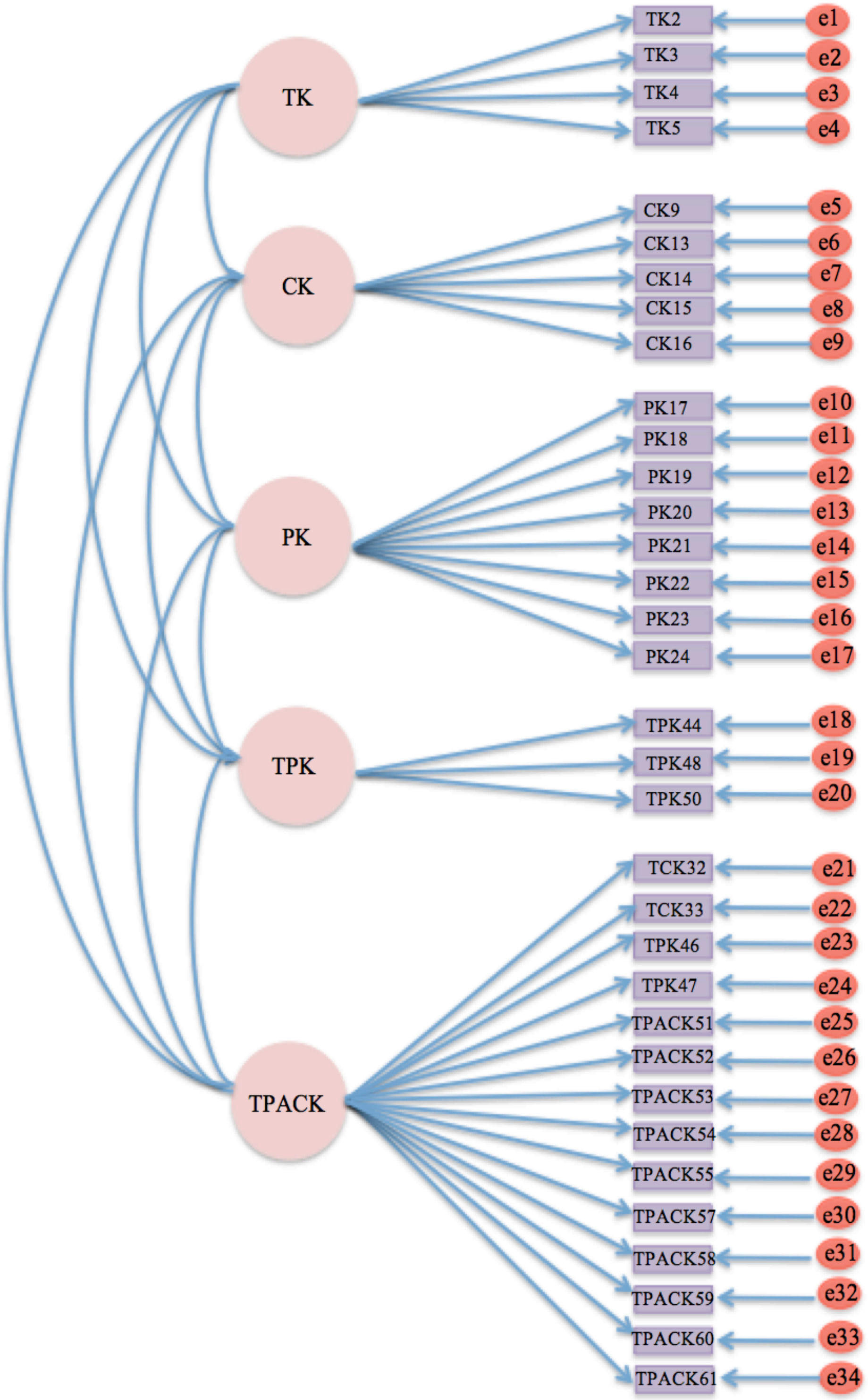
Factor	**TPACK**	**PK**	**CK**	**TK**	**TPK**
TPACK	-				
PK	.497	-			
CK	.414	.331	-		
TK	.465	.371	.157	-	
TPK	.174	.280	.106	.227	-

Note. Principal Axis Factoring extraction method with Promax oblique rotation

Further, the factor correlation matrix presented in Table 4.5 obtained through oblique rotation with Promax revealed there were correlations among the factors. However, the factors were not highly correlated with each other since all correlations were lower than .7 (Hinkle, Wiersma, & Jurs, 2003) and thus, I found there were no any issues related to discriminant validity. Therefore, I obtained the hypothesized factor structure of the Turkish TPACK scale (see Figure 4.6).

In addition to obtaining the hypothesized Turkish TPACK scale through EFA in the pilot study, I also checked the internal consistency of the Attitude scale for Computer-Aided Education (Arslan, 2006), which included 20 items, using Croncbach's alpha reliability analysis. First, I reversed the scores for the 10 negatively worded items in the Attitude scale. Second, I conducted the reliability analysis. The alpha reliability coefficient was .952 for the whole scale including 20 items, which indicated a strong internal consistency.

Figure 4.6 *The Hypothesized 5-factor Model after EFA through the Pilot Study*



The Main Study

Confirmatory Factor Analysis (CFA). As a part of the main study, I aimed to test the hypothesized or underlying factor structure of the Turkish TPACK scale obtained through EFA in the pilot study (see Figure 4.6), in which a well-defined 5 factors were estimated. In accordance with this purpose, following EFA, Confirmatory Factor Analysis (CFA) were performed to investigate the hypothesized 5-factor structure of the scale and to check its construct validity using the sample data of the main study. For performing CFA, Mplus version 7.4 statistics software (2012-2015) was used. In addition, the relevant assumptions before conducting CFA, such as sample size, missing data, normality, and multicollinearity and singularity were also investigated by utilizing IBM SPSS statistics version 24 software (2016).

With the screening the main study data in terms of descriptive statistics, I recognized there were a total of 6 missing values that showed a random pattern and consisted of one or two non-response items for 5 participants. According to Tabachnick and Fidell (2013), choosing to delete missing values is reasonable if missing data show a random pattern and when the proportion of missing values in the sample is very small. Therefore, the 5 participants with the six missing values were removed within the main study sample data. As a result, the sample for the main study consisted of 556 pre-service secondary mathematics teachers that fully completed the TPACK scale.

Next, I evaluated univariate normality for each of the remaining 34 items by checking minimum, maximum, skewness and kurtosis values. While the minimum values for all 34 items were 1, the maximum values were 5 (see Appendix K). In other words, all responses given by the participants in the main study were to change from 1 to 5, as expected from a 5 point Likert scale. Therefore, I found no any univariate outliers in the main study data. All skewness values were found in the acceptable range, between -2 and +2 (George & Mallery, 2010). In addition, all kurtosis values except for TK2, PK17, and PK18 items (see Appendix K), were in the desired range between -2 and +2. In order to examine non-normality of TK2, PK17, and PK18 items that had positive kurtosis, which were greater than 2, I re-checked these items with regard to if they were making sense for the main study sample. For these items, Turkish pre-service secondary mathematics teachers in the main study substantially preferred to respond by selecting "agree" answer option. For example, 338 out of 556 pre-service teachers marked "agree" answer option for TK2 item, which was " I can easily learn technology". This situation can highly be expected for Turkish pre-service teachers since they are involved in a generation to be used technology effectively. I met the same situation for other two items. Therefore, my investigations showed non-normality of these items made sense for the Turkish pre-service teachers in the main study. However, the data still had univariate normality problems, thereby causing multivariate normality problem for the data. My examination of the Mahalanobis distance scores identified multivariate outliers in the data, whose Mahalanobis distance scores exceeded the critical value (χ^2 (34) = 65.25, p = .001). In addition, I also assessed multivariate outliers by examining leverage values. Brown (2015) recommended an outlier could be identified when a leverage value is 5 times higher than the mean leverage value of the sample data. Considering to this, I did not detect any multivariate outliers in the main study data. It should be noticed that I did not deem these outliers as multivariate outliers in the light of aforementioned leverage value analysis, because they did not influence the main study data in such a manner they should be deleted from the data. In terms of a sample size assumption, Muthén and Muthén (2002) stated that a minimum sample size in order to perform CFA should be at least 150 for normally distributed data and 265 for non-normal data. Since my data included 556 pre-service secondary mathematics teachers, the sample size assumption was satisfied. Finally, I investigated the correlation matrix and found that all correlation coefficients' absolute values were less than .9, in which all correlation coefficients' values were ranging between -.085 and .754. Therefore, there were no severe multicollinearity and singularity problems for the main study data, as the variables were not too highly correlated with each other.

Following to the evaluation of the assumptions needed for CFA, I utilized a Maximum Likelihood Parameter estimates with standard errors (MLR) estimation method to conduct confirmatory factor analysis. According to researchers, the MLR estimation method is robust and performs well with a sample size above 500 for normality problems due to correcting the relevant model's chi-square and standards errors of parameter estimates (Tabachnick & Fidell, 2013; Brown, 2015; Muthén & Muthén, 1998-2015). Since the main study data had normality issues, I selected the MLR estimation method. I used goodness of fit indices in conjunction with chi-square test statistic to evaluate how the hypothesized 5-factor model of the Turkish TPACK scale fit the observed main study data. In the study therefore, I utilized: the standardized root mean square residual (SRMR), root mean of square error of approximation (RMSEA) and its 90% confidence interval (CI) and *p* of close fit (PCLOSE), comparative fit index (CFI) and the Tucker-Lewis index (TLI). Next, the leading recommendations provided by researchers (Bentler, 1990; Browne & Cudeck, 1993; Hu & Bentler, 1998; Hu & Bentler, 1999) were used to identify the following cut off criteria for acceptable model fit: CFI (≥ .9), TLI (≥ .9). PCLOSE (≥ .05, non-significant), SRMR (≤ .08), and RMSEA (≤ .06). The use of goodness of fit indices together supplied a more conservative and reliable assessment for the model fit instead of only use of global χ^2 test statistic, as it often identifies statistically significant results for trivial differences between the estimated model and sample data, especially when sample size is large (Tabachnick & Fidell, 2013).

Further inspections of the modification indices and re-running the CFA indicated the items whose factor loadings less than .55 had a tendency to decline the factor loadings to below .5. Therefore, a cut off criteria for the factor loadings was defined as .55, which Comrey and Lee (1992) suggested as a good value for factor loadings. Thus, some problematic items reducing model fit (TCK32, TCK33, PK22, PK23 and TPACK58, respectively) were removed within the scale. TCK32, TCK33 and TPACK58 items were eliminated from the TPACK factor or component. PK22 and PK23 were removed from the PK factor or component. In addition, the examination of modification indices showed allowing correlations between the error terms of TK4 and TK5, PK17 and PK18, TPK46 and TPK47, TPACK52 and TPACK 53, and TPACK60 and TPACK61 items provided to be obtained a better model fit (see Figure 4.7).

As a result, each of goodness of model fit indices showed the 5-factor model including 29 items fit the data well (see Table 4.6 and Figure 4.7). All factor loadings, factor correlations, residual variances, and residual correlations in the final model were found as significant (see Figure 4.7).

Table 4.6 *The Goodness of Fit Indices and χ^2 Test Statistic for the 5-factor Model (N = 556)*

Model	χ2	df	RMSEA	CI	PCLOSE	CFI	TLI	SRMR
5 factor	850.570*	362	.049	(.045 .054)	.604	.913	.902	.053

**p<.001*

The scale was also examined in respect to internal consistency. The alpha reliability coefficients were .885 for TPACK subscale, .871 for PK subscale, .832 for CK subscale, .824 for TK subscale, .713 for TPK subscale and .903 for overall TPACK scale (see Table 4.7). Since the TK subscale has only three items, it may have resulted in obtaining a lower alpha coefficient for this subscale. In conclusion, initial Turkish TPACK scale was finalized with 5 factors including 29 items after CFA and EFA (see Appendix L).

In addition to above, I checked the internal consistency of the Attitude scale for Computer- Aided Education using the main study data, after first reserving the scores of the 10 negatively worded items. The alpha reliability coefficient for overall attitude scale including 20 items was .947, which displayed a strong internal consistence (see Table 4.7).

Figure 4.7 *The Confirmed 5-factor Model with 29 items through CFA in the Main Study*

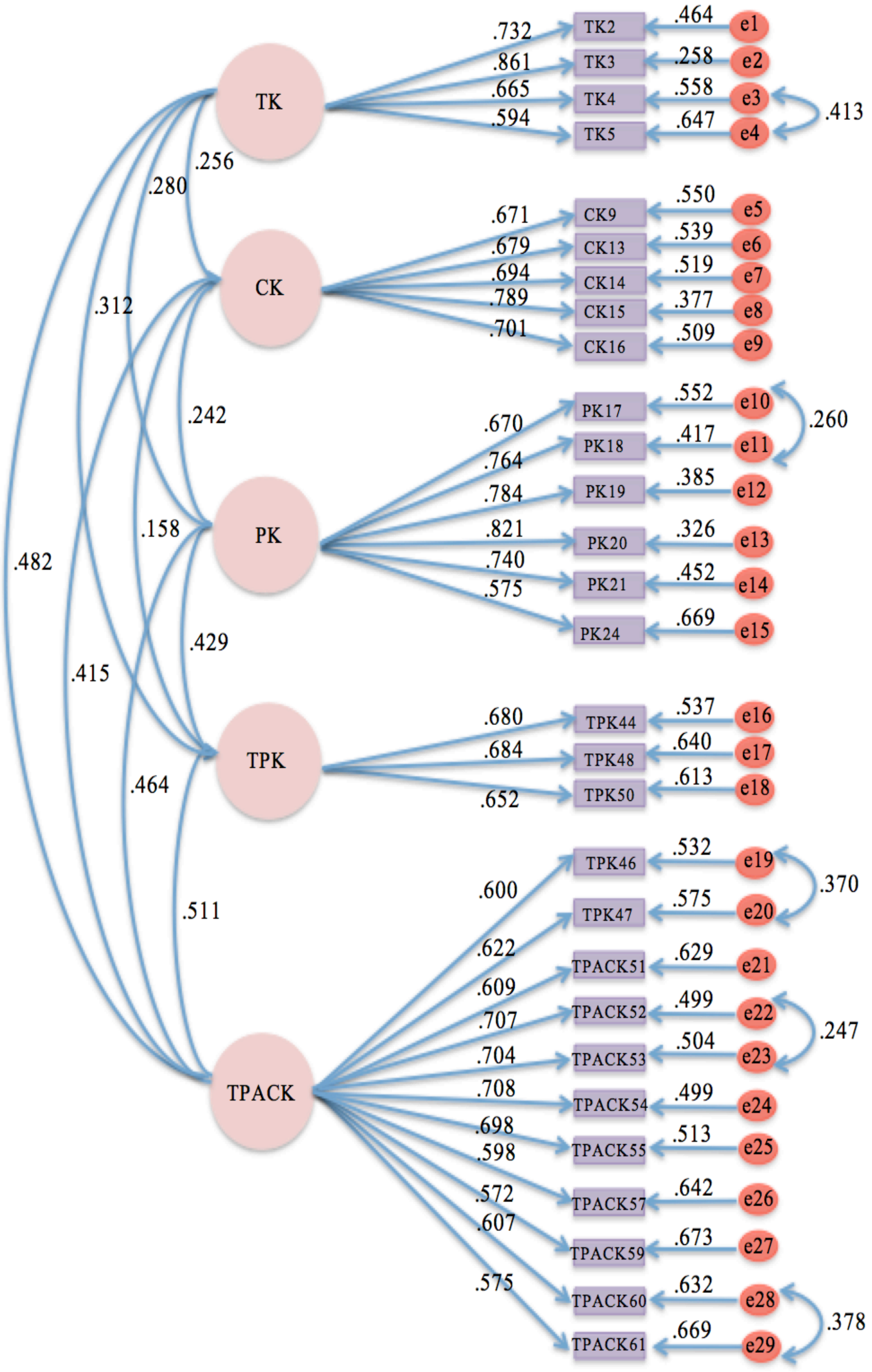


Table 4.7 *The Results of Reliability Analysis for the Survey Instruments used in the Main Study (N =556)*

Scales	**Number of Items**	**Cronbach's Alpha**
Technological Pedagogical Content Knowledge (TPACK) scale	29	.903
Technological Pedagogical Content Knowledge (TPACK) subscale	11	.885
Pedagogical Knowledge (PK) subscale	6	.871
Content Knowledge (CK) subscale	5	.832
Technological Knowledge (TK) subscale	4	.824
Technological Pedagogical Knowledge (TPK) subscale	3	.713
The Attitude scale for Computer-Aided Education	20	.947

Testing the Research Questions. After obtaining the finalized factor structure of Turkish TPACK scale through CFA in the main study, I calculated the average scores of TK, CK, PK, TPK and TPACK components for each of 556 pre-service secondary mathematics teachers. In the same way, the average score and total score of the Attitude scale for each of participant were also calculated. Prior to conducting further statistical analysis to test the research questions, the acquired data were examined with regard to missing values and univariate outliers. I did not find any missing values within the data. In order to detect univariate outliers within all the data and each of the cells (by grouping the dependent variables according to independent variables), from which would be utilized in the later analysis phases, I used the criteria $z = |3.3|$, ($\alpha = .001$), as suggested by Tabachnick and Fidell (2013). In addition, I investigated histograms, box plots and Q-Q normality plots. The cases with standardized *z*-scores in excess of $|3.3|$ and the visual examination of the histograms and the plots indicated there were seven univariate outliers in the TPACK data and three univariate outliers in the Attitude data. I removed the identified outliers within the data; and as a result, I attained approximately normal distributions for all TPACK components and Attitude component (see Table 4.8). I then completed further statistical analysis using IBM SPSS statistics version 24 software (2016) using 549 participants' scores for the TPACK components and 558 participants' score for the Attitude component.

Question 1**:** *What are Turkish pre-service secondary mathematics teachers' perceived technological pedagogical content knowledge as it specifically pertains to secondary mathematics?*

I used descriptive statistics to explore and illustrate Turkish pre-service secondary mathematics teachers' perceptions associated with TK, CK, PK, TPK and TPACK knowledge domains. In order to interpret their perception levels, I utilized a classification based on previous research (e.g., Ersoy & Aktay, 2007) for the mean values of the relevant components according to the following rule: "very low = 1-1.79", " low = 1.8-2.59", "medium = 2.6-3.39", " high = 3.4 -4.19", and "very high = 4.2-5". The results of the descriptive analysis indicated that Turkish pre-service secondary mathematics teachers had the highest perception on PK. In addition, their perceived CK was the lowest knowledge component in the scale. Pre-service teachers' perceptions about TK, PK, TPK and TPACK were ranked high, while their perception on CK was ranked medium (see Table 4.8). Noticing that I found there might be a mean difference among some of TPACK components for this sample. However, more statistical testing was necessary for revealing statistically significant mean differences.

Table 4.8 *Descriptive Analysis related to Pre-service Teachers' Perceptions about TPACK Knowledge Domains in the Scale; and related to Attitude Component*

Variable	N	Min	Max	Mean	SD	Skewness	Kurtosis
TK	549	1.5	5	3.650	.695	-.145	-.261
CK	549	1	5	3.007	.697	-.222	-.014
PK	549	1.83	5	3.856	.520	-.526	1.242
TPK	549	1.67	5	3.794	.581	-.391	.576
TPACK	549	1.73	5	3.503	.521	-.452	.737
Attitude	558	1.7	5	3.753	.630	-.358	.054

In addition, I investigated the main study sample with regard to gender and year of enrollment levels using descriptive statistics in order to describe the sample before answering the research question 4. Given the mean values of TPACK components with respect to gender, I determined the mean values of female participants' perceptions on PK and TPK were higher than those of male participants. On the other hand, the mean values of male participants' perceptions on TK, CK and TPACK were greater than those of their female counterparts. While male participants believed themselves most competent on TK, female participants believed themselves most competent on PK. Both the mean values of female and male participants' perception on CK were seemed to be the lowest. In addition, I saw female and male participants had high level of perceptions on TK, PK, TPK and TPACK components while they had medium level of perception on CK component (see Table 4.9).

Table 4.9 *Descriptive Analysis in terms of Gender for TPACK Knowledge Domains in the Scale*

Gender	Variables	N	Mean	SD	Skewness	Kurtosis
Female	TK	377	3.546	.635	-.102	-.218
	CK	377	2.953	.686	-.336	.120
	PK	377	3.859	.494	-.504	1.507
	TPK	377	3.817	.582	-.369	.655
	TPACK	377	3.488	.509	-.388	.579
Male	TK	172	3.878	.764	-.521	-.044
	CK	172	3.124	.708	-.043	-.440
	PK	172	3.851	.573	-.545	.775
	TPK	172	3.742	.575	-.460	.429
	TPACK	172	3.534	.545	-.596	1.093

When I investigated the pre-service teachers' perception on TPACK components in terms of year in college, the highest mean values of their perceptions pertained to PK while the lowest ones of their perceptions referred to CK for all grade levels. The fifth-grade participants' mean values of perceptions related to CK and TPACK were greater than those of the remaining grade levels. Similarly, the mean values of third-grade participants' perceived TK, PK and TPK components were greater than the others. In addition, I determined the participants within each of grade levels had high level of perceptions on TK, PK, TPK and TPACK components while they had medium level of perception on CK component (see Table 4.10). It should be also paid attention to the aforementioned results of this sample were based on the descriptive statistics analysis. Therefore, I needed to conduct further statistical analysis to explore if there was a statistically significant mean difference between TPACK components in terms of research question 4.

Table 4.10 *Descriptive Analysis in terms of Year in College* for TPACK Knowledge Domains in the Scale

Year in College	Variables	N	Mean	SD	Skewness	Kurtosis
First Grade	TK	115	3.661	.757	.022	-.420
	CK	115	2.765	.727	-.038	.080
	PK	115	3.820	.621	-.585	.471
	TPK	115	3.815	.620	-.255	.171
	TPACK	115	3.402	.598	-.099	.631
Second Grade	TK	132	3.580	.655	-.224	-.418
	CK	132	2.849	.696	-.369	-.064
	PK	132	3.807	.526	-.773	1.942
	TPK	132	3.700	.630	-.682	.979
	TPACK	132	3.420	.493	-.434	.209
Third Grade	TK	113	3.735	.605	.062	.018
	CK	113	3.094	.649	.008	.205
	PK	113	3.960	.477	.039	.881
	TPK	113	3.888	.559	-.157	-.439
	TPACK	113	3.550	.498	-.454	.958
Fifth Grade	TK	189	3.642	.730	-.264	-.332
	CK	189	3.212	.638	-.185	-.366
	PK	189	3.850	.465	-.420	.888
	TPK	189	3.789	.524	-.278	.630
	TPACK	189	3.595	.484	-.722	1.386

In addition to Table 4.9 and 4.10, the mean value changes for each of TPACK components according to both gender and year of enrollment are presented in Figures 4.8, 4.9, 4.10, 4.11, and 4.12.

Figure 4.8 *The Mean Value Change of TK Component according to Interaction between Gender and Year of Enrollment*

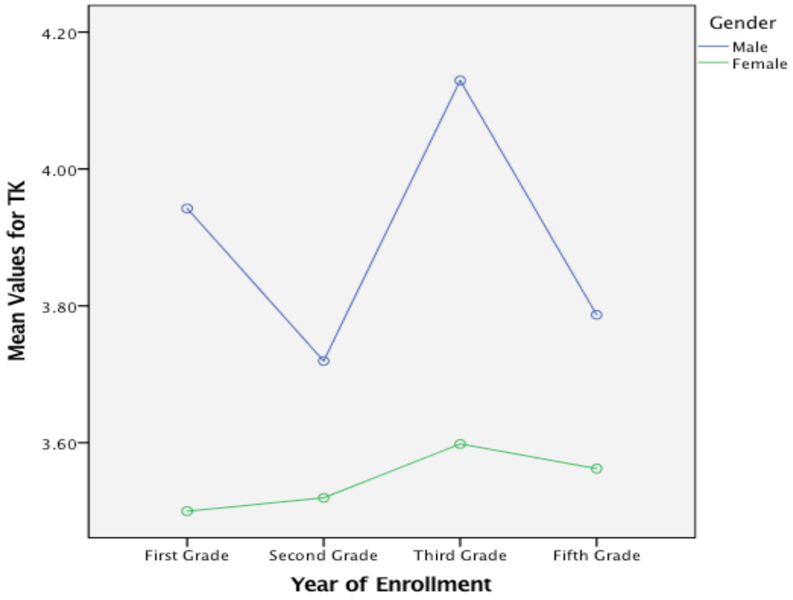


Figure 4.9 *The Mean Value Change of CK Component according to Interaction between Gender and Year of Enrollment*

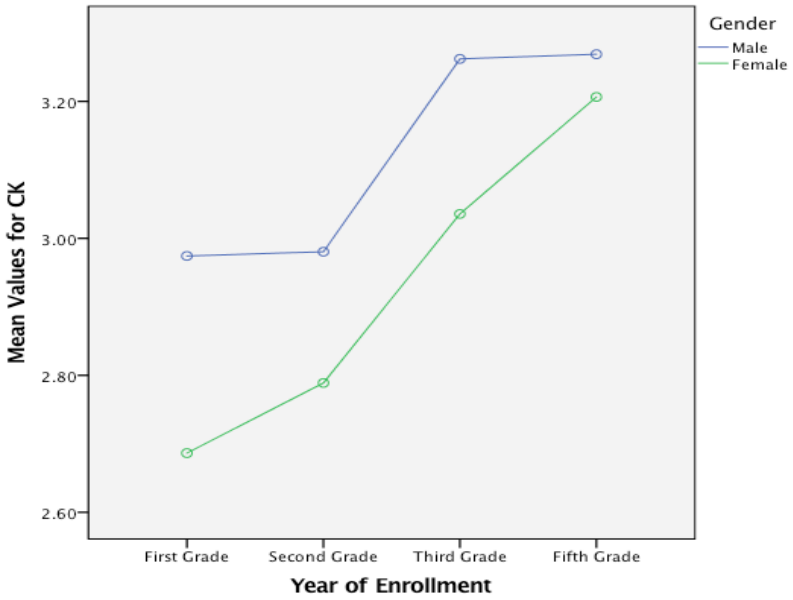


Figure 4.10 *The Mean Value Change of PK Component according to Interaction between Gender and Year of Enrollment*

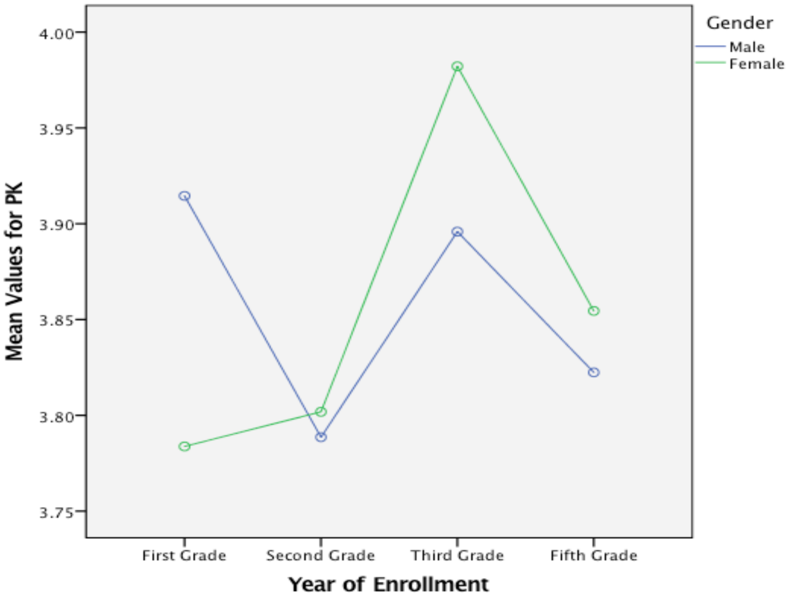


Figure 4.11 *The Mean Value Change of TPK Component according to Interaction between Gender and Year of Enrollment*

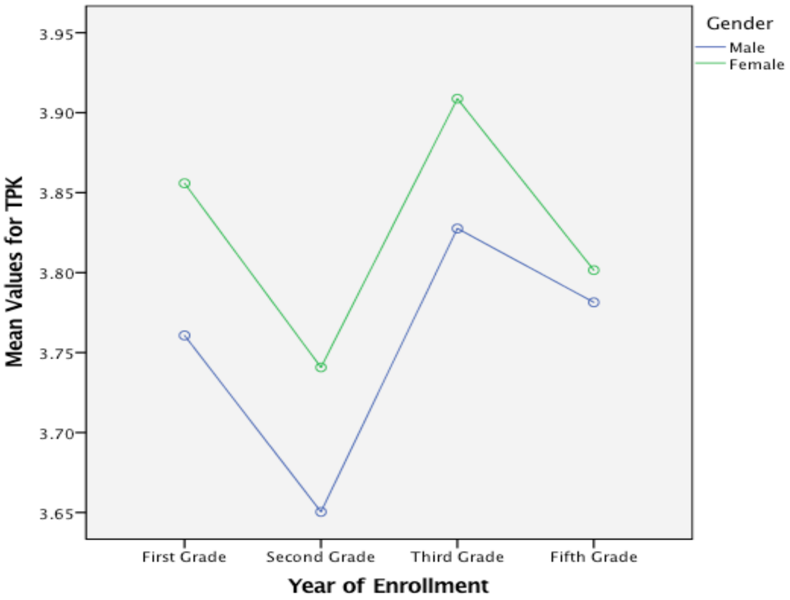
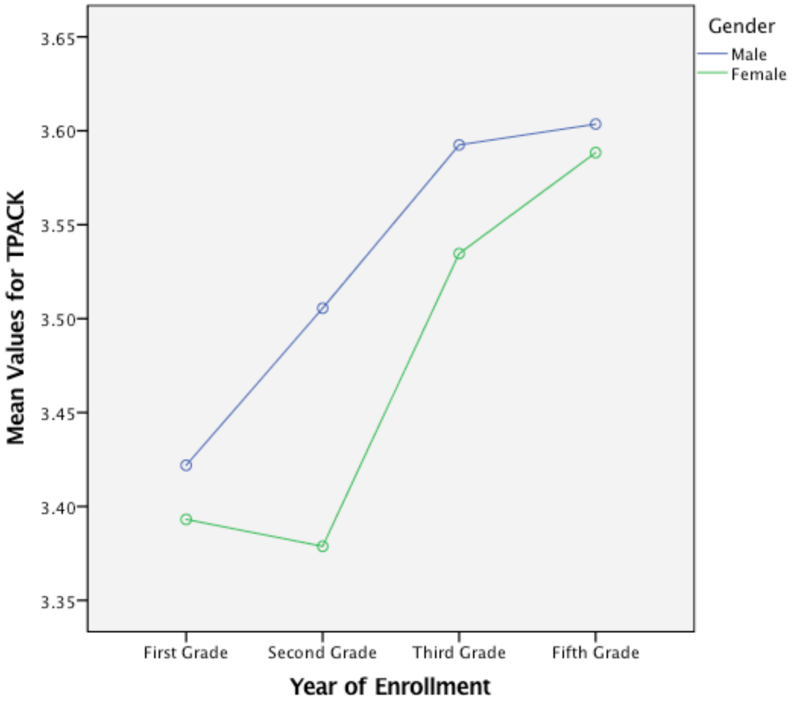


Figure 4.12 *The Mean Value Change of TPK Component according to Interaction between Gender and Year of Enrollment*



Question 2: *What are the relationships among the components of TPACK pertaining to secondary mathematics as measured by Pearson correlations?*

In order to measure the relationships among TK, CK, PK, TPK and TPACK components, I calculated Pearson product-moment correlation coefficients through bivariate correlation analysis. Before performing bivariate correlation analysis, I investigated the factors affecting the size of Pearson correlation. Therefore, I examined normality of the variables, and linearity and homoscedasticity among the variables were in terms of histograms, normality Q-Q plots and scatter plot matrix. The visual examination of histograms and normality Q-Q plots suggested each of the distributions of the variables were seen as approximately normal (see Table 4.8). Further, they satisfied normality assumption since all skewness and kurtosis values for each of TPACK components were in acceptable range between -2 and +2 (George & Mallery, 2010; see Table 4.8). In addition, the visual examination of the scatter matrix plot showed the variables did not exhibit curvilinear relationship patterns and there were no serious threats with regard to homoscedasticity (see Appendix M). In addition, I used the guiding suggestions related to effect size of correlations provided by Cohen (1988) (small (.1-.3), moderate (.3-.5) and strong (.5-1)) to interpret the magnitude of the correlation coefficients.

The results of the bivariate correlation analysis revealed statistically significant positive small correlations between TK and each of CK, PK and TPK components (see Table 4.11). In addition, 7.56%, 6.71% and 5.2% of variance in TK was associated with the variances in CK, PK and TPK, respectively. There were also significant positive small correlations between CK and each of PK and TPK components (see Table 4.11). 6.81% and 3.1% of variances in CK were associated with PK and TPK, respectively.

The results also indicated statistically positive linear relationships between TPACK and each of TK, CK, PK, and TPK components. Further, the correlation of PK with TPK was statistically significant, also indicating positive linear relationship with moderate effect size. These correlations between TPACK and each of TK, CK, PK and TPK had moderate effect size (see Table 4.11). The variance in the one variable was associated with 20%, 15%, 22%, 16% and 15% of variance in the other variable, respectively.

Table 4.11 *Pearson Product-Moment Correlations among TPACK Components*

Variables	**TK**	**CK**	**PK**	**TPK**	**TPACK**
TK	-				
CK	.275*	-			
PK	.259*	.261*	-		
TPK	.228*	.176*	.386*	-	
TPACK	.448*	.388*	.464*	.404*	-

*p <.001.

Further, I investigated the relationships among pre-service teachers' perceptions regarding TPACK components by considering their gender and year of enrollment. The scatter plots were obtained in terms of JMP Pro statistics version 12 software (2015). The visual examination of the scatter plots (see Appendix O) indicated the correlation between male pre-service teachers' perceived TPK and each of TK and CK components were slightly stronger than those of female pre-service teachers. However, the other correlations among TPACK components with regards to gender were observed to be very similar to each other. Given pre-service teachers' year of enrollment, I observed that all relationships among TPACK components were very close to one another, except for the relationship between TK and PK components (see Appendix O). The scatter plot for TK and PK with respect to year of enrollment showed that the relationship between pre-service second grade teachers' perceived TK and PK components were somewhat weaker than pre-service first, third, and fifth grades (see Appendix O).

***Question 3*: *Is there a significant relationship between Turkish pre-service secondary mathematics teachers' attitudes towards use of technology and their perceptions of TPACK domains (TK, CK, PK, TPK and TPACK)*?**

In order to investigate the relationships between the Attitude component and each of the TPACK components, I computed Pearson product-moment correlation coefficients. I used 546 pre-service teachers' data for bivariate correlation analysis due to the fact there were unpaired scores, which stemmed from the deletion of univariate outliers within the data. Next, I investigated the factors influencing the effect size of the correlation coefficients. And therefore, I examined normality, linearity and homoscedasticity with use of histograms, normality Q-Q plots and scatter plot matrix. With the examination of descriptive statistics, I determined all skewness and kurtosis values were in acceptable range for this study (see Appendix N). In addition, the visual investigations of histograms and normality Q-Q plots displayed that the distributions for each of variables were approximately normal. Further, the examination of scatter plot matrix showed that there were no curvilinear relationships among the variables and any serious problem for homoscedasticity (see Appendix M). Therefore, I considered that the magnitudes of the correlations among variables were not substantially affected by the factors.

Table 4.12 *Pearson Product-Moment Correlations between Attitude Component and each of TPACK Components*

Variables	TK	CK	PK	TPK	TPACK
Attitude	.328*	.14*	.184*	.286*	.423*

**p* <.001.

The results of bivariate correlation analysis revealed that there were statistically significant positive correlations between Attitude and each of TK, CK, PK, TPK and

TPACK components (see Table 4.12). Overall, there were small positive correlations among Attitude, CK, PK and TPK while there were moderate positive correlations of Attitude with TK and TPACK. In addition, 18% of variance in TPACK, 8.2% of variance in TPK, 3.4% of variance in PK, 2% of variance in CK and 11% of variance in TK could be associated with the variance in Attitude.

In addition to above analyses, I examined the relationships between Attitude and each of TPACK components with respect to gender, and year of enrollment by utilizing JMP Pro statistics version 12 software (2015). The visual inspections of the scatter plots displayed that the relationship between male pre-service teachers' Attitude towards use of technology in mathematics education and their perceived TK were slightly stronger than those of female pre-service teachers (see Appendix P). However, the other relationships between Attitude and each of CK, PK, TPK and TPACK with respect to gender were very close to one another (see Appendix P). Considering pre-service teachers' year of enrollment, my observations showed that the relationship between pre-service third grade teachers' Attitude and TK were somewhat weaker than those of first, second and fifth grades (see Appendix P). The relationship between first grade pre-service teachers' Attitude and CK were slightly weaker than those of the other grades. Further, the relationship between pre-service fifth grade teachers' Attitude and PK were stronger than those of the other grades (see Appendix P). However, I observed all relationships between pre-service teachers' Attitude and TPK, as well as Attitude and TPACK were very similar to each other regardless of their year of enrollment (see Appendix P).

Question 4: *Is there a significant mean difference in Turkish pre-service secondary mathematics teachers' perceptions of TPACK domains with respect to the following factors:*

c. *Gender*
d. *Year of enrollment in the program of secondary mathematics education*

Instead of conducting a series of one-way ANOVA analysis to examine whether the pre-service teachers' perceptions on TK, CK, PK, TPK and TPACK components significantly differentiate with regard to their gender (male and female), a one-way Multivariate Analysis of Variance (MANOVA) was utilized to reduce the inflation of Type I error (Tabachnick & Fidell, 2013). I investigated the relevant assumptions prior to performing the MANOVA. The assumptions of univariate normality for each of within-cells, linearity and multicollinearity already evaluated in terms of the research questions 1 and 2, which were satisfactory (see Table 4.9 and Table 4.11). As for the sample size assumption, Tabachnick and Fidell (2013) recommended that every cell in MANOVA should be have more cases than the number of dependent variables. Since the number of dependent variables was 5 and the smallest cell had 170 cases in this study (see Table 4.9), I considered sample size assumption met. Additionally, I investigated whether there were any multivariate outliers in the data due to the fact that MANOVA was sensitive to outliers. The examinations of the Mahalanobis distance scores displayed that there were six multivariate outliers in the data, of which Mahalanobis distance scores exceeded the critical value (χ^2 (5) = 20.52, p = .001). Therefore, the multivariate outliers were eliminated from the data and the data including 543 pre-service teachers' responses were used.

Next I examined the homogeneity of covariance matrices assumption. The Box's *M* test for the equality of homogeneity of variance-covariance matrices across the groups resulted in the value of 29.964 in associated with $p = .013$. I interpreted these values by using the alpha level as .001, based on Tabachnick and Fidell's suggestions for the data with unequal sample size (2013). Therefore, the non-significant Box's *M* test implied that the covariance matrices between male and female pre-service teachers were found to be equal. This result also implied that the assumption was not violated.

Next, I performed a one-way MANOVA to examine the effect of gender on the linear combination of TK, CK, PK, TPK and TPACK dependent variables. To interpret the MANOVA results, Pillais' Trace criterion was chosen due to unequal sample sizes. The results of multivariate test statistics displayed the linear combination of the dependent variables significantly differed on gender, Pillais' Trace = .067, F (5, 537), $p < .001$, $\eta_p^2 = .067$.

Before performing the follow-up univariate ANOVAs in order to determine which of the dependent variables differentiated on gender, I checked the homogeneity of variance assumption. The results presented in Table 4.13 show two of the five *Levene*'s *F* tests were statistically significant ($p< .05$). In other words, the variances related to TK and PK dependent variables were not homogenous across the male and female pre-service teachers. According to Tabachnick and Fidell (2013), the violation related to equality of homogeneity of variances for relatively equal sample sizes (when the ratio of the largest cell's size to the smallest cell's size is equal to 4 or less), is acceptable if

Hartley's F_{max} value is less than 10, which indicates univariate ANOVA *F* test is robust for the violation.

Table 4.13 *Levene's the Homogeneity of Error Variances Test for TPACK Components with respect to Gender*

Variables	***F***	***df1***	***df2***	***p-value***
TK	6.883	1	541	.009
CK	2.177	1	541	.141
PK	4.628	1	541	.032
TPK	.003	1	541	.957
TPACK	.410	1	541	.522

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups

In this study, the largest and smallest sample size of TK and PK dependent variables were respectively 373 (female) and 170 (Male), suggesting the sample size ratio is less than 4. Additionally, since the F_{max} values were respectively 1.44 and 1.35 and less than 10, the homogeneity of variances of TK and PK were considered approximately to be equal. Therefore, the homogeneity of variance assumption was satisfied.

Further, a Bonferroni correction was made for the alpha significance level to reduce the probability of making Type I error that would stem from conducting the series of univariate ANOVA. The Bonferroni-corrected alpha level was determined as .01 by dividing the alpha level of .05 by the number of dependent variables, 5 (.05/5 =. 01). Thus, the result of univariate ANOVAs indicated a statistically significant mean difference between male pre-service and female pre-service secondary mathematics teachers' perceptions on TK, $F\ (1,541) = 25.871, p < .001, \eta_p^2 = .046$, as well as their perception on CK, $F\ (1,541) = 6.856, p = 009, \eta_p^2 = .013$. In other words, male pre-service secondary mathematics teachers' perceptions on TK (M = 3.865, SD = .758) were significantly greater than female counterparts (*M* = 3.548, *SD* = .632). In addition, male participants' perceived CK (*M* = 3.131, *SD* = .709) was significantly greater than female participants (*M* = 2.964, *SD* = .677).

I next performed another one-way MANOVA to test the effect of year of enrollment independent variable on the linear combination of pre-service teachers' perceptions associated with TK, CK, PK, TPK, and TPACK dependent variables. The assumptions for univariate normality, absence of univariate and multivariate outliers, linearity, and multicollinearity through the results presented in Table 4.10, Table 4.11 and the MANOVA analysis above were assessed and satisfied. In addition, the sample size assumption was met since the smallest cell consisted of 113 cases and its size exceeded the number of dependent variables, which was 5 in this study. As for the assumption of homogeneity of covariance matrices, The Box's *M* test resulted in the value of 65.504 associated with $p = .03$. Considering the alpha value as .001 for an unequal sample, a non-significant Box's *M* test result indicated the covariance matrices among the groups (the levels of year of enrollment independent variable) were equal.

The one-way MANOVA was conducted with use of Pillais' Trace criterion due to unequal sample sizes. The multivariate test statistics showed the linear combination of TK, CK, PK, TPK and TPACK dependent variables significantly differentiated on the year of enrolment independent variable; Pillais' Trace = .108, F (15, 1611) = 4.029, $p < .001$, $\eta_p^2 = .036$.

Prior to employing a series of univariate ANOVAs to determine which of the dependent variables were differentiated on pre-service teachers' year of enrollment, I evaluated the homogeneity of variance assumptions for each of the dependent variables. The results of homogeneity of variances in Table 4.14 demonstrate two of the five *Levene*'s *F* tests were statistically significant ($p < .05$). Therefore, I found the variances of TK and PK dependent variables were not homogenous across year of enrollment with four levels. Since both the largest cell's sample size was 186 (Fifth Grade) and the smallest' one was 113 (First or Second Grade) for TK and PK, the ratio of the largest sample to the smallest was less than four. Therefore, I assumed the samples for groups were relatively equal, supporting use of Hartley's F_{max} test. Since the F_{max} values of TK and PK were respectively 1.58 and 1.83 and less than 10, the homogeneity of variances of TK and PK were considered approximately to be equal. Therefore, the homogeneity of variance assumption was satisfied; and thus, the univariate ANOVA *F* tests were robust.

Table 4.14 *Levene's the Homogeneity of Error Variances Test for TPACK Components with respect to Year of Enrollment*

Variables	*F*	*df1*	*df2*	*p-value*
TK	3.486	3	539	.016
CK	1.075	3	539	.359
PK	4.005	3	539	.008
TPK	1.550	3	539	.201
TPACK	2.020	3	539	.110

***Note*.** Tests the null hypothesis that the error variance of the dependent variable is equal across groups

In order to interpret the follow-up univariate ANOVAs, the Bonferroni-corrected alpha level was still used as .01 as the number of dependent variables was the same. The univariate ANOVAs indicated statistically significant mean differences among the pre-service teachers' year of enrollment for CK, F (3, 539) = 13.927, $p < .001$, $\eta_p^2 = .072$, as well as for TPACK, F (3, 539) = 5.038, $p = .002$, $\eta_p^2 = .027$.

Post hoc comparisons, using Tukey's HSD post hoc procedure, were performed to determine which pairs of means for the levels of year in enrollment differed significantly with regard to CK and TPACK. Since the numbers of tests conducted during Tukey's HSD post hoc procedure was six, another Bonferroni correction was made by dividing the alpha level .05 by 6. Therefore, I used the Bonferroni -corrected alpha value of .0083 for the post hoc comparisons. The results of Tukey's HSD is presented in Table 4.15 and indicated the fifth grade pre-service teachers' perceived CK were significantly different than those of both the second and first grade pre-service teachers. In addition, the third grade pre-service teachers' perceptions on CK were statistically different than the first grade pre-service teachers' perceptions on CK. In other words, the fifth grade pre-service mathematics teachers had higher perception of their CK (*M* = 3.227, *SD* = .627) than the second grade pre-service teachers (*M* = 2.849, *SD* = .698), as well as the first grade pre-service teachers (*M* = 2.786, *SD* = .712). The third grade pre-service teachers also had higher perceptions on CK (*M* = 3.094, *SD* = .649) than first grade pre-service teachers (*M* = 2.786, *SD* = .712). Further, the fifth grade pre-service teachers' perceived TPACK was significantly different from both the first grade and second grade pre-service teachers. In other words, the fifth grades had higher perceptions on TPACK (*M* = 3.593, *SD* = .464) than first grade pre-service teachers (*M* = 3.403, *SD* = .577), as well second grade pre-service teachers (*M* = 3.419, *SD* = .494).

Table 4.15 *Tukey's HSD Comparison for CK and PK Components with respect to Year of Enrollment*

Dependent Variables	Comparisons	Mean Attitude Difference	*p*-value	95% CI Lower Bound	95% CI Upper Bound
CK	First Grade vs. Second Grade	-.063	.883	-.2838	.1578
	First Grade vs. Third Grade	-.308*	.003	-.5368	-.0792
	First Grade vs. Fifth Grade	-.441*	.000	-.6462	-.2360
	Second Grade vs. Third Grade	-.245**	.023	-.4657	-.0242
	Second Grade vs. Fifth Grade	-.378*	.000	-.5742	-.1819
	Third Grade vs. Fifth Grade	-.133	.339	-.3383	.0720
TPACK	First Grade vs. Second Grade	-.015	.995	-.1819	.1511
	First Grade vs. Third Grade	-.146	.128	-.3190	.0261
	First Grade vs. Fifth Grade	-.190*	.004	-.3450	-.0356
	Second Grade vs. Third Grade	-.131	.179	-.2975	.0355
	Second Grade vs. Fifth Grade	-.175*	.007	-.3228	-.0270
	Third Grade vs. Fifth Grade	-.044	.885	-.1986	.1108

* $p < .0083$ ** $p < .05$

Question 5: *Is there a significant mean difference in Turkish pre-service secondary mathematics teachers' attitudes towards use of technology with respect to the following factors:*

a. *Gender*
b. *Year of enrollment in the program of secondary mathematics education*

I performed a one-way ANOVA to investigate the question of whether Turkish pre-service secondary mathematics teachers' attitudes towards Computer-Aided Education were statistically different with regard to gender. Prior to conducting ANOVA, I examined the normality assumption and the homogeneity of variance assumption. As indicated in table 4.16, all skewness and kurtosis values were between -2 and +2. In addition, the visual examination of the histograms and normality Q-Q plots based on gender with two levels independent variable showed that the data were approximately normal. Therefore, normality assumption for each of cells was met. The *Levene's F* test by using a .05 alpha level revealed the homogeneity of variances assumption was satisfied for the data (*F* (1,556) = .022, *p* = .883). Thus, I considered there were no violations in order to employ an ANOVA. In the following analysis I used the alpha level of .05.

Table 4.16 *Descriptive Statistics for Pre-service Teachers' Attitude Score in terms of Gender*

Gender	N	Min	Max	Mean	SD	Skewness	Kurtosis
Female	382	1.7	5	3.765	.634	-.375	.140
Male	176	2.05	5	3.726	.624	-.328	-.101

I performed the one-way ANOVA using the Turkish' pre-service teachers' average score on the Attitude scale (see Table 4.17). The ANOVA results indicated no statistically mean difference (*F* (1,556) = .46, *p* = .498) between male pre-service teachers (*M* = 3.726, *SD* = .624) and female pre-service teachers (*M* = 3.765, *SD* = .634). Thus, I concluded that Turkish pre-service secondary mathematics teachers' attitudes towards Computer-Aided education did not differ with respect to their gender.

Table 4.17 *Analysis of Variance (ANOVA) in terms of Turkish Pre-service Teachers' Gender related to Attitude*

Source	***df***	***SS***	***MS***	***F***	***p***
Between groups	1	.183	.183	0.46	.498
Within groups	556	220.994	.397		
Total	557	221.176			

I conducted another ANOVA to test whether Turkish pre-service secondary mathematics teachers' attitudes towards Computer-Aided education was differentiated according to their year of enrollment. The normality assumption was examined through the histograms, normality Q-Q plots and skewness and kurtosis values for each of independent variable's levels. Table 4.18 shows skewness and kurtosis values were within the acceptable range. In addition, the visual examination of the histograms and normality Q-Q plots displayed that the distributions for the levels of the independent variable (year of enrollment) were approximately normal. The *Levene*'s F test were statistically non-significant, *F* (3, 554) = 1.575, *p* = .194, suggesting the homogeneity of variance assumption was satisfied. Therefore, there were no violations for performing the one-way ANOVA. The one-way of ANOVA on the Turkish pre-service teachers'

Attitude scores towards Computer-Aided education yielded statistically significant mean differences at the alpha level of .05 among their year of enrolment, F (3, 554) = 8.629, $p < .001$, $\eta_p^2 = .045$ (see Table 4.19).

Table 4.18 *Descriptive Statistics for Pre-service Teachers' Attitude Score in terms of Year in College*

Year in College	N	Min	Max	Mean	SD	Skewness	Kurtosis
First Grade	114	2.1	5	3.568	.662	-.157	-.279
Second Grade	136	1.7	5	3.657	.641	-.350	.225
Third Grade	113	1.9	5	3.787	.643	-.565	.476
Fifth Grade	195	2.6	5	3.907	.556	-.153	-.403

Table 4.19 *Analysis of Variance (ANOVA) in terms of Turkish Pre-service Teachers' Year of Enrolment related to Attitude*

Source	*df*	*SS*	*MS*	*F*	η_p^2
Between groups	3	9.874	3.291	8.629*	.045
Within groups	554	211.302	.381		
Total	557	221.176			

*p <.001

Post hoc comparisons, using Tukey's HSD post hoc procedure, were employed to determine which pairs of year of enrollment of the Turkish pre-service secondary mathematics teachers differed significantly. Since there were no any violations regarding normality and homogeneity of variances, which could cause the inflation of type 1 errors, the alpha level was still considered as .05. The results of the pairwise comparisons are given in Table 4.20 and indicate fifth grade pre-service teachers' attitude were statistically different from both the first grade and second grade pre-service teachers' attitude. Further, the third grade pre-service teachers' attitude was statistically different from those of the first grade. In other words, the fifth grade pre-service teachers (*M* = 3.907, *SD* = .556) showed a significantly more positive attitude towards Computer-Aided education than the second grade pre-service teachers (*M* = 3.657, *SD* = .641), as well as the first grade pre-service teachers (*M* = 3.568, *SD* = .662). Additionally, the third grade pre-service teachers (*M* = 3.787, *SD* = .643) indicated a significantly more positive attitude towards Computer-Aided education than the first grade pre-service teachers (*M* = 3.568, *SD* = .662).

Table 4.20. *Tukey's HSD Comparison for the Attitude* towards Computer-Aided Education

				95% CI	
Comparisons	**Mean Attitude Difference**	**Std. Error**	***p*-value**	**Lower Bound**	**Upper Bound**
First Grade vs. Second Grade	-.089	.078	.672	-.2906	.1135
First Grade vs. Third Grade	-.219*	.082	.039	-.4300	-.0075
First Grade vs. Fifth Grade	-.338*	.073	.000	-.5259	-.1506
Second Grade vs. Third Grade	-.130	.079	.348	-.3328	.0724
Second Grade vs. Fifth Grade	-.250*	.069	.002	-.4275	-.0719
Third Grade vs. Fifth Grade	-.120	.073	.359	-.3076	.0687

* $p < 0.05$

CHAPTER FIVE

DISCUSSION

In the previous chapter, I described how the final version of TPACK scale was obtained through EFA, CFA and reliability analysis. In addition, I reported the results of the data analysis related to the research questions in the research study. This final chapter consists of five sections: summary of the study, discussion of the findings, implications for practice, limitations, and recommendations for future research.

Summary of the Study

According to the TPACK framework introduced by Mishra and Koehler (2006), in order to effectively integrate technology into teaching their content area; teachers require seven knowledge domains emanating from the interactions among Technological Knowledge (TK), Content Knowledge (CK) and Pedagogical Knowledge (PK). These interactions create four additional knowledge domains: Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK).

In the literature review, I presented a variety of valid and reliable self-reported survey instruments to investigate pre-or-inservice teachers' perceptions of TPACK knowledge domains. However, the research studies associated with development of a survey instrument for pre-service secondary mathematics teachers were minimal, especially in Turkey. Therefore, this study aimed to examine Turkish pre-service secondary mathematics teachers' perceptions about TPACK domains related to secondary mathematics. This was accomplished by translating and adapting the TPACK scale developed by Zelkowski and his colleagues (2013) into the Turkish language and context. Another goal of this study was to investigate the effects of demographics differences between pre-service secondary mathematics teachers such as gender and year of enrollment on their perceived TPACK domains. Further, this study examined the effects of pre-service secondary mathematics teachers' demographic differences on their attitudes towards Computer-Aided Education. The research questions I addressed in this study were:

1) What are Turkish pre-service secondary mathematics teachers' perceived technological pedagogical content knowledge as it specifically pertains to secondary mathematics?
2) What are the relationships among the components of TPACK pertaining to secondary mathematics as measured by Pearson correlations?
3) Is there a significant relationship between Turkish pre-service secondary mathematics teachers' attitudes towards use of technology and their perceptions of the TPACK domains?
4) Is there a significant mean difference in Turkish pre-service secondary mathematics teachers' perceptions of TPACK domains with respect to the following factors:
    a. Gender
    b. Year of enrollment in the program of secondary mathematics education

5) Is there a significant mean difference in Turkish pre-service secondary mathematics teachers' attitudes towards use of technology with respect to the following factors:
    a. Gender
    b. Year of enrollment in the program of secondary mathematics education

The adaptation of the TPACK survey instrument into the Turkish language and context included the processes of: forward translation, backwards translation, comparisons of the original TPACK scale and backward translation, expert reviews, and cognitive interviews. In addition, psychometrics analysis was conducted to obtain a valid and reliable final version of the Turkish TPACK scale. In this regard, I used explanatory factor analysis (EFA) and reliability analysis on my pilot study data set, which included 217 pre-service teachers' responses, to determine the hypothesized factor structure of Turkish TPACK scale. After determining the hypothesized factor structure, I performed confirmatory factor analysis (CFA) and reliability analysis using date from my main study, which included 561 pre-service teachers' responses, to test the hypothesized factor structure of the Turkish TPACK scale. Through these processes, I checked the construct validity and reliability of the scale and I obtained the final version of Turkish TPACK scale. I utilized the 561 pre-service teachers' responses from the final version of Turkish TPACK scale and the Attitude scale towards Computer- Aided Education to answer the research questions in this study. In order to answer the research questions, I used a variety of statistical techniques, which included: descriptive statistics analysis (Research Question 1), bivariate correlation analysis (Research Questions 2 and 3), Multivariate

Analysis of Variance (MANOVA) (Research Question 4) and Analysis of Variance (ANOVA) (Research Question 5).

Discussions of the Findings

As the result of measurement invariance analysis, which was conducted as a separate study, I determined the factor structure of the TPACK survey instrument was not equivalent across the US and Turkey samples. As a result, I conducted EFA to determine the hypothesized factor structure of the Turkish TPACK scale. Then, I performed CFA to test the hypothesized factor structure of the Turkish TPACK scale obtained through EFA. The factor analysis yielded five factors with 29 items. The factors were labeled: Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). Similar to other research studies in the literature (e.g., Koh et al., 2010; Zelkowski et al., 2013), I also observed the disappearance of some subscales within the TPACK survey instrument. In parallel with Zelkowski and his colleagues' research study (2013), I found neither the Technological Content Knowledge (TCK) nor Pedagogical Content Knowledge (PCK) components were of consequence in the factor analysis. However, distinct from their research study, I identified a TPK factor in the study. One explanation of this difference is although like their US counterparts, Turkish pre-service secondary mathematics teachers may have difficulty in recognizing reciprocal interactions among Technology and Content, and Pedagogy and Content, they were able to perceive the interactions among Technology and Pedagogy. The is evidenced by the fact PCK and TCK constructs in comparison with TPK had disappeared from initial Turkish TPACK scale after EFA analysis for pre-service secondary mathematics teachers in Turkey. In addition, the findings of the cognitive interviews supported this interpretation as many pre-service teachers highlighted the relationship between technology and pedagogy by drawing attention to use of technology for pedagogic purposes, such as increasing students' motivation towards lessons, making lessons more attractive, and saving time for teaching.

In addition, the cultural and educational differences between the US and Turkey, may lead to different perceptions of some items in the scale for Turkish pre-service secondary mathematics teachers. In this study, a total of 18 items seemed to be loaded into the same constructs in the way the original final version of TPACK scale. Given TK, CK, PK, and TPACK components, items TK1, TK6, CK11, and CK12 did not explain Turkish pre-service teachers' perceptions about the related components (see Table 5 .1 and Appendix B). Conversely, some eliminated items in Zelkowski and his colleagues' study (2013), such as CK15, CK16, PK24, TPACK54, TPACK57, and TPACK61 did explain Turkish pre-service teachers' perceptions about the relevant components (see Appendix B). Further, the eliminated TPK44, TPK48, and TPK50 items in Zelkowski and his colleagues' study (2013) yielded TPK component for my research study. In addition, TPK46 and TPK47 items designed for TPK component in Zelkowski and his colleagues' study (2013), but removed from their TPACK scale, served to explain Turkish pre-service teachers' perceptions on TPACK component (see Table 5. 1) instead of TPK component for this study.

Table 5.1 *The Comparison of the Previous TPACK Research Study and the Present TPACK Research Study*

Zelkowski and his colleagues' Research Study (2013)		**The Present Research Study**	
Factors	**Items**	**Factors**	**Items**
TK	TK1, TK2, TK3, TK4, TK5, TK6	TK	TK2, TK3, TK4, TK5
CK	CK9, CK11, CK12, C13, CK14	CK	CK9, CK13, CK14, CK15, CK16
PK	PK17, PK18, PK19, PK20, PK21	PK	PK17, PK18, PK19, PK20, PK21, PK24
TPK		TPK	TPK44, TPK48, TPK50
TPACK	TPACK51, TPACK52, TPACK53, TPACK55, TPACK59, TPACK60	TPACK	TPK46, TPK47, TPACK51, TPACK52, TPACK53, TPACK54, TPACK55, TPACK57, TPACK59, TPACK60, TPACK61

Note. TPK is not a construct for Zelkowski and his colleagues' final TPACK instrument

After identifying the factor structure of the Turkish TPACK scale, I utilized these five factors as the dependent variables in my analysis procedures to answer my research questions. The results of descriptive analysis pertaining to the research question 1 indicated that regardless of demographic differences, pre-service secondary mathematics teachers held relatively higher perceptions regarding TK, PK, and TPK and held lowest perceptions regarding CK. Considering gender independent variable, the mean values of female pre-service teachers' perceptions of PK and TPK were higher than their male counterparts while the mean values of male pre-service teachers' perceptions of TK, CK, and TPACK were higher than those of female pre-service teachers. In addition, descriptive statistics revealed an increase of year of enrollment improved pre-service teachers' perceptions of their TPACK and CK (see Figure 5.1). Although descriptive statistics provided mean differences for some of TPACK components, it should not be forgotten that there were in need of more inferential testing to show if these differences were statically significant. In other words, descriptive statistics could provide a general depiction about the sample.

In order to answer my second research question, I examined the relationships among TK, CK, PK, TPK, and TPACK components through correlation analysis. The results of the correlation analysis revealed that all relationships among TPACK components were statistically significant, although the correlations themselves were mostly in the low range. The correlations among TK, CK, PK, and TPK components were found to be low with the exception of the relationship between PK and TPK, which was in the moderate range. The relationships of TPACK component with the other components however, were all found to be of moderate correlation.

According to Koehler, Mishra, and Yahya (2007), effective teaching of subject matter through technology not only depends on content, pedagogy, and technology, but also the relationships among them. In other words, the relationships among TK, CK, and PK components may be used to determine effectively technology integration in teaching mathematics. Therefore, one may interpret the low positive correlations among TK, CK, and PK as a need for the secondary mathematics education programs in Turkey to develop and introduce new courses or redesign current courses, which would highlight these relationships.

I also investigated the relationship of Turkish pre-service secondary mathematics teachers' attitudes towards Computer-Aided Education with their perceptions about

TPACK components. My correlations analysis indicated all relationships between Attitude and TPACK components had statistically significant correlations. There were positive linear relationships with moderate effect size between Attitude and each of the TK and TPACK components; and low effect size in regards to Attitude and each of the CK, PK, and TPK components. From these results, I posit an increase in pre-service teachers' positive attitudes towards the use of technology across their educational program can lead to higher perceptions of TPACK.

I also investigated the effects of gender and year of enrolment on Turkish pre-service secondary mathematics teachers' perceptions regarding TPACK components by performing MANOVA. The findings indicated gender had statistically significant effects on the linear combination of TK, CK, PK, TPK, and TPACK components. Following MANOVA, a univariate ANOVA analysis was conducted to determine which TPACK components differentiated on gender. The results of ANOVA displayed that male pre-service secondary mathematics teachers had higher perceptions on TK and CK than female counterparts while identifying no statistically significant mean differences for their perceived PK, TPK, and TPACK domains. Similar to my findings, other research studies in the literature found male pre-service teachers' perception level in TK and/or CK was/were higher than females (Erdogan & Sahin, 2010; Koh et al., 2010; Canbolat, 2011; Cetin-Berber & Erdem, 2015). However, at other times my findings were inconsistent with the findings in Turkish research studies (Erdogan & Sahin, 2010; Canbolat, 2011) as these researchers found statistically mean differences in TPK and TPACK according to gender. The differing results in my study may be attributed to the fact that the TPACK scale used in this study was specific to pre-service secondary mathematics teachers, while others were not.

In addition, it should be noted that my research study was quite different from the aforementioned research studies with regards to the population that were used, TPACK survey instruments, and their factor structures; even though this current study found some extent similar or distinct findings with their results. The target population for Erdogan and Sahin' (2010) research study was Turkish pre-service elementary and secondary mathematics teachers. And, they used a TPACK survey instrument (Sahin, 2011) designed for all pre-service teachers without considering any specific content knowledge, as well as its factor structure included seven TPACK knowledge domains. In a similar way, the research study conducted by Canbolat (2011) used the same TPACK scale (Sahin, 2011) to investigate pre-service elementary mathematics teachers in Turkey. Further, Cetin-Berber and Erdem (2015) utilized a TPACK survey instrument (Schmidt et al., 2009) to collect data from all pre-service teachers in Turkey. Although this TPACK survey instrument was adapted into Turkish language and context by Kaya and Dag (2013), they did not conduct measurement invariance analysis to check if its factor structure was equivalent to across the Turkey and the USA samples. As for Koh et al.'s research study (2010), their target population was Singapore pre-service elementary and secondary teachers. Although their TPACK instrument' factor structure consisted of 5 factors, it also used general statements for content knowledge without focusing on a specific content area.

I performed another MANOVA to examine the effects of year of enrollment on the combined TK, CK, PK, TPK, and TPACK dependent variables. The findings of MANOVA, follows-up univariate ANOVAs and post hoc Tukey' HSD indicated fifth grade participants' level of perception in CK and TPACK were better than both first and second grade participants. Third grade participants also have higher perception levels than first grade participants in terms of CK. Although other research studies also determined mean differences in pre-service teachers perceived PK and TPK (Canbolat, 2011; Cetin-Berber & Erdem, 2015) with respect to year of enrollment, I did not found any significant mean differences for TK, PK, and TPK in this study.

Finally, this study examined the effects of gender and year of enrollment on Turkish pre-service secondary mathematics teachers' attitudes towards Computer-Aided Education. The results of ANOVAs revealed that male pre-service teachers' attitude was not statistically different from females' attitude. On the other hand, I found statistically significant mean differences for the pre-service teachers' attitude with regard to year of enrollment. Following ANOVAs, a post hoc Tukey's HSD procedure indicated that fifth grade pre-service teachers held more positive attitude towards use of technology or computers in education than second grades and first grade pre-service teachers. In addition, third grade pre-service teachers also held more positive attitude than first grade pre-service teachers. Therefore, these results imply that as Turkish pre-service secondary mathematics teachers progress through their program, they tend to develop more positive attitude towards the use of technology for mathematics teaching.

Implications for Practice

This study has some important implications for secondary mathematics education, especially in Turkey. Perhaps most importantly, this study served to adapt and validate the TPACK survey instrument into the Turkish language and context, and will now be available for use throughout Turkey. In terms of the adapted Turkish TPACK survey instrument, Turkish teacher educators or educational policymakers may evaluate the effectiveness of current courses with respect to their contribution to the development of pre-service teachers' TPACK domains. In addition, the Turkish TPACK survey instrument may be useful to assess contributions of newly designed courses in the secondary mathematics education for pre-service teachers' TPACK development by utilizing experimental studies.

The findings of this study also provided a general description of Turkish pre-service secondary mathematics teachers' perceived TPACK and their attitudes towards use of technology in education. During the adaptation of TPACK scale, I was confronted with a problem related to the disappearance of TCK and PCK components within the TPACK scale. This implies that Turkish pre-service teachers may be in need of new mathematics teaching courses in integration with technology, such as Algebra Teaching, Geometry Teaching, and Probability and Statistics Teaching, so that they can develop a knowledge associated with TCK and PCK. In addition, the results of correlation analysis showed that most of the relationships among TK, CK, and PK component were not sufficiently strong. According to Mishra and Koehler (2006), teachers need to understand mutual complex relationships among TK, CK, and PK in order to integrate technology into their teaching. In this regard, the findings in this study may imply that Turkish pre-service secondary mathematics teachers need new or redesigned technology-based mathematics courses and mathematics method courses that would highlight the complex relationships among technology, pedagogy and secondary mathematics. These new or redesigned courses should provide pre-service teachers a learning environment in which they can simultaneously learn technology, secondary mathematics content, and pedagogy. By means of these courses, pre-service teachers may have an opportunity to understand how to teach secondary mathematics content applying pedagogical strategies and technologies peculiar to it while they are learning secondary mathematics in the same way. In addition, these courses and field placements should provide opportunities for pre-service teachers so that they can gain enough experiences for teaching, planning lessons, and designing lesson materials towards use of technology as a learning tool.

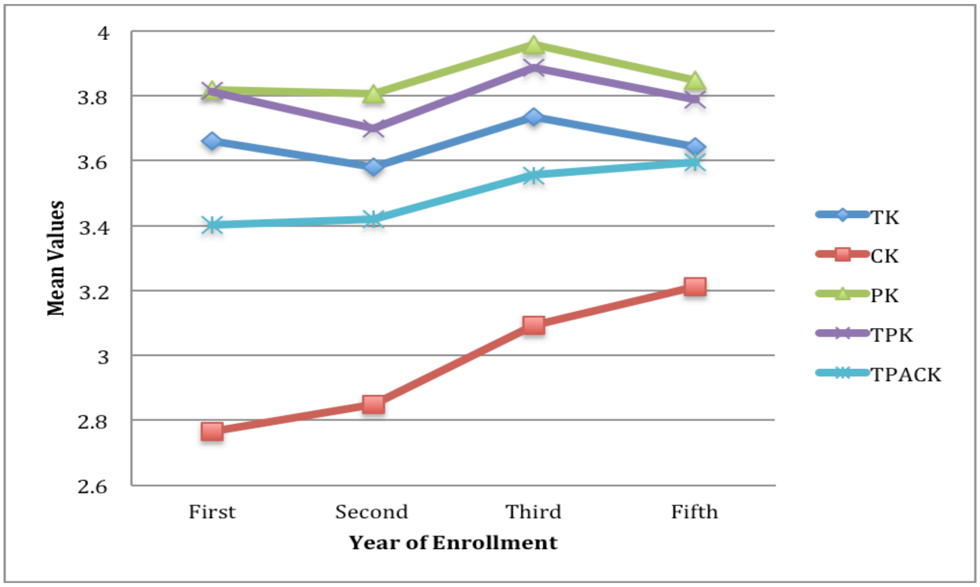
Another important finding for Turkish teacher educators is that Turkish pre-service secondary mathematics teachers had the lowest perceptions on secondary mathematics content knowledge while they had the highest knowledge on pedagogy. A lack of content knowledge can be a significant barrier to for Turkish pre-service teachers' development of TCK, PCK, and TPACK since these knowledge bases only can occur through the interactions of CK with TK and PK (Mishra & Koehler, 2006). And therefore, a lack of content knowledge might hinder the development of the aforementioned knowledge domains. Understanding pre-service teachers' current perception levels of CK may encourage Turkish teacher educators or educational policy makers to closely examine why existing mathematics courses resulted in preservice secondary mathematics teachers' having the lowest perception level on CK.

Limitations

Although this study served to adapt the TPACK survey instrument into the Turkish language and provided significant results associated with Turkish pre-service secondary mathematics teachers' perceived TPACK, it also had some limitations.
Since the population in this study was large and widespread, coming from 16 education faculties located 6 of 7 different geographical regions in Turkey, random selection of participants was impractical. Therefore, this study used a non-random sample selection to collect data. The data in this study was obtained from participants who were available and agreed to participate within the 12 universities that allowed the data collection during the fall semester of 2016. Due to non-randomized selection of the sample, the sample in this study may have an issue related to representativeness of the population even though it reached a total of 778 Turkish pre-service secondary mathematics teachers. In addition, this study did not include any 4th grade pre-service teachers, as a decision of the Council of Higher Education did not accept new teachers into secondary education program in the academic year of 2013-2014. Thus, this situation also may be considered as an issue related to absence of representative of 4th grade pre-service teachers in this study.

However, I posited that the absence of representative 4th grade pre-service teachers did not substantially influence to this study since the mean value of TPACK components for 4th grade preservice teachers could roughly estimate by considering the trend of mean values across year of enrollment (see Figure 5.1). The mean values for CK and TPACK components indicated continuous increase as the grade level progressed; and therefore, it can be assumed 4th grade pre-service teachers' mean values for these components were between those of 3rd and 5th grades. When the trend of the mean values for TK, PK, and TPK components across year of enrollment was examined, the decrease of mean values of 2nd grades for the relevant components may be stemmed from the majority of courses for 2nd grade have consisted of pure mathematics courses (see Figure 5.1). In a similar way, it may be predicted 4th grade pre-service teachers' mean values for TK, PK, and TPK would be lower than 3th grades, and also higher than 5th grades; since the proportion of the courses related to technology and pedagogy in the secondary mathematics education coursework decreases from 3th grade to 5th grade.

Figure 5.1 *The Mean Value Changes for TPACK Components with respect to Year of Enrollment*



Another limitation of this study stemmed from the utilization of survey methodology. According to Green, Camilli, and Elmore (2006), surveys are very beneficial to collect information related to participants' perceptions about their behavior or knowledge, but they have limitations arising from participants' potential to provide responses in an honest and willing way, or to not accurately remembering situation or events. Although, this study employed an expert review, cognitive interviews, EFA, CFA, and reliability analysis processes to obtain content validity, construct validity and reliability of the Turkish TPACK survey instrument, the aforementioned limitations could be a threat to statistical conclusion validity.

Recommendations for Future Research

This research study used quantitative research methodology to adapt the TPACK survey instrument to the Turkish language and presented an overview of Turkish pre-service secondary mathematics teachers' perceptions about TPACK domains. In addition, it revealed the relationships among TPACK components and Attitude towards use of technology in education as well as the effects of demographic differences on Turkish pre-service teachers' perceptions of TPACK components and Attitude. Although this study sought to address the research gap related to TPACK research studies on secondary mathematics in Turkey, it was not able to present information to explain why gender or year of enrollment had effects on pre-service teachers' perceptions. Therefore, future studies using qualitative research methodologies may focus on why female pre-service secondary mathematics teachers had lower perceptions on TK and CK than males. In addition, future studies may be conducted to investigate why pre-service teachers' perceptions were not differentiated on TK, PK, and TPK while they were differentiated on CK and TPACK with respect to year of enrollment.

Moreover, future studies may be carried out to explore the contribution of method courses, technology-based mathematics courses, and field experiences in secondary mathematics education program for pre-service teachers' TPACK development by utilizing qualitative and/or quantitative research methods. In addition, the Turkish TPACK survey instrument might be extended to examine in-service secondary mathematics teachers in Turkey. Therefore, future research studies may be conducted to examine in-service teachers' perceptions on TPACK domains and factors that might affect their use of technology in mathematics teaching.

APPENDICES

Appendix A

The Forward Translation of the TPACK Survey Instrument in Turkish Language

Items	Teknoloji Bilgisi (TB)
TK1	**1.**Teknik problemlerimi nasıl çözeceğimi biliyorum.
TK2	**2.** Teknolojiyi kolaylıkla öğrenebilirim.
TK3	**3.** Önemli yeni teknolojileri takip ederim/ ayak uydurabilirim.
TK4	**4.** Sıklıkla teknolojiyle haşir nesir olurum.
TK5	**5.** Birçok farklı teknoloji hakkında bilgi sahibiyim.
TK6	**6.** Teknoloji kullanmak için gereken teknik becerilere sahibim.
TK7	**7.** Farklı teknolojilerle yeterince çalışma fırsatı buldum.
TK8	**8.** Teknoloji kullanırken bir problemle karşılaştığımda, dışardan yardım talebinde bulunurum.
	Alan Bilgisi (AB)
CK9	**9.** Matematik hakkında yeterli bilgiye sahibim.
CK10	**10.** Matematiksel düşünme yöntemlerini kullanabilirim.
CK11	**11.** Matematiksel anlayışımı veya anlamamı geliştirmek için çeşitli stratejilere sahibim.
CK12	**12.** Gerçek hayatta, matematiğin nasıl uygulandığını gösteren çeşitli örnekler bilirim.
CK13	**13.** Cebir hakkında derin ve geniş bir anlayışa sahibim.
CK14	**14.** Geometri hakkında derin ve geniş bir anlayışa sahibim.
CK15	**15.** Analiz hakkında derin ve geniş bir anlayışa sahibim.
CK16	**16.** İleri derecede lisans matematiği hakkında derin ve geniş bir anlayışa sahibim.

Pedagoji Bilgisi (PB)

PK17 **17.** Sınıf içerisinde öğrenci performansını nasıl değerlendireceğimi bilirim.

PK18 **18.** Öğrencilerin mevcut durumda neyi anlayıp neyi anlayamadıklarına göre, öğretme etkinliklerimi düzenleyebilirim.

PK19 **19.** Farklı şekilde öğrenen öğrencilere göre öğretim stilimi uyarlayabilirim.

PK20 **20.** Farklı yöntemlerle öğrencilerin öğrenmesini değerlendirebilirim.

PK21 **21.** Sınıf ortamında geniş bir yelpazede öğretim yaklaşımlarını kullanabilirim.

PK22 **22.** Yaygın öğrenci kavrayışlarını ve kavram yanılgılarını iyi bilirim.

PK23 **23.** Sınıf yönetimini nasıl sürdüreceğimi(koruyacağımı) ve organize edeceğimi iyi bilirim.

PK24 **24.** Sınıf ortamında çeşitli öğretim yaklaşımlarını (problem/proje tabanlı öğrenme, sorgulayıcı öğrenme, işbirlikçi öğrenme ve düz anlatım gibi) kullanmak için uygun zamanı bilirim.

Pedagojik Alan Bilgisi (PAB)

PCK25 **25.** Matematikte öğrencinin düşünmesine ve öğrenmesine rehberlik etmek/yol göstermek için etkili olabilecek öğretme yaklaşımlarını nasıl seçeceğimi bilirim.

PCK26 **26.** Oran ve orantı kavramlarını öğretmek için farklı yaklaşımları/stratejileri bilirim.

PCK27 **27.** Olasılık ve istatistik kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.

PCK28 **28.** Cebir kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.

PCK29 **29.** Geometri kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.

PCK30 **30.** Trigonometri kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.

PCK31 **31.** Analiz kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.

	Teknolojik Alan Bilgisi (TAB)
TCK32	**32.** Oran ve orantı hesabi yapmak (uygulamak) ve anlamak için kullanabileceğim teknolojileri bilirim.
TCK33	**33.** Olasılık ve istatistik hesabi yapmak (uygulamak) ve anlamak için kullanabileceğim teknolojileri bilirim.
TCK34	**34.** Cebir hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.
TCK35	**35.** Geometri hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.
TCK36	**36.** Trigonometri hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.
TCK37	**37.** Analiz hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.
	Teknolojik Pedagoji Bilgisi (TPB)
TCK38	**38.** Kişinin matematik kavramlarını anlamasını geliştirebilecek uygun teknolojiler kullanmayı bilirim.
TPK39	**39.** Bir dersin öğretim sürecini zenginleştiren(geliştiren, güzelleştiren ve arttıran) teknolojileri seçebilirim.
TPK40	**40.** Bir derste öğrencilerin öğrenmelerini geliştiren (ilerleten) ve kuvvetlendiren teknolojileri seçebilirim.
TPK41	**41.** Fakültede aldığım öğretmen eğitim programım; sınıfımda kullanacağım öğretim yaklaşımlarını, teknolojinin nasıl etkileyebileceği konusunda daha derin bir şekilde düşünmeme neden oldu.
TPK42	**42.** Sınıfımda teknolojiyi nasıl kullanacağım hakkında ciddi olarak düşünüyorum.
TPK43	**43.** Hakkında bilgi sahibi olduğum teknolojilerin kullanımını, farklı öğretme aktivitelerine uyarlayabilirim.
TPK44	**44.** Farklı öğretim yaklaşımları farklı teknolojileri gerektirir.
TPK45	**45.** Öğretim içerisinde uygun olarak teknoloji kullanmak için gereken teknik becerilere sahibim.
TPK46	**46.** Öğretim içerisinde uygun bir şekilde teknoloji kullanmak için gereken sınıf yönetimi becerilerine sahibim.
TPK47	**47.** Farklı öğretim yaklaşımları içerisinde teknolojiyi nasıl kullanacağımı biliyorum.

TPK48	**48.** Bir sınıf içerisinde teknoloji kullandığım zaman, ona göre öğretme yaklaşımlarım da değişir.
TPK49	**49.** Belirli bir teknolojinin nasıl kullanıldığını bilmek, onu derslerde öğretme amaçlı kullanabileceğimiz anlamına gelir.
TPK50	**50.** Farklı teknolojiler farklı öğretme yaklaşımlarını gerektirir.
	Teknolojik Pedagojik Alan Bilgisi (TPAB)
TPACK51	**51.** Sınıfta, akademik çalışmalarım içerisinde öğrendiğim öğretim yaklaşımları, teknolojiler ve matematiği bir araya getiren (birleştiren) stratejiler kullanabilirim.
TPACK52	**52.** Bir ders için matematiğin değerini arttıran (geliştiren, zenginleştiren) teknolojileri seçebilirim.
TPACK53	**53.** Ne öğrettiğimi, nasıl öğrettiğimi ve öğrencilerin ne öğrendiklerini geliştirecek/ ilerletecek teknolojileri sınıfımda kullanmak için seçebilirim.
TPACK54	**54.** Okulumda ve/veya eğitim bölgemde matematik, teknoloji ve öğretim yaklaşımlarının kullanımını koordine etmek için başkalarına yardım etmede öncülük edebilirim.
TPACK55	**55.** Uygun olarak matematik, teknoloji ve öğretim yaklaşımlarını bir araya getiren/ birleştiren dersleri öğretebilirim.
TPACK56	**56.** Benim için matematik öğretimine teknolojiyi dahil etmek/entegre etmek, kolay ve anlaşılır olacak.
TPACK57	**57.** Uygun bir şekilde oran ve orantı, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.
TPACK58	**58.** Uygun bir şekilde istatistik ve olasılık, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.
TPACK59	**59.** Uygun bir şekilde cebir, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.
TPACK60	**60.** Uygun bir şekilde geometri, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.
TPACK61	**61.** Uygun bir şekilde trigonometri, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.
TPACK62	**62.** Uygun bir şekilde analiz, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.

Appendix B

The Backwards Translation of the Turkish Version of TPACK Survey to English

Items	Technological Knowledge (TK)
TK1	I know how to solve my technical problems.
TK2	I can easily learn technology.
TK3	I keep up with the recent technologies.
TK4	I often mingle with technologies.
TK5	I am aware of many different technologies.
TK6	I have necessary technical abilities to use technology.
TK7	I have had enough opportunity to work with different technologies.
TK8	I ask for somebody to help me when I meet a problem with using technology.
	Content Knowledge (CK)
CK9	I have enough knowledge of mathematics.
CK10	I can use mathematical thinking methods.
CK11	I have different strategies to develop my mathematical understanding or knowledge.
CK12	I know various examples related to how mathematics applies in the real world.
CK13	I have deep and vast knowledge about algebra.
CK14	I have deep and vast knowledge about geometry.
CK15	I have deep and vast knowledge about analysis.
CK16	I have deep and vast knowledge about undergraduate math in advanced level.
	Pedagogical Knowledge (PK)
PK17	I know how to evaluate student performance in the class.
PK18	I can adjust my teaching depending on whether the students have understood the subject or not.

PK19	I can adjust my way of teaching according to the students having different way of learning.
PK20	I can evaluate the student’s learning in many ways.
PK21	I can use various teaching methods in the class.
PK22	I am familiar with common student concepts and concept misleadings.
PK23	I know well how to sustain and organize class management.
PK24	I know the appropriate time to use various teaching methods (e.g., problem/project based learning, questioning learning, cooperative learning, and simple teaching) in the class.
	Pedagogical Content Knowledge (PCK)
PCK25	I know how to choose effective teaching approaches to guide student’s learning and thinking in math.
PCK26	I know various teaching approaches/strategies to teach the concepts of ratio and proportion.
PCK27	I know different approaches/strategies to teach the concepts of probability and statistics.
PCK28	I know different teaching approaches /strategies to teach the concepts of algebra.
PCK29	I know different teaching approaches /strategies to teach the concepts of geometry.
PCK30	I know different teaching approaches /strategies to teach the concepts of trigonometry.
PCK31	I know different teaching approaches /strategies to teach the concepts of analysis.
	Technological Content Knowledge (TCK)
TCK32	I know the technologies that I can employ to understand and calculate ratio and proportion problems.
TCK33	I know the technologies that I can employ to understand and calculate probability and statistics problems.

TCK34 I know the technologies that I can employ to understand and calculate algebra problems.

TCK35 I know the technologies that I can employ to understand and calculate geometry problems.

TCK36 I know the technologies that I can employ to understand and calculate trigonometry problems.

TCK37 I know the technologies that I can employ to understand and calculate analysis problems.

TCK38 I know the use of appropriate technology to improve the student's understanding of mathematical concepts.

Technological Pedagogical Knowledge (TPK)

TPK39 I can choose the technologies which enrich/improve the teaching of a course.

TPK40 I can choose the technologies that improve (enrich) and strengthen the learning of student for a lesson

TPK41 Teacher training program has caused me to think deeply on how technology would influence the teaching approaches I would use in the class.

TPK42 I seriously think over how I can use technology in my class.

TPK43 I can adapt the use of technologies about which I have information to different teaching activities.

TPK44 Different teaching approaches require different technologies.

TPK45 I have adequate technical abilities to use technology in my teaching process properly.

TPK46 I have adequate class management skills to use technology in my teaching process properly.

TPK47 I know how to use technology in different teaching approaches.

TPK48 Once I use technology in the class, my teaching approaches also change in accordance with it.

TPK49 Knowing how to use a specific technology means using it for teaching.

TPK50	Different technologies require different teaching approaches.
	Technological Pedagogical Content Knowledge (TPACK)
TPACK51	I can use strategies in the class, which gather the teaching approaches, technologies, and mathematics that I have learnt during my academic studies.
TPACK52	I can choose the technologies which improve/enrich the value of mathematics.
TPACK53	I can choose the technologies, which will increase/improve what I have taught, how I have taught and what the students have learnt.
TPACK54	I can lead the other people to coordinate the use of mathematics, technology and teaching approaches in my school, my district or my educational district.
TPACK55	I can teach the courses which combine /gather mathematics, technology and teaching approaches.
TPACK56	It will be easy and understandable for me to integrate technology into the teaching of mathematics.
TPACK57	I can teach the lessons, which combine ratio and proportion, technology, and teaching approaches properly.
TPACK58	I can teach the lessons, which combine statistics and probability, technology, and teaching approaches properly.
TPACK59	I can teach the lessons, which combine algebra, technology, and teaching approaches properly.
TPACK60	I can teach the lessons, which combine geometry, technology, and teaching approaches properly.
TPACK61	I can teach the lessons, which combine trigonometry, technology and teaching approaches properly.
TPACK62	I can teach the lessons, which combine analysis, technology, and teaching approaches properly.

Appendix C

The Attitude Scale for Computer- Aided Education

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Computer technologies cannot be used efficiently in education.					
2. I would like to use computer technologies in a willing way in my class.					
3. If it is not necessary, I do not use computer technologies to support the lesson.					
4. Computer-aided education (CAE) is an important topic for me.					
5. During teaching with CAE, students do not improve their creativeness.					
6. I look for effective techniques in order to use computer technologies for my teaching.					
7. I do not associate computer technologies with education.					
8. Students learn better in lessons in which computer technologies are used.					
9. I would prefer to teach my classes without using computer technologies.					
10. Teachers should encourage to computer technologies for teaching.					
11. Have a class with CAE is loss of time.					
12. Computer technologies are an effective tool to arouse students' interests.					
13. Students learn less the lessons with use of computer technologies than use of other teaching approaches and methods.					
14. Teaching with CAE is fun for students.					
15. CAE does not encounter teachers' affords.					
16. Computer technologies should be actively used for each class.					

17. I do not think to use of computer technologies with the intent of instruction in my class.					
18. I think computer technologies are effective learning tools.					
19. I would like to go away from the computer immediately when I am on the computer.					
20. I try to use computer technologies during my teaching.					

Appendix D

Questions for the Content Experts

Directions: Please read the original version of TPACK survey instrument and profoundly review the translated version of TPACK survey instrument in Turkish. Then, please answer the following questions by considering the translated TPACK survey instrument.

1. What is your overall impression of the survey?
    a. What other questions do you think we should ask?
2. Were there any items that were unclear? If so,
    a. Please state the item(s) number:
    b. Please explain your confusion about the item(s) and why you had difficulty in understanding the item(s):
    c. If possible, please suggest how the item might be altered to overcome the comprehension issue.
3. Have you faced with any item(s) in the translated instrument that does not represent the original item(s) or has loss of meaning? If so,
    - Please state the item(s) number:
    - Please explain your reason(s) about why the item (s) might had been loss of meaning:
    - If you have any suggestion(s) to overcome the loss of meaning with regard to the item(s), please explain:
4. Have you faced with any item(s) in the translated instrument, in which you think that the relevant item(s) has inappropriate selection of words or phrases in terms

of terminology of secondary mathematics, pedagogy and technology in Turkish language and context?

- Please state the item(s) number:
- Please state the inappropriate word(s) or phrase(s) in these items and give suggestions about more feasible word(s) or phrase(s):

5. When considering the mathematics contents in the translated items, do you think Turkish pre-service secondary mathematics teachers will be able to recognize the differences among:

    a. Ratio and proportion
    b. Probability and statistics
    c. Algebra
    d. Geometry
    e. Trigonometry
    f. Analysis (Calculus)

    If not, please give suggestions for making the translated items related to the mathematics areas mentioned above more understandable

6. Have you faced with any translated item(s) in the instrument in which you think it is be able to be inapplicable for Turkish pre-service mathematics teachers to determine their perceived TPACK?

    - If so, which item(s) might be inappropriate?
    - Why do you think that the item(s) is able to be inappropriate? Please explain and give suggestions to make the item(s) more suitable:

7. Do the answer options for each translated items make sense?
    - If not, what changes will you suggest?
8. Do you have any other thoughts, concerns, suggestions or comments? Please explain:

Appendix E

The Revisions for the Turkish TPACK Scale after the two Native English Speakers' Reviews

Items	The Draft for the Turkish TPACK Scale	The Backward Translated Version	Accepted Revise in Turkish	Accepted Revise for the Backward Translation
22	Yaygın öğrenci kavrayışlarını ve kavram yanılgılarını iyi bilirim.	I am familiar with common student concepts and concept misleadings.		I am well acquainted with common student conceptions and misconceptions.
39	Bir dersin öğretim sürecini zenginleştiren(geliştiren, güzelleştiren ve arttıran) teknolojileri seçebilirim.	I can choose the technologies which enrich/improve the teaching of a course.		I can choose the technologies which enrich/improve the teaching of a lesson.
42	Sınıfımda teknolojiyi nasıl kullanacağım hakkında ciddi olarak düşünüyorum.	I seriously think over how I can use technology in my class.	Sınıfımda teknolojiyi nasıl kullanacağım hakkında yoğun bir şekilde (derinlemesine) düşünüyorum.	I intensely (deeply) think about how to use technology in my class.

51	Sınıfta, akademik çalışmalarım içerisinde öğrendiğim öğretim yaklaşımları, teknolojiler ve matematiği bir araya getiren (birleştiren) stratejiler kullanabilirim.	I can use strategies in the class, which gather the teaching approaches, technologies, and mathematics that I have learnt during my academic studies.		I can use strategies in the class, which combine the teaching approaches, technologies, and mathematics that I have learned during my academic studies.

Appendix F

The Revisions for the Turkish TPACK Scale after the Expert Reviews

Items	The Draft for the Turkish TPACK Scale	The Backward-Translated Version	Accepted Revise in Turkish	Accepted Revise for the Backward Translation
4	Sıklıkla teknolojiyle haşir nesir olurum.	I often mingle with technologies.	Sıklıkla teknolojiyle oyalanırım/vakit geçiririm.	I often fiddle around (spend time) with technologies.
12	Gerçek hayatta, matematiğin nasıl uygulandığını gösteren çeşitli örnekler bilirim.	I know various examples related to how mathematics applies in the real world.	Matematiğin gerçek hayattaki uygulamalarının çeşitli örneklerini bilirim.	I know various examples of real life practices of mathematics.
21	Sınıf ortamında geniş bir yelpazede öğretim yaklaşımlarını kullanabilirim.	I can use various teaching methods in the class.	Sınıf ortamında birden çok(çeşitli, farklı farklı) öğretme yaklaşımlarını kullanabilirim.	I can use multiple (diverse, different) teaching approaches in a classroom setting.
32	Oran ve orantı hesabi yapmak (uygulamak) ve anlamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can employ to understand and calculate ratio and proportion problems.	Oran ve orantı kavramlarını anlamak ve hesaplamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can use to understand and calculate the concepts of ratio and proportion.

33	Olasılık ve istatistik hesabi yapmak (uygulamak) ve anlamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can employ to understand and calculate probability and statistics problems.	Olasılık ve istatistik hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can use to make probability and statistics calculations and to understand it.
34	Cebir hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can employ to understand and calculate algebra problems.	Cebiri anlamak ve hesaplamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can use to understand algebra and make algebraic calculations.
35	Geometri hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can employ to understand and calculate geometry problems.	Geometriyi anlamak ve hesaplamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can use to understand and calculate geometry.
36	Trigonometri hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can employ to understand and calculate trigonometry problems.	Trigonometriyi anlamak ve hesaplamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can use to understand trigonometry and make trigonometric calculations
37	Analiz hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can employ to understand and calculate analysis problems.	Analiz hesabi yapmak ve anlamak için kullanabileceğim teknolojileri bilirim.	I know the technologies that I can use to make analysis calculations and understand it.

45	Öğretim içerisinde uygun olarak teknoloji kullanmak için gereken teknik becerilere sahibim.	I have adequate technical abilities to use technology in my teaching process properly.	Derslerimde teknolojiyi uygun bir şekilde kullanmak için gereken teknik becerilere sahibim.	I have the technical skills requiring to use technology appropriately in my lessons.
46	Öğretim içerisinde uygun bir şekilde teknoloji kullanmak için gereken sınıf yönetimi becerilerine sahibim.	I have adequate class management skills to use technology in my teaching process properly.	Derslerimde teknolojiyi uygun bir şekilde kullanmak için ihtiyaç duyduğum sınıf yönetimi becerisine sahibim.	I have the class management skills requiring to use technology appropriately in my lessons.
57	Uygun bir şekilde oran ve orantı, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons, which combine ratio and proportion, technology, and teaching approaches properly.	Oran ve orantı kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons, which combine to technology and teaching approaches that are suitable for the concepts/subjects of ratio and proportion.
58	Uygun bir şekilde istatistik ve olasılık, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons, which combine statistics and probability, technology, and teaching approaches properly.	İstatistik ve olasılık kavramlarına/ konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons, which combine to technology and teaching approaches that are suitable for the concepts/subjects of statistics and probability.

59	Uygun bir şekilde cebir, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons which combine algebra, technology, and teaching approaches properly.	Cebir kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons, which combine to technology and teaching approaches that are suitable for the concepts/subjects of algebra.
60	Uygun bir şekilde geometri, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons which combine geometry, technology, and teaching approaches properly.	Geometri kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons, which combine to technology and teaching approaches that are suitable for the concepts/subjects of geometry.
61	Uygun bir şekilde trigonometri, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons which combine trigonometry, technology and teaching approaches properly.	Trigonometri kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons, which combine to technology and teaching approaches that are suitable for the concepts/subjects of trigonometry.
62	Uygun bir şekilde analiz, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons which combine analysis, technology, and teaching approaches properly.	Analiz kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.	I can teach the lessons, which combine to technology and teaching approaches that are suitable for the concepts/subjects of analysis.

Appendix G

Cognitive Interview Protocol

<u>Directions:</u> Please take the translated version of TPACK survey instrument in Turkish. As soon as you have completed the survey instrument, please answer the following questions to the best of your ability.

1. How much time did you take to complete to the Turkish version of TPACK survey instrument?
    a. Was it too long or too short?
2. What is your overall impression of the survey?
    a. What other questions do you think we should ask?
3. Were there any items that were unclear?
    a. Please state the item(s) number:
    b. Please explain your confusion about the item(s) and why you had difficulty in understanding the item(s):
    c. If possible, please suggest how the item might be altered to overcome the comprehension issue.
    d. Did you read any item(s) in the survey instrument in which you believed the selections of word(s) or phrase(s) in terms of terminology of secondary mathematics, pedagogy and/or technology were not appropriate or caused confusion? Please state the item(s) numbers:
4. Do the answer options for each translated items make sense?

    a. If not, what changes would you suggest?

5. When considering the wording in item 4,
    a. What is your understanding of the statement in this item? Please explain:
    b. How did you interpret the verb ‘mingle with’? Please explain:
6. What does the word technologies mean?
7. What comes to your mind when you think of:
    a. Ration and proportion
    b. Probability and statistics
    c. Algebra
    d. Geometry
    e. Trigonometry
    f. Analysis (Calculus)
8. Do you have any other thoughts, concerns, suggestions or comments? Please explain:

Appendix H

The Revisions of the Turkish TPACK Scale after the Cognitive Interviews

Items	Turkish version after Expert Reviews	English version after Expert reviews	Accepted Revise in Turkish	Accepted revise in English
1	Teknik problemlerimi nasıl çözeceğimi biliyorum.	I know how to tackle my technical problems.	Teknolojiyle ilgili teknik bir problemle karşılaştığımda, onu nasıl çözeceğimi biliyorum.	When I encounter a technical problem related to technology, I know how to solve it.
4	Sıklıkla teknolojiyle oyalanırım/vakit geçiririm.	I often fiddle around (spend time) with technologies	Sıklıkla teknolojiyle ilgilenirim/uğraşırım/vakit geçiririm.	I am often interested in (spend time/cope with) the technologies.
16	İleri derecede lisans matematiği hakkında derin ve geniş bilgiye sahibim.	I have deep and vast knowledge about undergraduate math in advanced level.	Lisans matematiği hakkında ileri seviyede derin ve geniş bilgiye sahibim.	I have deep and extensive knowledge in advanced level about undergraduate math
51	Sınıfta, akademik çalışmalarım içerisinde öğrendiğim öğretim yaklaşımları, teknolojiler ve matematiği bir araya getiren (birleştiren) stratejiler kullanabilirim.	I can use strategies in the class, which combine the teaching approaches, technologies, and mathematics that I have learnt during my academic studies.	Sınıfta, lisans eğitimim esnasında öğrendiğim öğretim yaklaşımlarını, teknolojileri ve matematiği bir araya getirecek (birleştiren) stratejileri kullanabilirim.	I can use strategies in the class, which combine the teaching approaches, technologies and mathematics that I have learnt during my undergraduate education.

52	Bir ders için matematiğin değerini arttıran (geliştiren, zenginleştiren) teknolojileri seçebilirim.	I can choose the technologies which improve/enrich the value of mathematics.	Bir matematik dersinde, matematiğin değerini arttıran (geliştiren, zenginleştiren) teknolojileri seçebilirim.	I can choose the technologies which improve/enrich the value of mathematics in a mathematics lesson.

Appendix I

The Initial Turkish TPACK Survey Instrument and the Attitude Scale for Computer-Aided Education

Bu ankete katılmak için zaman ayırdığınız için teşekkürler. Bu çalışma Teknolojik Pedagojik Alan Bilgisi (TPAB) anketi ve Bilgisayar Destekli Eğitim için Turum Ölçeğinden oluşmaktadır. Lütfen her bir soruda size en uygun olan seçeneği işaretleyiniz. Öncelikle demografik bilgilerinizi cevaplayınız, sonra her bir soruyu okuyup ilk kanaatinize göre secim yapınız. Herhangi bir soru üzerinde çok zaman harcamanıza gerek yoktur. Yaklaşık 25 dakikada bu iki anketi tamamlayabilirsiniz.

Sizin düşünceli ve samimi yanıtlarınız fazlasıyla takdir edilecektir. Sizin gizliliğinizi korumak için elimizden gelenin en iyisini yapacağız ve isminiz hiçbir şekilde vermiş olduğunuz cevaplarla ilişkilendirilmeyecektir.

Cevaplarınız tamamen gizli bir şekilde tutulacak ve ders notunuzu etkilemeyecektir.

Demografik Bilgiler

1. Yas Aralığınız:

☐ 19'un altında ☐ 19-22

☐ 23-26 ☐ 27-30

☐ 30'un üstü

2. Lisans Programındaki Yılınız:

☐ Birinci sınıf öğrencisi ☐ İkinci sınıf öğrencisi

☐ Üçüncü sınıf öğrencisi ☐ Dördüncü sınıf öğrencisi

☐ Besinci sınıf öğrencisi ☐ Diğer.................(lütfen belirtiniz)

3. Cinsiyetiniz:

☐ Erkek ☐ Kadın

4. Öğretmenlik meslek uygulaması veya staj dersinizi tamamladınız mi?

☐ Evet ☐ Hayır

Teknoloji birçok şeyi ifade edebilen geniş bir kavramdır. Bu anketin amacı için, teknoloji dijital teknolojilerle ilişkilendirilir. Bizim kullandığımız bilgisayarlar, laptoplar, akıllı tahtalar, tabletler, bilgisayar yazılımları, grafik hesap makineleri ve hesap makineleri gibi dijital araçlar bu çalışmada dikkate alınacak teknolojilerdir. Lütfen bütün soruları işaretleyiniz. Ayrıca herhangi bir sorudan emin değilseniz veya kararsızsanız, o zaman kararsızım/nötürüm seçeneğini işaretleyebilirsiniz.

Bu ankette tüm sorulara verilecek cevaplar, **Kesinlikle Katılmıyorum, Katılmıyorum, Kararsızım/ Nötürüm, Katılıyorum ve Kesinlikle Katılıyorum** seklindedir.

1) Teknolojik Pedagojik Alan Bilgisi Anketi

Teknoloji Bilgisi (TK)	**Kesinlikle Katılmıyorum**	**Katılmıyorum**	**Kararsızım/ Nötürüm**	**Katılıyorum**	**Kesinlikle katılıyorum**
1. Teknolojiyle ilgili teknik bir problemle karşılaştığımda, onu nasıl çözeceğimi biliyorum.					
2. Teknolojiyi kolaylıkla öğrenebilirim.					
3. Önemli yeni teknolojileri takip edebilirim/ ayak uydurabilirim.					
4. Sıklıkla teknolojiyle ilgilenirim/uğraşırım/vakit geçiririm.					
5. Birçok farklı teknoloji hakkında bilgi sahibiyim.					
6. Teknolojiyi kullanmak için gereken teknik becerilere sahibim.					
7. Farklı teknolojilerle yeterince çalışma fırsatı buldum.					
8. Teknoloji kullanırken bir problemle karşılaştığımda, dışardan yardım talebinde bulunurum.					

Alan Bilgisi (AB)	**Kesinlikle Katılmıyorum**	**Katılmıyorum**	**Kararsızım/ Nötürüm**	**Katılıyorum**	**Kesinlikle katılıyorum**
9. Matematik hakkında yeterli bilgiye sahibim.					
10. Matematiksel düşünme yöntemlerini kullanabilirim.					
11. Matematiksel anlayışımı veya anlamamı geliştirmek için çeşitli stratejilere sahibim.					
12. Matematiğin gerçek hayattaki uygulamalarının çeşitli örneklerini bilirim.					
13. Cebir hakkında derin ve geniş bilgiye sahibim.					
14. Geometri hakkında derin ve geniş bilgiye sahibim.					
15. Analiz hakkında derin ve geniş bilgiye sahibim.					
16. Lisans matematiği hakkında ileri seviyede derin ve geniş bilgiye sahibim.					
Pedagoji Bilgisi (PB)					
17. Sınıf içerisinde öğrenci performansını nasıl değerlendireceğimi bilirim.					
18. Öğrencilerin mevcut durumda neyi anlayıp neyi anlayamadıklarına göre, öğretme etkinliklerimi düzenleyebilirim.					
19. Farklı şekilde öğrenen öğrencilere göre öğretim stilimi uyarlayabilirim.					
20. Farklı yöntemlerle öğrencilerin öğrenmesini değerlendirebilirim.					

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım/ Nötürüm	Katılıyorum	Kesinlikle katılıyorum
21. Sınıf ortamında birden çok (çeşitli, farklı farklı) öğretme yaklaşımlarını kullanabilirim.					
22. Yaygın öğrenci kavrayışlarını ve kavram yanılgılarını iyi bilirim.					
23. Sınıf yönetimini nasıl sürdüreceğimi(koruyacağımı) ve organize edeceğimi iyi bilirim.					
24. Sınıf ortamında çeşitli öğretim yaklaşımlarını (problem/proje tabanlı öğrenme, sorgulayıcı öğrenme, işbirlikçi öğrenme ve düz anlatım gibi) kullanmak için uygun zamanı bilirim.					
Pedagojik Alan Bilgisi (AB)					
25. Matematikte öğrencinin düşünmesine ve öğrenmesine rehberlik etmek/yol göstermek için etkili olabilecek öğretme yaklaşımlarını nasıl seçeceğimi bilirim.					
26. Oran ve orantı kavramlarını öğretmek için farklı yaklaşımları/stratejileri bilirim.					
27. Olasılık ve istatistik kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.					
28. Cebir kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.					
29. Geometri kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.					
30. Trigonometri kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.					
31. Analiz kavramlarını/konularını öğretmek için farklı yaklaşımları/stratejileri bilirim.					

Teknolojik Alan Bilgisi (TAB)	**Kesinlikle Katılmıyorum**	**Katılmıyorum**	**Kararsızım/ Nötürüm**	**Katılıyorum**	**Kesinlikle katılıyorum**
32. Oran ve orantı kavramlarını anlamak ve hesaplamak için kullanabileceğim teknolojileri bilirim.					
33. Olasılık ve istatistik hesabi yapmak ve onu anlamak için kullanabileceğim teknolojileri bilirim.					
34. Cebiri anlamak ve cebirsel hesaplamalar yapmak için kullanabileceğim teknolojileri bilirim.					
35. Geometriyi anlamak ve hesaplamak için kullanabileceğim teknolojileri bilirim.					
36. Trigonometriyi anlamak ve trigonometrik hesaplamalar yapmak için kullanabileceğim teknolojileri bilirim.					
37. Analiz hesabi yapmak ve analizi anlamak için kullanabileceğim teknolojileri bilirim.					
38. Kişinin matematik kavramlarını anlamasını geliştirebilecek uygun teknolojiler kullanmayı bilirim.					
Teknolojik Pedagoji Bilgisi (TPB)					
39. Bir dersin öğretim sürecini zenginleştiren(geliştiren, güzelleştiren ve arttıran) teknolojileri seçebilirim.					
40. Bir derste öğrencilerin öğrenmelerini geliştiren (ilerleten) ve kuvvetlendiren teknolojileri seçebilirim.					
41. Fakültede aldığım öğretmen eğitim programım; sınıfımda kullanacağım öğretim yaklaşımlarını, teknolojinin nasıl etkileyebileceği konusunda daha derin bir şekilde düşünmeme neden oldu.					

	Kesinlikle Katılmıyorum	**Katılmıyorum**	**Kararsızım/ Nötürüm**	**Katılıyorum**	**Kesinlikle katılıyorum**
42. Sınıfımda teknolojiyi nasıl kullanacağım hakkında yoğun bir şekilde (derinlemesine) düşünüyorum.					
43. Hakkında bilgi sahibi olduğum teknolojilerin kullanımını, farklı öğretme aktivitelerine uyarlayabilirim.					
44. Farklı öğretim yaklaşımları farklı teknolojileri gerektirir.					
45. Derslerimde teknolojiyi uygun bir şekilde kullanmak için gereken teknik becerilere sahibim.					
46. Derslerimde teknolojiyi uygun bir şekilde kullanmak için gereken sınıf yönetimi becerisine sahibim.					
47. Farklı öğretim yaklaşımları içerisinde teknolojiyi nasıl kullanacağımı biliyorum.					
48. Bir sınıf içerisinde teknoloji kullandığım zaman, ona göre öğretme yaklaşımlarım da değişir.					
49. Belirli bir teknolojinin nasıl kullanıldığını bilmek, onu derslerde öğretme amaçlı kullanabileceğimiz anlamına gelir.					
50. Farklı teknolojiler farklı öğretme yaklaşımlarını gerektirir.					
Teknolojik Pedagojik Alan Bilgisi (TPAB)					
51. Sınıfta, lisans eğitimim esnasında öğrendiğim öğretim yaklaşımlarını, teknolojileri ve matematiği bir araya getirecek (birleştiren) stratejileri kullanabilirim.					
52. Bir matematik dersinde, matematiğin değerini arttıran (geliştiren, zenginleştiren) teknolojileri seçebilirim.					

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım/ Nötürüm	Katılıyorum	Kesinlikle katılıyorum
53. Ne öğrettiğimi, nasıl öğrettiğimi ve öğrencilerin ne öğrendiklerini geliştirecek/ ilerletecek teknolojileri sınıfımda kullanmak için seçebilirim.					
54. Okulumda ve/veya eğitim bölgemde matematik, teknoloji ve öğretim yaklaşımlarının kullanımını koordine etmek için başkalarına yardım etmede öncülük edebilirim.					
55. Uygun olarak matematik, teknoloji ve öğretim yaklaşımlarını bir araya getiren/ birleştiren dersleri öğretebilirim.					
56. Benim için matematik öğretimine teknolojiyi dahil etmek/entegre etmek, kolay ve anlaşılır olacak.					
57. Oran ve orantı kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.					
58. İstatistik ve olasılık kavramlarına/ konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.					
59. Cebir kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.					
60. Geometri kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.					
61. Trigonometri kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.					
62. Analiz kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.					

2) Bilgisayar Destekli Eğitim (BDE) için Tutum Ölçeği	**Kesinlikle Katılmıyorum**	**Katılmıyorum**	**Kararsızım/ Nötürüm**	**Katılıyorum**	**Kesinlikle katılıyorum**
1. Bilgisayar eğitimde etkili kullanılamaz.					
2. Bilgisayarı derste isteyerek ve severek kullanırım.					
3. Mecbur kalmadıkça bilgisayarı dersi desteklemek amacıyla kullanmam.					
4. BDE benim için önemli bir konudur.					
5. BDE ile yapılan derslerde öğrenciler yaratıcılıklarını geliştiremez.					
6. Bilgisayarı derslerimde daha etkili kullanmanın yollarını araştırırım.					
7. Bilgisayar ile eğitimi bir türlü bağdaştıramıyorum.					
8. Bilgisayarın kullanıldığı derslerde öğrenciler daha iyi öğrenir.					
9. BDE yapmak yerine konuyu kendim anlatırım.					
10. Öğretmenler bilgisayar kullanmaya teşvik edilmelidir.					
11. BDE ile ders yapmak zaman kaybıdır.					
12. Bilgisayar öğrencilerin dikkatini çekmede etkili araçtır.					
13. BDE ile öğrenciler diğer yöntem ve tekniklere göre daha az öğrenir.					
14. Bilgisayar yardımıyla yapılan dersler eğlenceli geçer.					
15. Bilgisayar desteği ile yapılan eğitimin katkısı harcanan emeği karşılamaz.					
16. Her sınıfta bilgisayar aktif bir şekilde kullanılmalıdır.					
17. Dersleri yaparken bilgisayarı öğretim amaçlı kullanmayı düşünmem.					
18. Bilgisayarın etkili bir öğretim aracı olduğunu düşünüyorum.					
19. Bilgisayarın başından biran önce kalkmak isterim.					
20. Derslerimde bilgisayar kullanmaya çalışırım.					

Appendix J

Descriptive Statistics for all 62 items in Initial Turkish TPACK Scale for the Pilot Study

Items	Minimum	Maximum	Mean	Skewness	Kurtosis
TK01	1	5	3.25	-.237	-.474
TK02	1	5	4.04	-.878	.893
TK03	1	5	3.88	-.719	.889
TK04	1	5	3.43	-.157	-.533
TK05	1	5	3.08	.032	-.405
TK06	1	5	3.38	-.158	-.602
TK07	1	5	2.66	.299	-.397
TK08	1	5	4.03	-1.079	1.694
CK09	1	5	3.52	-.837	.704
CK10	2	5	3.79	-.523	.575
CK11	1	5	3.69	-.607	.918
CK12	1	5	3.68	-.647	.568
CK13	1	5	3.04	-.124	-.252
CK14	1	5	3.14	-.135	-.374
CK15	1	5	3.15	-.195	-.071
CK16	1	5	2.76	.136	-.314
PK17	1	5	3.76	.668	.915
PK18	1	5	3.94	-.738	1.654
PK19	2	5	3.83	.533	.328
PK20	1	5	3.94	-.693	1.220
PK21	1	5	3.80	-.408	.486
PK22	2	5	3.54	-.045	-.576
PK23	1	5	3.66	-.548	.421
PK24	1	5	3.53	-.298	-.224
PCK25	1	5	3.71	-.718	.999
PCK26	2	5	3.67	-.378	-.084
PCK27	2	5	3.43	.030	-.458
PCK28	1	5	3.47	-.338	-.088
PCK29	1	5	3.62	-.344	-.147
PCK30	1	5	3.68	-.389	.129
PCK31	1	5	3.41	-.230	-.147
TCK32	1	5	3.16	.026	-.100
TCK33	1	5	3.08	-.061	.059
TCK34	1	5	3.12	-.429	-.031
TCK35	1	5	3.51	-.484	.002
TCK36	1	5	3.38	-.449	-.179
TCK37	1	5	3.05	-.136	-.122
TCK38	1	5	3.43	-.388	-.108

TPK39	1	5	3.67	-.811	1.113
TPK40	1	5	3.66	-.567	.417
TPK41	1	5	3.61	-.767	.345
TPK42	1	5	3.41	-.295	-.285
TPK43	1	5	3.61	-.523	.459
TPK44	1	5	3.94	-.958	1.379
TPK45	1	5	3.31	-.458	.263
TPK46	1	5	3.44	-.472	.638
TPK47	1	5	3.26	-.204	.102
TPK48	1	5	3.87	-1.195	2.562
TPK49	1	5	3.57	-.792	-.004
TPK50	1	5	3.98	-1.268	3.165
TPACK51	1	5	3.50	-.850	.720
TPACK52	1	5	3.65	-.713	1.435
TPACK53	1	5	3.71	-1.011	1.728
TPACK54	1	5	3.31	-.316	-.522
TPACK55	1	5	3.49	-.677	.410
TPACK56	1	5	3.62	-.649	.358
TPACK57	1	5	3.37	-.523	.437
TPACK58	1	5	3.30	-.357	.037
TPACK59	1	5	3.25	-.425	.127
TPACK60	1	5	3.63	-.739	.662
TPACK61	1	5	3.51	-.653	.451
TPACK62	1	5	3.28	-.445	.038

Note. N=217 for all 62 items

Appendix K

Descriptive Statistics for all 34 items in Initial Turkish TPACK Scale for CFA in the Main study

Items	Mean	Skewness	Kurtosis
TK02	4.07	-1.037	2.333
TK03	3.90	-.793	.785
TK04	3.47	-.166	-.784
TK05	3.11	.084	-.548
CK09	3.43	-.629	.200
CK13	2.81	.123	-.233
CK14	3.06	-.105	-.585
CK15	3.09	-.120	-.246
CK16	2.62	.020	-.378
PK17	3.75	-1.178	2.255
PK18	3.96	-1.15	3.154
PK19	3.92	-.871	1.853
PK20	3.97	-.658	1.804
PK21	3.88	-.473	.834
PK22	3.46	-.091	-.127
PK23	3.65	-.393	.256
PK24	3.56	-.365	.179
TCK32	3.16	-.022	-.504
TCK33	3.14	-.125	-.514
TPK44	3.92	-.938	1.741
TPK46	3.44	-.388	-.016
TPK47	3.30	-.249	.011
TPK48	3.84	-1.001	1.843
TPK50	3.90	-.947	1.794
TPACK51	3.53	-.637	.473
TPACK52	3.74	-.863	1.594
TPACK53	3.79	-.835	1.541
TPACK54	3.41	-.408	-.047
TPACK55	3.49	-.366	.014
TPACK57	3.37	-.418	.056
TPACK58	3.23	-.340	.031
TPACK59	3.16	-.312	-.121
TPACK60	3.58	-.717	.577
TPACK61	3.49	-.513	.156

Note. N= 556, Min=1, and Max=5 for all 34 items

Appendix L

The Final Turkish TPACK Scale

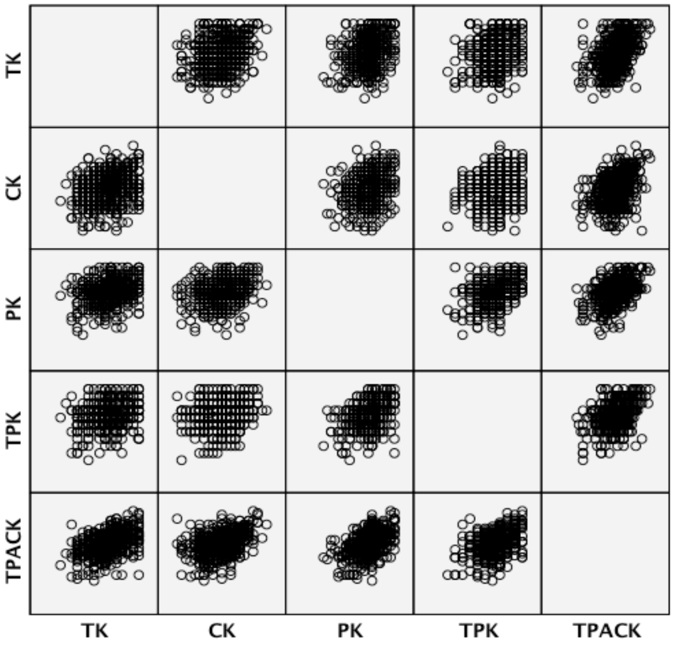
Subscales	Old labels for the Items	Items in Turkish
TK	TK02	**1.**Teknolojiyi kolaylıkla öğrenebilirim.
	TK03	**2.** Önemli yeni teknolojileri takip edebilirim/ ayak uydurabilirim.
	TK04	**3.** Sıklıkla teknolojiyle ilgilenirim/uğraşırım/vakit geçiririm.
	TK05	**4.** Birçok farklı teknoloji hakkında bilgi sahibiyim.
CK	CK09	**5.** Matematik hakkında yeterli bilgiye sahibim.
	CK13	**6.** Cebir hakkında derin ve geniş bilgiye sahibim.
	CK14	**7.** Geometri hakkında derin ve geniş bilgiye sahibim.
	CK15	**8.** Analiz hakkında derin ve geniş bilgiye sahibim.
	CK16	**9.** Lisans matematiği hakkında ileri seviyede derin ve geniş bilgiye sahibim.
PK	PK17	**10.** Sınıf içerisinde öğrenci performansını nasıl değerlendireceğimi bilirim.
	PK18	**11.** Öğrencilerin mevcut durumda neyi anlayıp neyi anlayamadıklarına göre, öğretme etkinliklerimi düzenleyebilirim.
	PK19	**12.** Farklı şekilde öğrenen öğrencilere göre öğretim stilimi uyarlayabilirim.
	PK20	**13.** Farklı yöntemlerle öğrencilerin öğrenmesini değerlendirebilirim.
	PK21	**14.** Sınıf ortamında birden çok (çeşitli, farklı farklı) öğretme yaklaşımlarını kullanabilirim.
	PK24	**15.** Sınıf ortamında çeşitli öğretim yaklaşımlarını (problem/proje tabanlı öğrenme, sorgulayıcı öğrenme, işbirlikçi öğrenme ve düz anlatım gibi) kullanmak için uygun zamanı bilirim.
TPK	TPK44	**16.** Farklı öğretim yaklaşımları farklı teknolojileri gerektirir.
	TPK48	**17.** Bir sınıf içerisinde teknoloji kullandığım zaman, ona göre öğretme yaklaşımlarım da değişir.

	TPK50	**18.** Farklı teknolojiler farklı öğretme yaklaşımlarını gerektirir.
	TPK46	**19.** Derslerimde teknolojiyi uygun bir şekilde kullanmak için gereken sınıf yönetimi becerisine sahibim.
	TPK47	**20.** Farklı öğretim yaklaşımları içerisinde teknolojiyi nasıl kullanacağımı biliyorum.
TPACK	TPACK51	**21.** Sınıfta, lisans eğitimim esnasında öğrendiğim öğretim yaklaşımlarını, teknolojileri ve matematiği bir araya getirecek (birleştiren) stratejileri kullanabilirim.
	TPACK52	**22.** Bir matematik dersinde, matematiğin değerini arttıran (geliştiren, zenginleştiren) teknolojileri seçebilirim.
	TPACK53	**23.** Ne öğrettiğimi, nasıl öğrettiğimi ve öğrencilerin ne öğrendiklerini geliştirecek/ ilerletecek teknolojileri sınıfımda kullanmak için seçebilirim.
	TPACK54	**24.** Okulumda ve/veya eğitim bölgemde matematik, teknoloji ve öğretim yaklaşımlarının kullanımını koordine etmek için başkalarına yardım etmede öncülük edebilirim.
	TPACK55	**25.** Uygun olarak matematik, teknoloji ve öğretim yaklaşımlarını bir araya getiren/ birleştiren dersleri öğretebilirim.
	TPACK57	**26.** Oran ve orantı kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.
	TPACK59	**26.** Cebir kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.
	TPACK60	**28.** Geometri kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.
	TPACK61	**29.** Trigonometri kavramlarına/konularına uygun, teknoloji ve öğretim yaklaşımlarını bir araya getiren dersleri öğretebilirim.

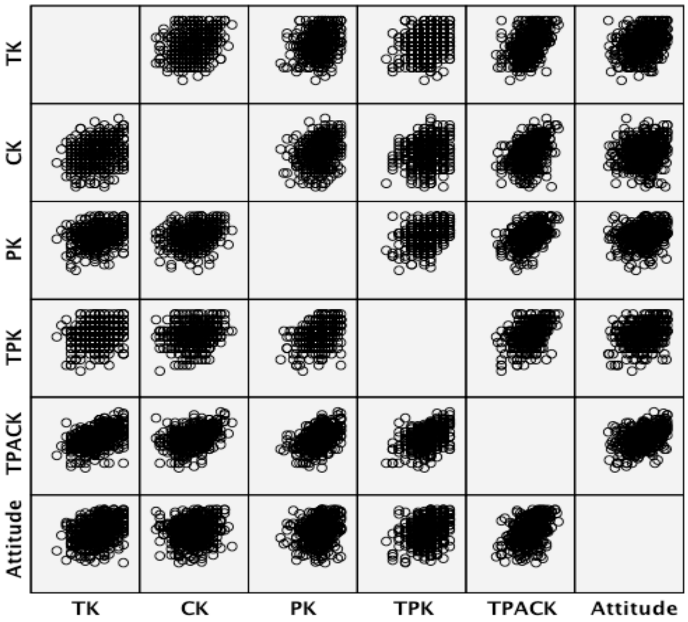
Appendix M

The Scatter Plot Matrices for TPACK and Attitude

TPACK



Attitude



Appendix N

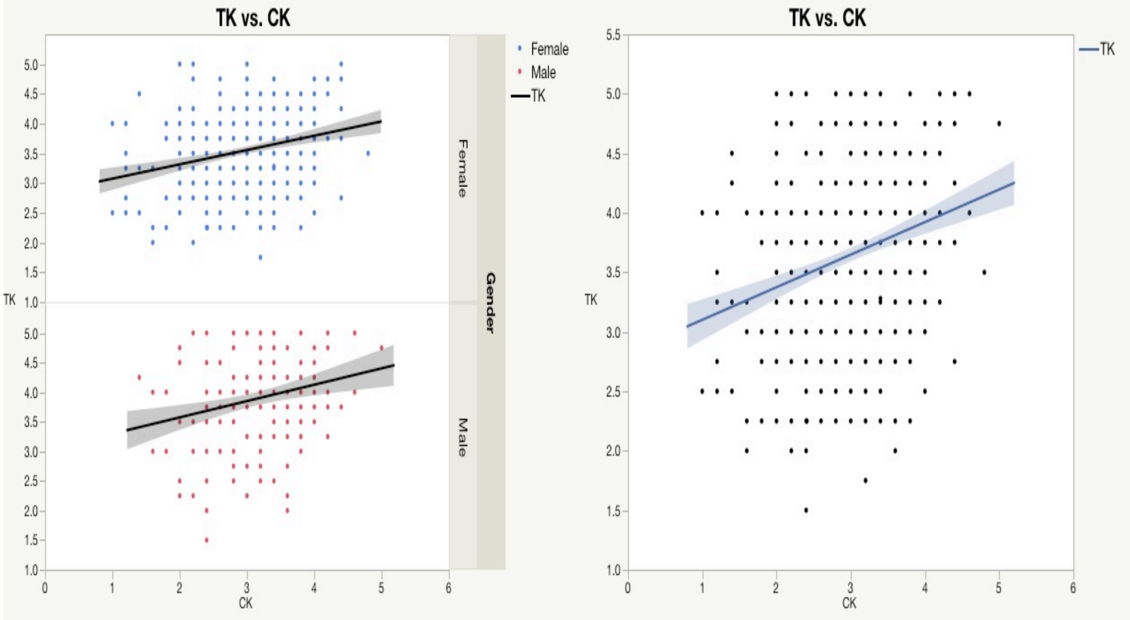
The Descriptive Statistics for the Correlations among Attitude and each of TPACK Components

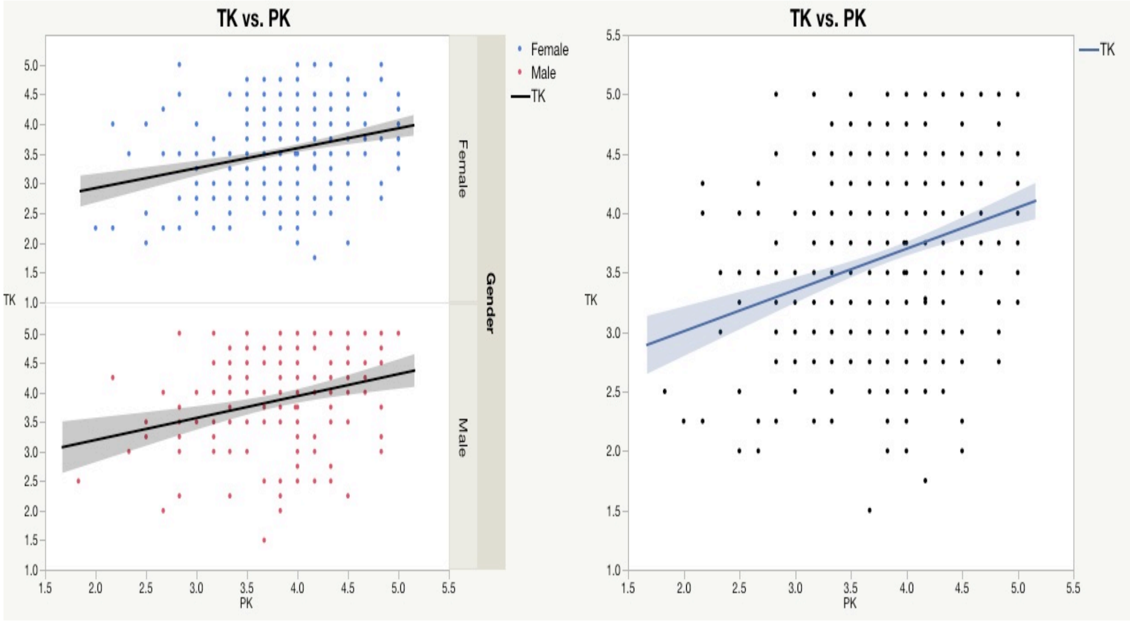
Variables	N	Min	Max	Mean	SD	Skewness	Kurtosis
TK	546	1.5	5	3.655	.692	-.142	-.264
CK	546	1	5	3.010	.696	-.224	-.005
PK	546	1.83	5	3.861	.514	-.509	1.282
TPK	546	1.67	5	3.797	.578	-.404	.611
TPACK	546	1.73	5	3.508	.513	-.414	.700
Attitude	546	1.9	5	3.756	.622	-.333	.002

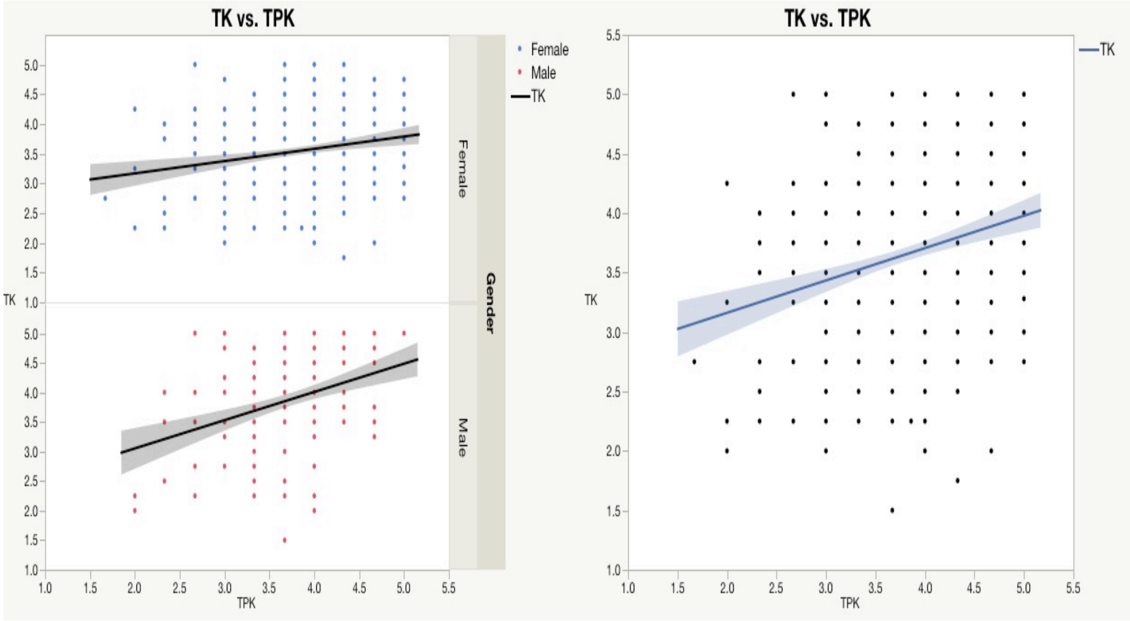
Appendix O

The Relationships among TPACK Components with respect to Gender, and Year of Enrollment

Gender






TK vs. TPK
Female
Male
TK
Gender
TK
TPK
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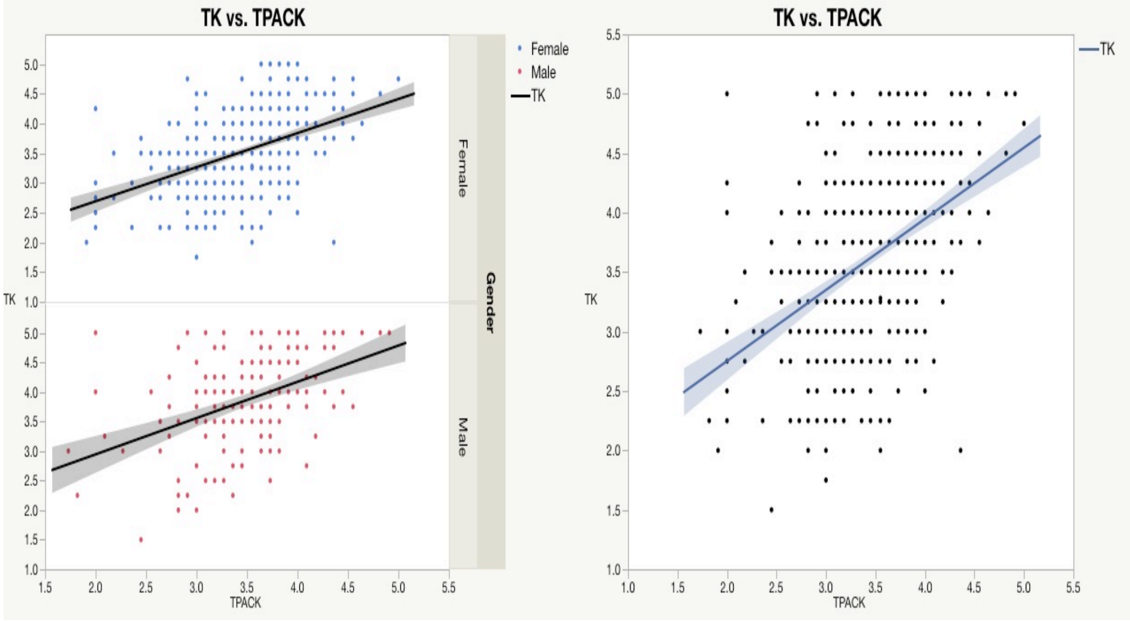
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
TK vs. TPK
TK
TK
TPK


TK vs. TPACK
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Male
TK
Gender
TK
TPACK
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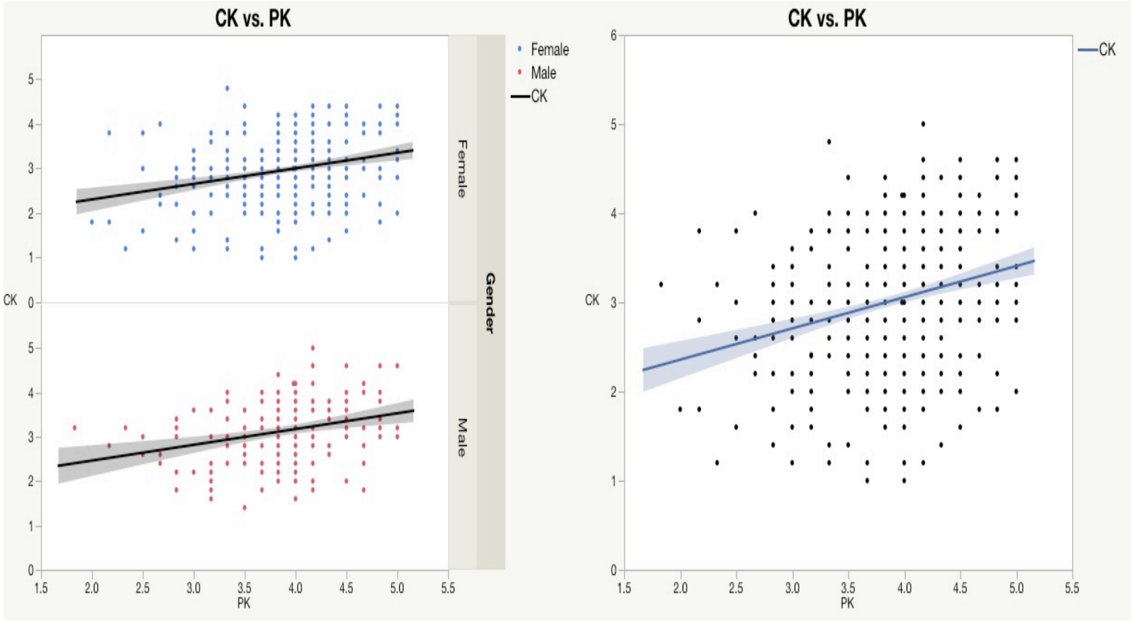
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
TK vs. TPACK
TK
TK
TPACK


CK vs. PK
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CK
Gender
CK
PK
CK vs. PK
CK
CK
PK
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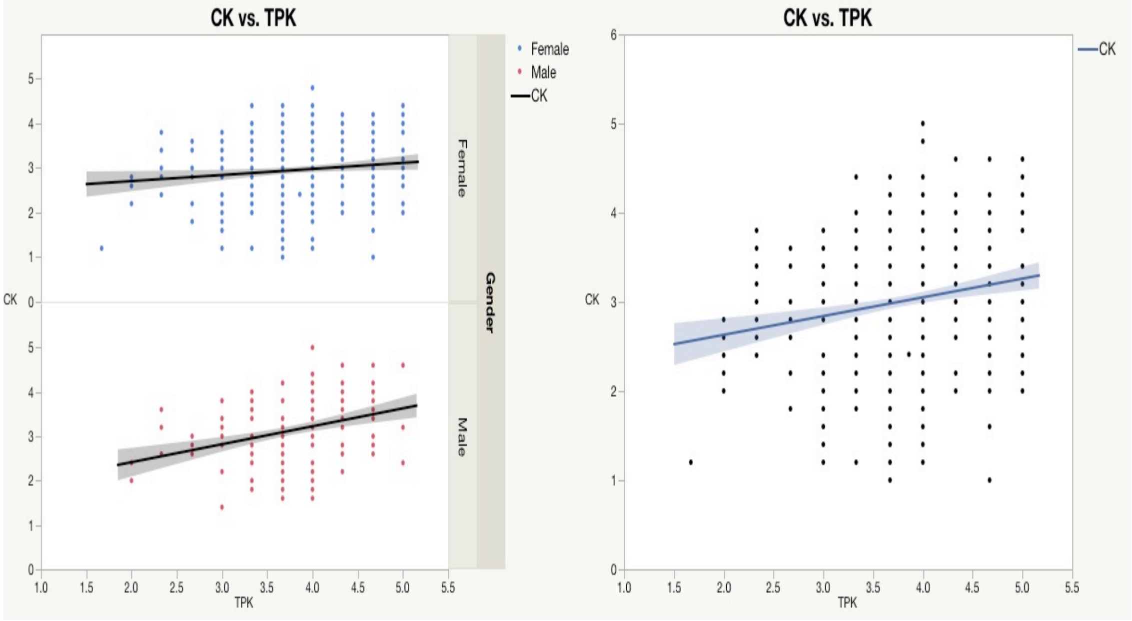
4.5
5.0
5.5


CK vs. TPK
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CK
Gender
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TPK
CK vs. TPK
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CK
TPK
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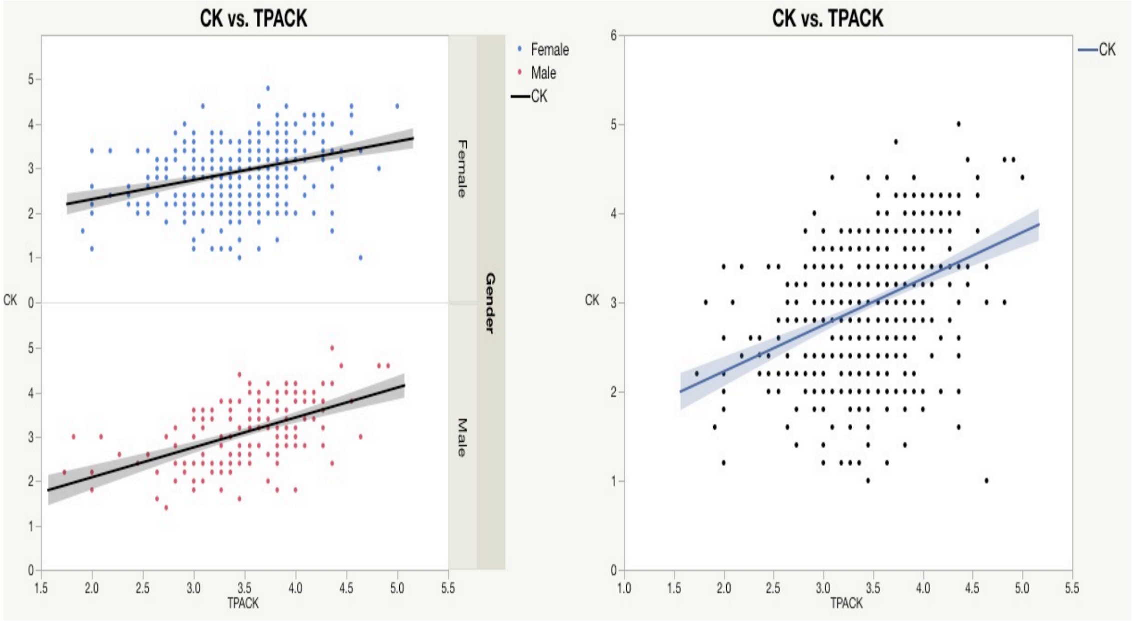
CK vs. TPACK
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Male
CK
Gender
CK
TPACK
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4.0
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5.5
CK vs. TPACK
CK
CK
TPACK
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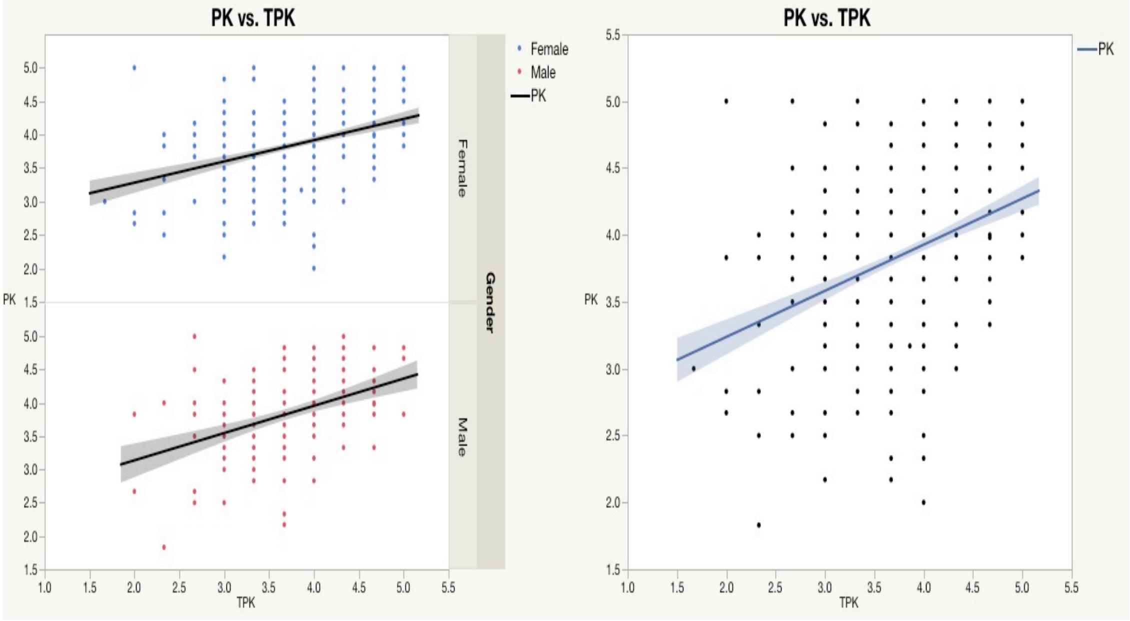
PK vs. TPK
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Male
PK
Gender
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TPK
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3.5
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4.5
5.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
PK vs. TPK
PK
PK
TPK
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
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4.5
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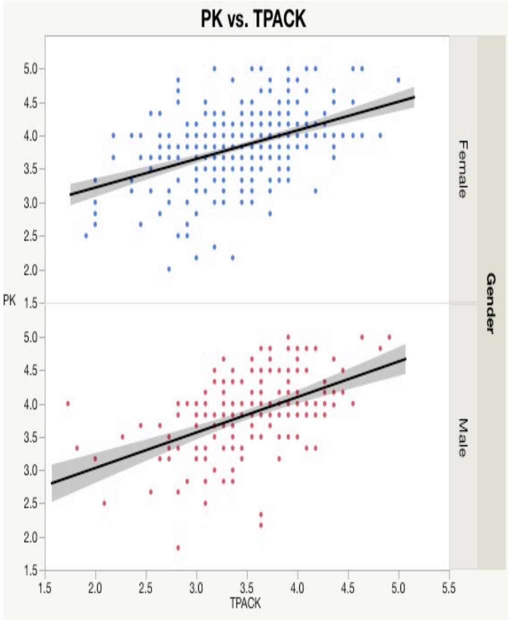
5.5


PK vs. TPACK
Female
Male
PK
Gender
PK
TPACK
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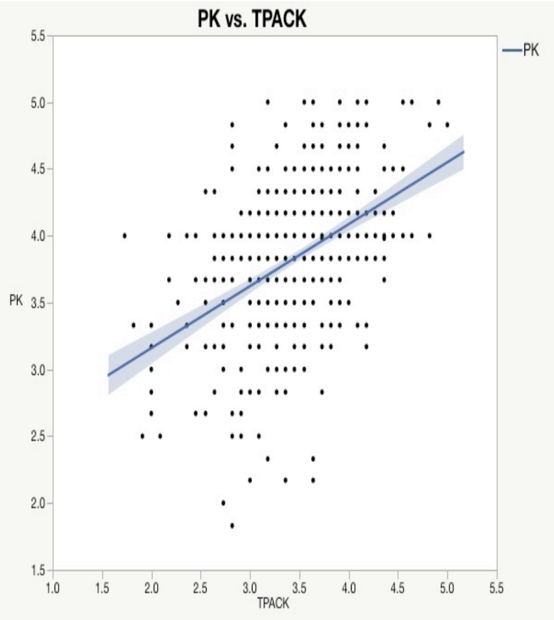
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5


PK vs. TPACK
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PK
TPACK
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3.0
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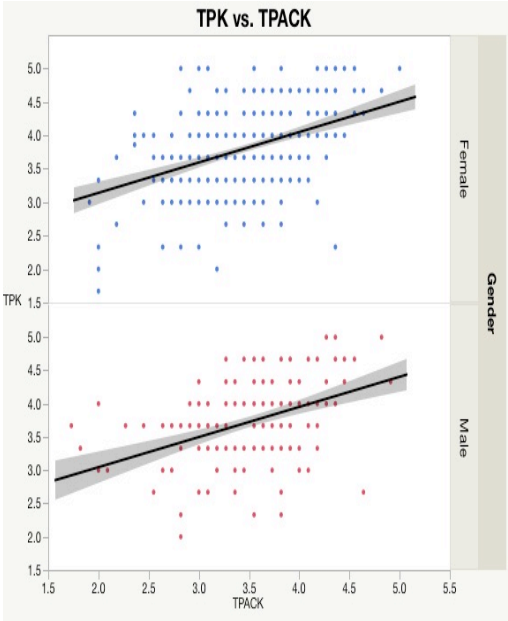
5.5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Male
TPK
Gender
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TPACK
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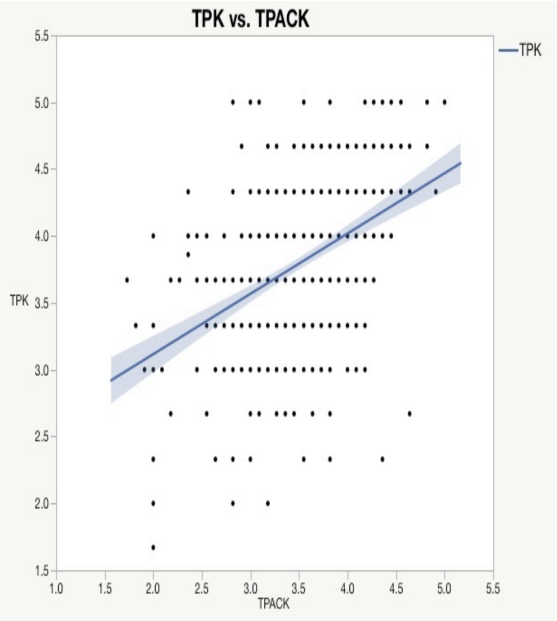
5.5


TPK vs. TPACK
TPK
TPK
TPACK
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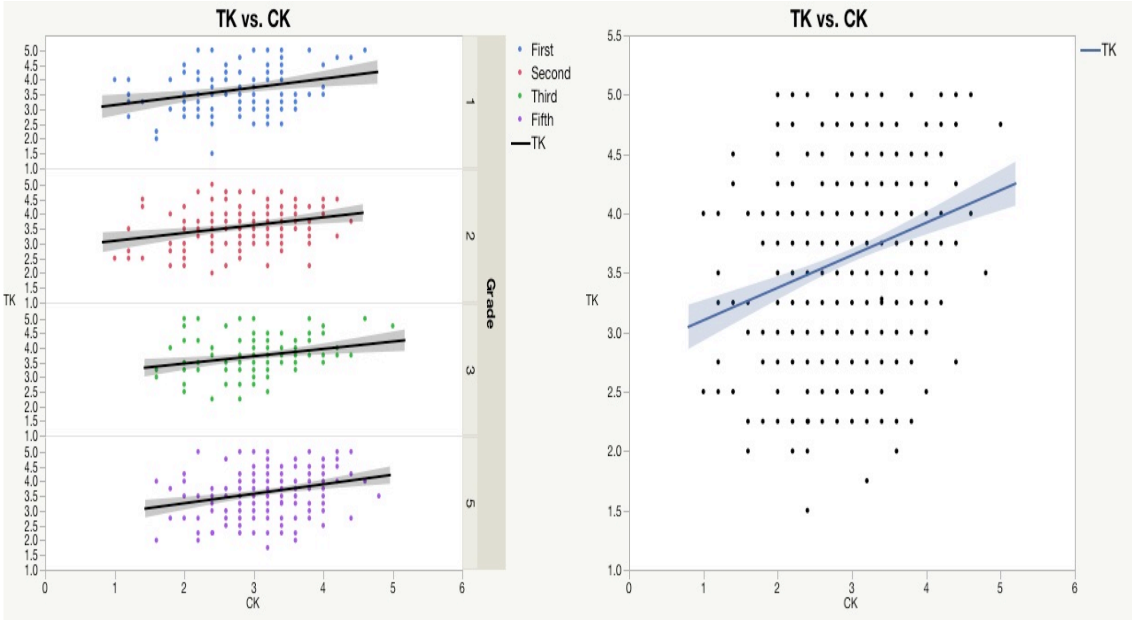
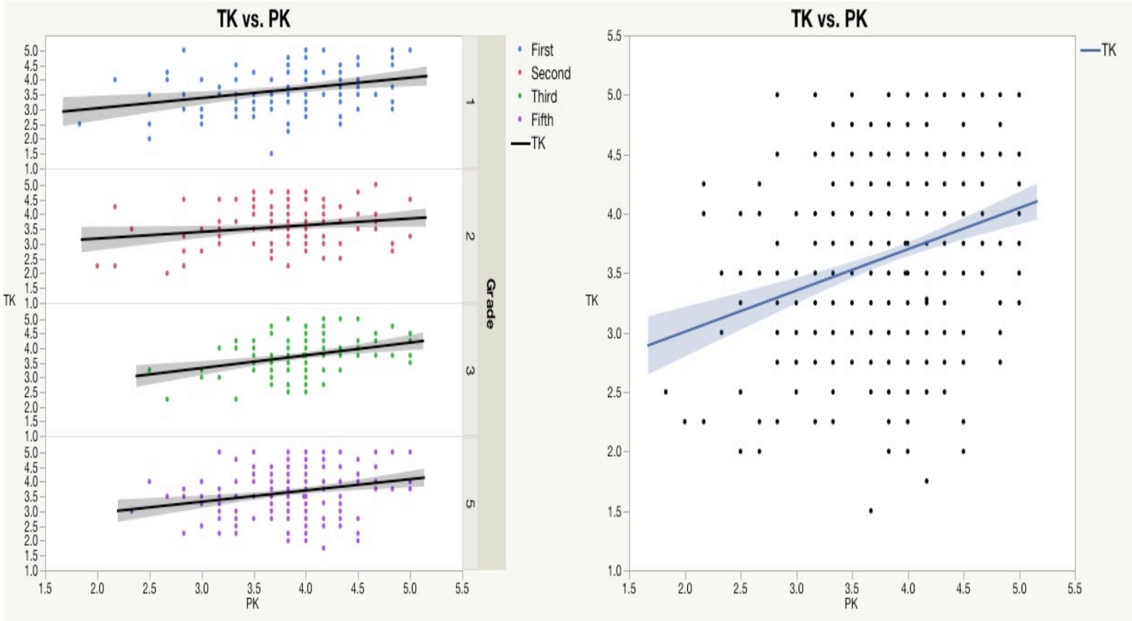
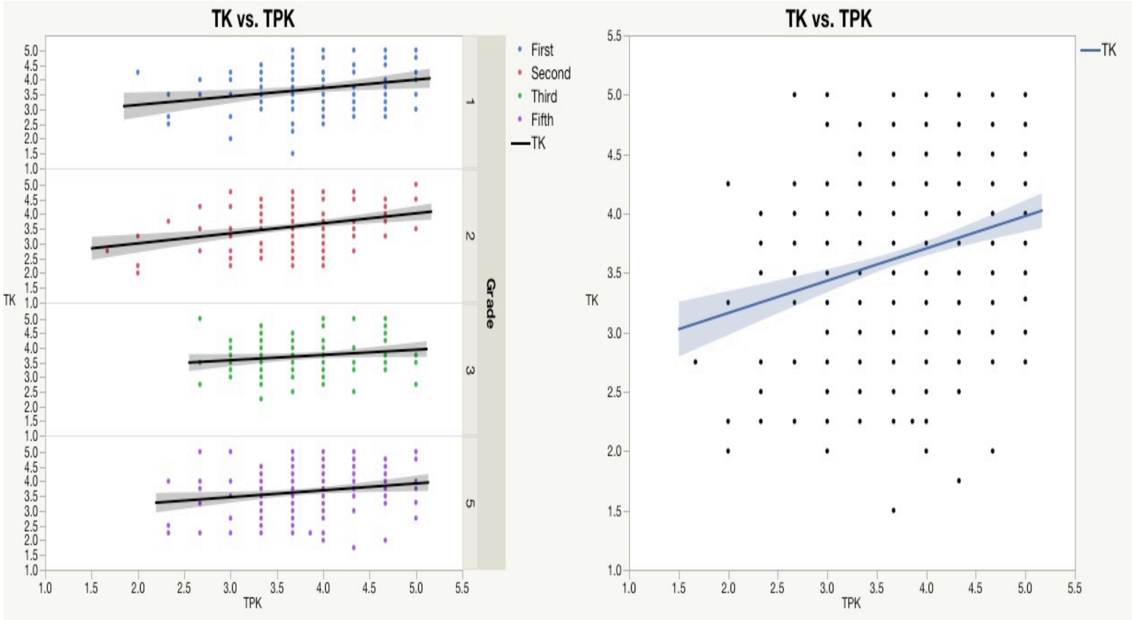
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5

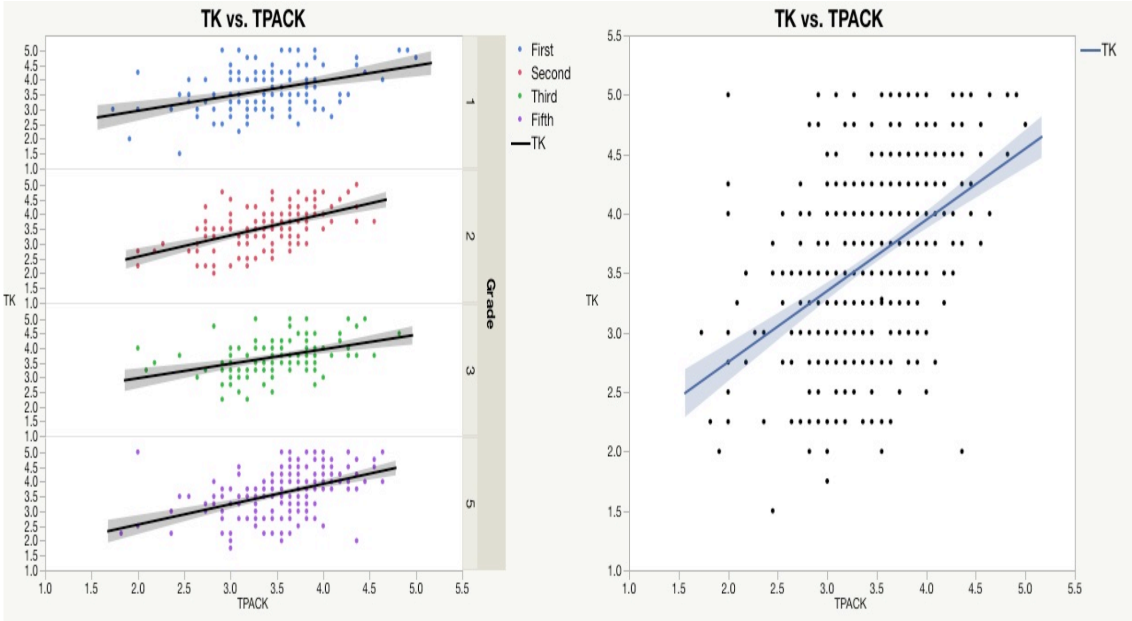
Year of Enrollment



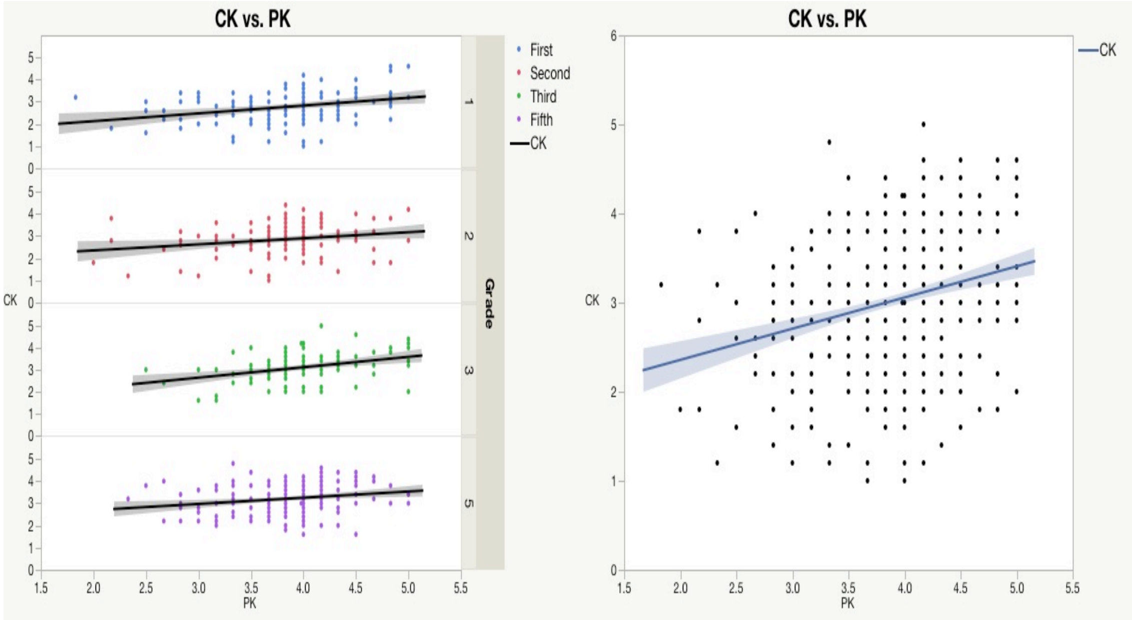




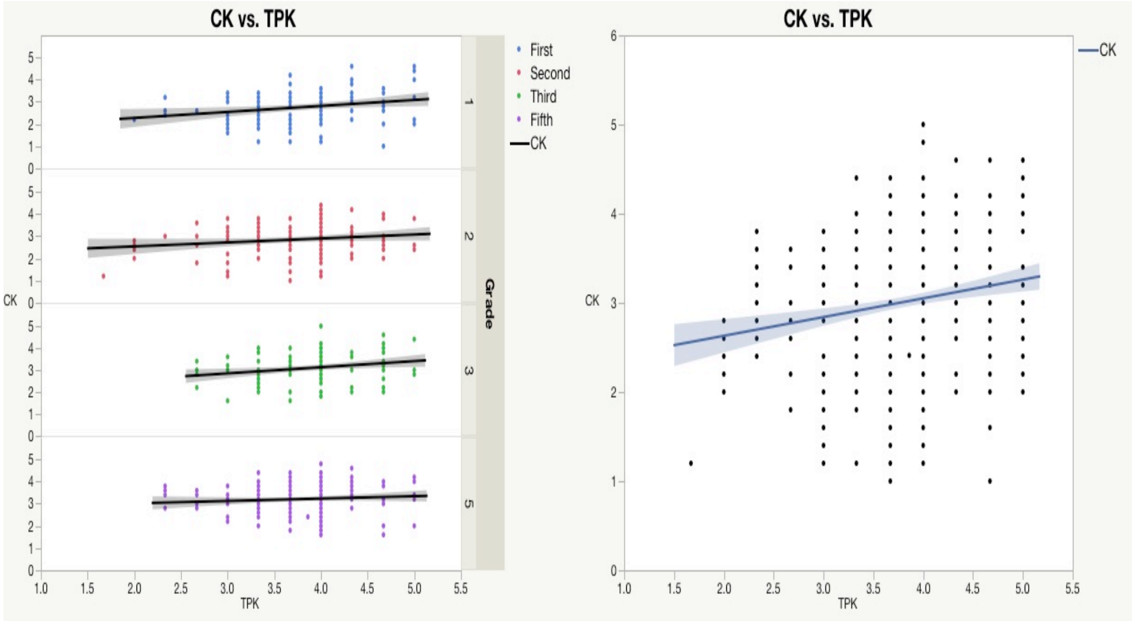
TK vs. TPK
First
Second
Third
Fifth
TK
Grade
1
2
3
5
TK
TPK
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5
TK vs. TPK
TK
TK
TPK
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5



TK vs. TPACK
First
Second
Third
Fifth
TK
Grade
1
2
3
5
TK
TPACK
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5
TK vs. TPACK
TK
TK
TPACK
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5



CK vs. PK
First
Second
Third
Fifth
CK
Grade
1
2
3
5
CK
PK
CK vs. PK
CK
CK
PK



CK vs. TPK
First
Second
Third
Fifth
CK
Grade
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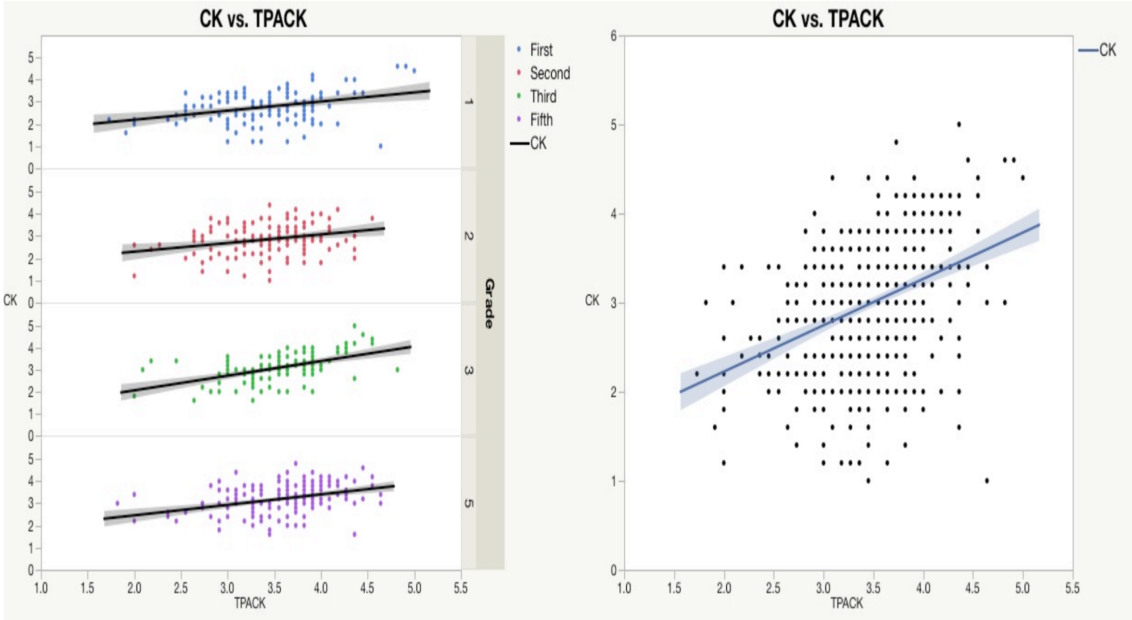
2
3
5
CK
TPK
CK vs. TPK
CK
CK
TPK


CK vs. TPACK
First
Second
Third
Fifth
CK
Grade
1
2
3
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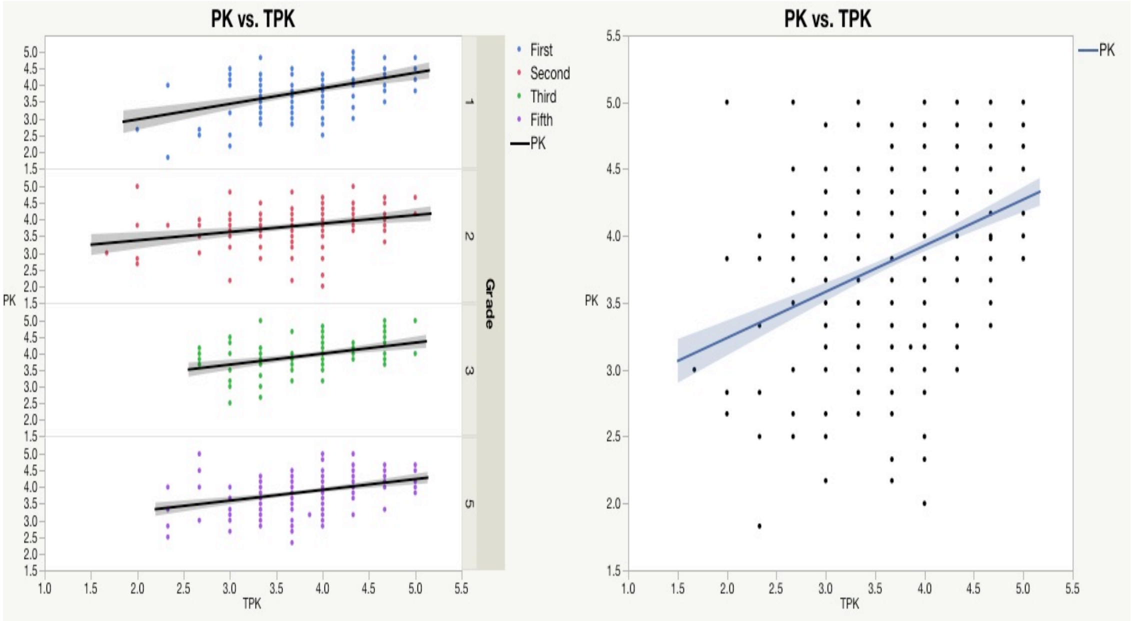
CK
TPACK
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5
0 1 2 3 4 5
CK vs. TPACK
CK
CK
TPACK
0 1 2 3 4 5 6


PK vs. TPK
First
Second
Third
Fifth
PK
Grade
1
2
3
5
PK
TPK
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1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
PK vs. TPK
PK
PK
TPK
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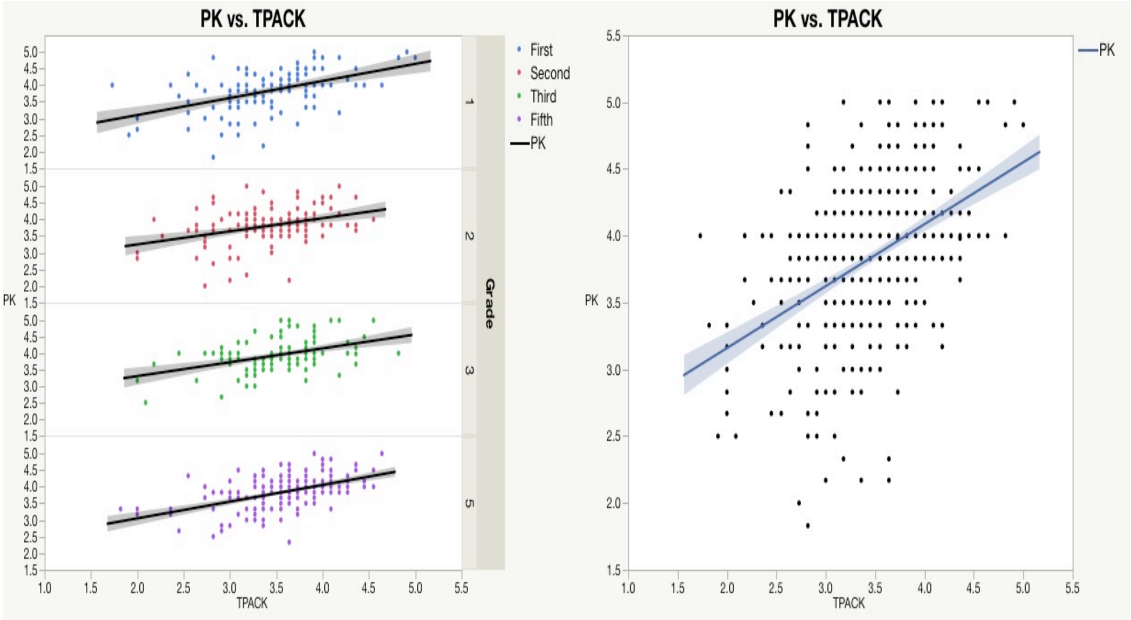
PK vs. TPACK
PK
TPACK
Grade
1
2
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First
Second
Third
Fifth
PK
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1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
PK vs. TPACK
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TPACK
PK
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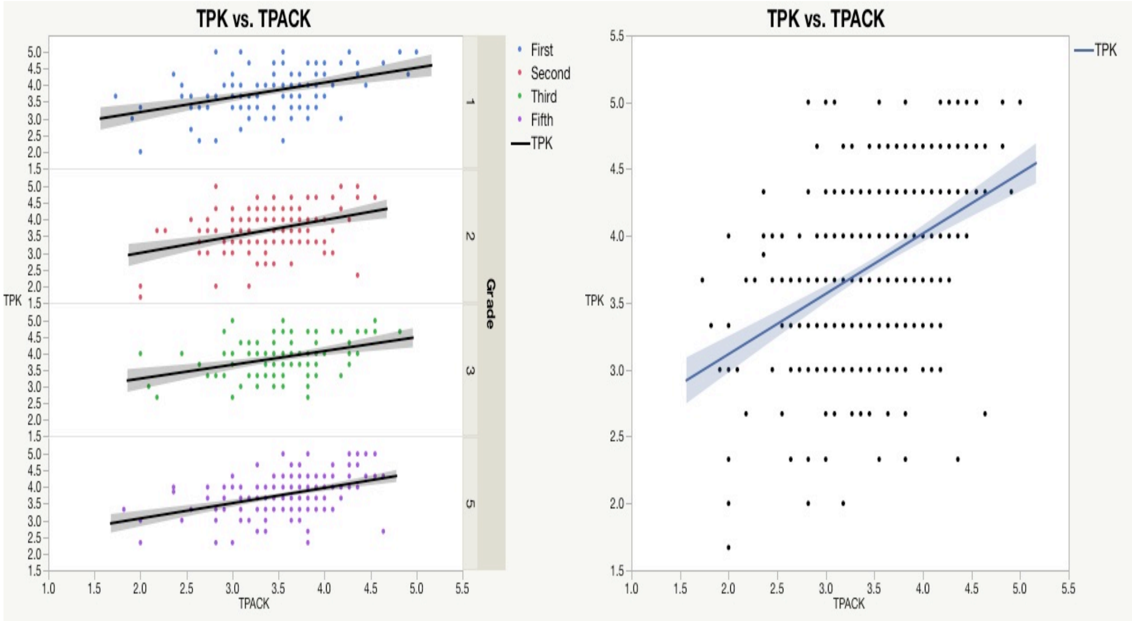
TPK vs. TPACK
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TPACK
Grade
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3
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First
Second
Third
Fifth
TPK
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TPK vs. TPACK
TPK
TPACK
TPK
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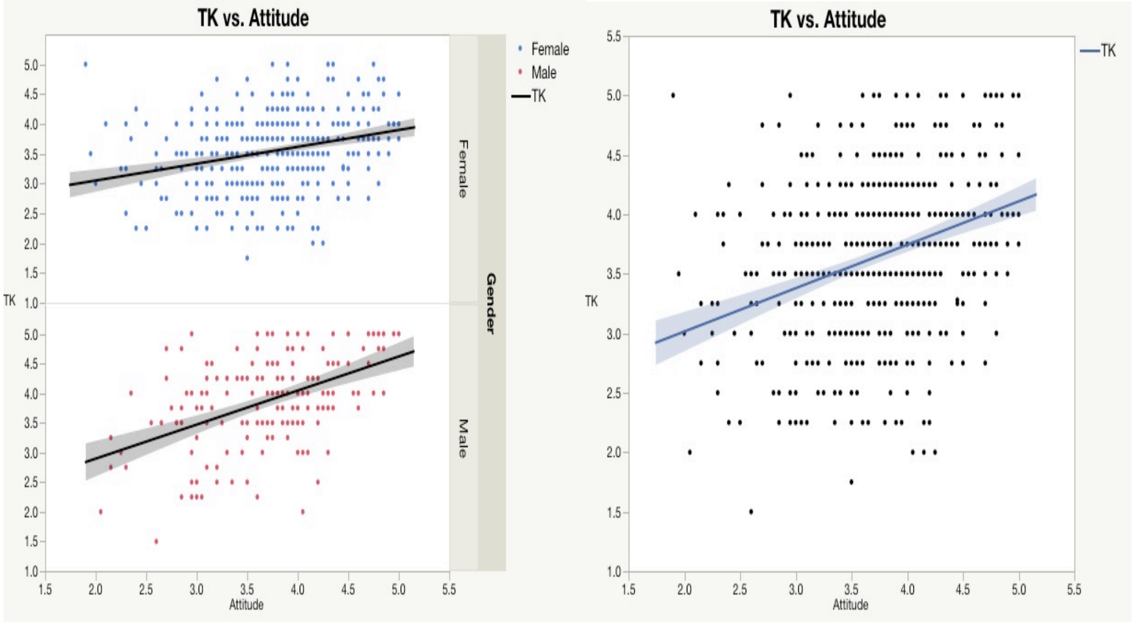
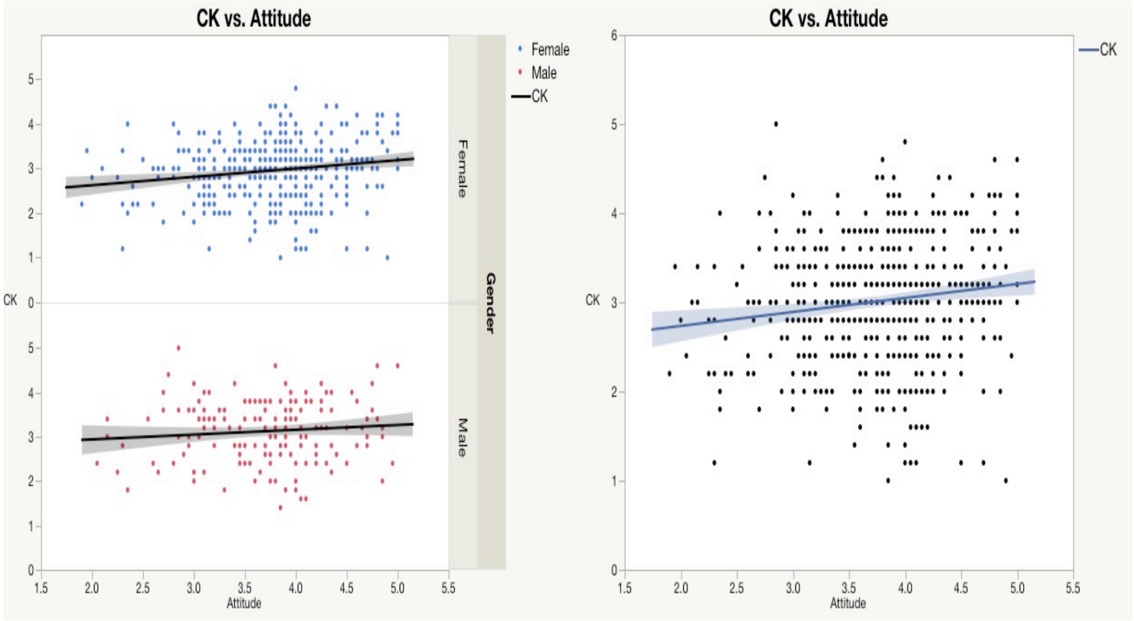
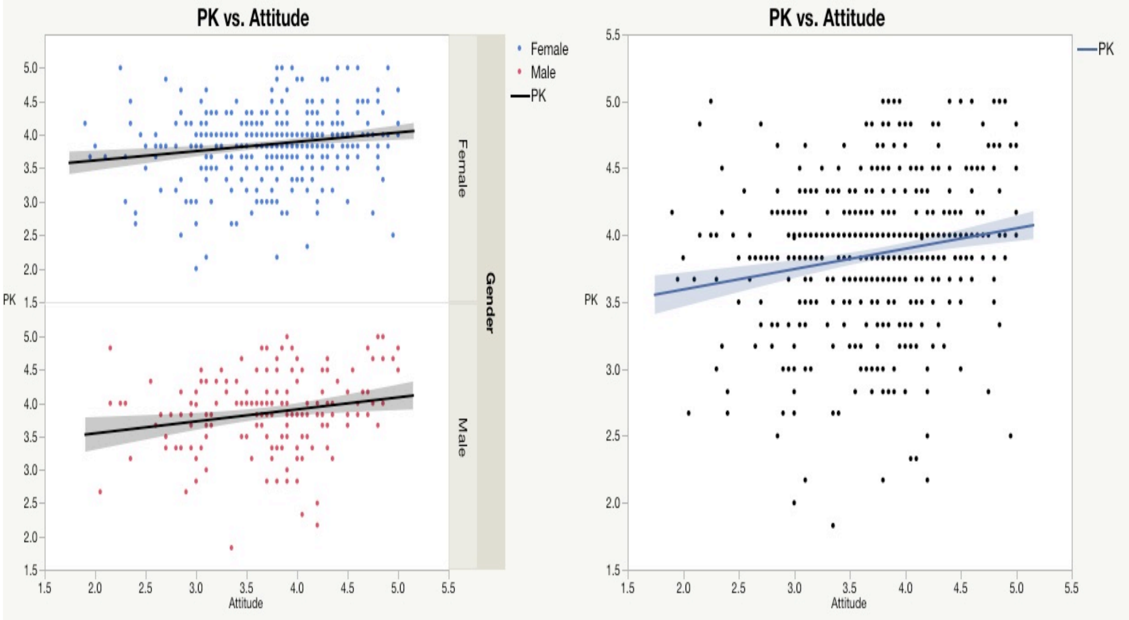
Appendix P

The Relationships between Attitude and each of TPACK components with respect to Gender, and Year of Enrollment

Gender






PK vs. Attitude
Female
Male
PK
Gender
Female
Male
PK
Attitude
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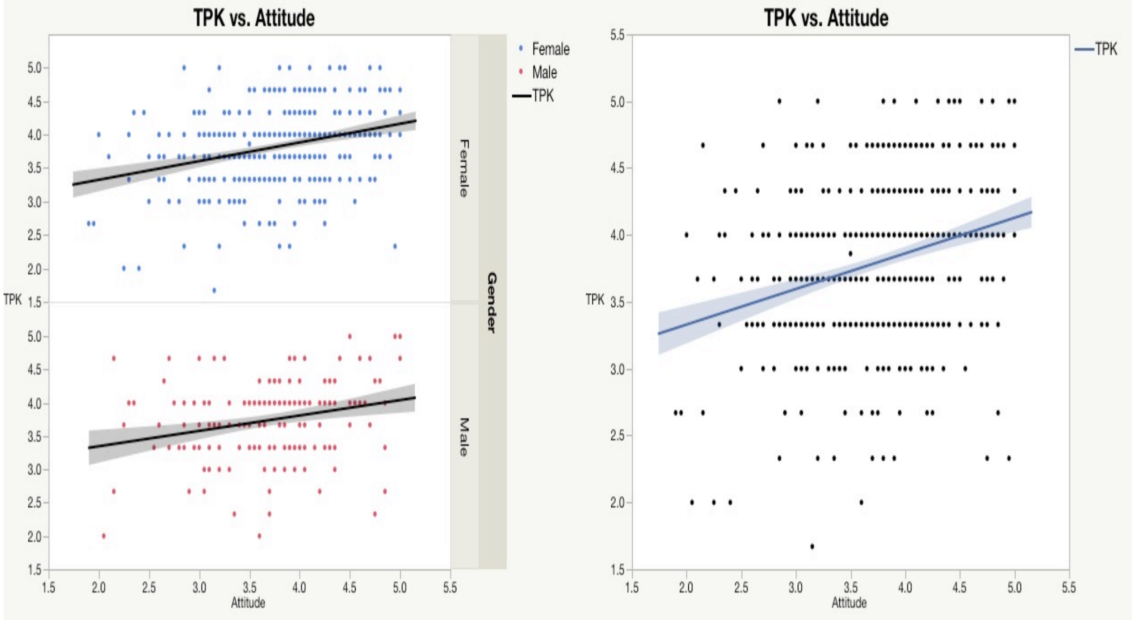
2.5
3.0
3.5
4.0
4.5
5.0
5.5
PK vs. Attitude
PK
PK
Attitude


TPK vs. Attitude
Female
Male
TPK
Gender
Female
Male
TPK
Attitude
1.5
2.0
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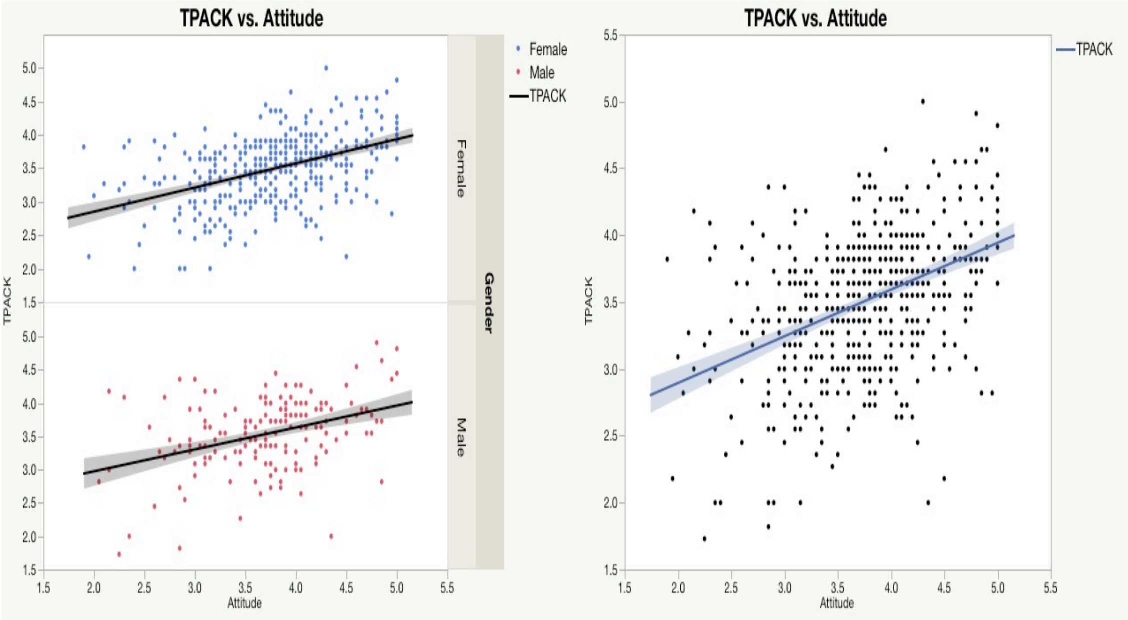
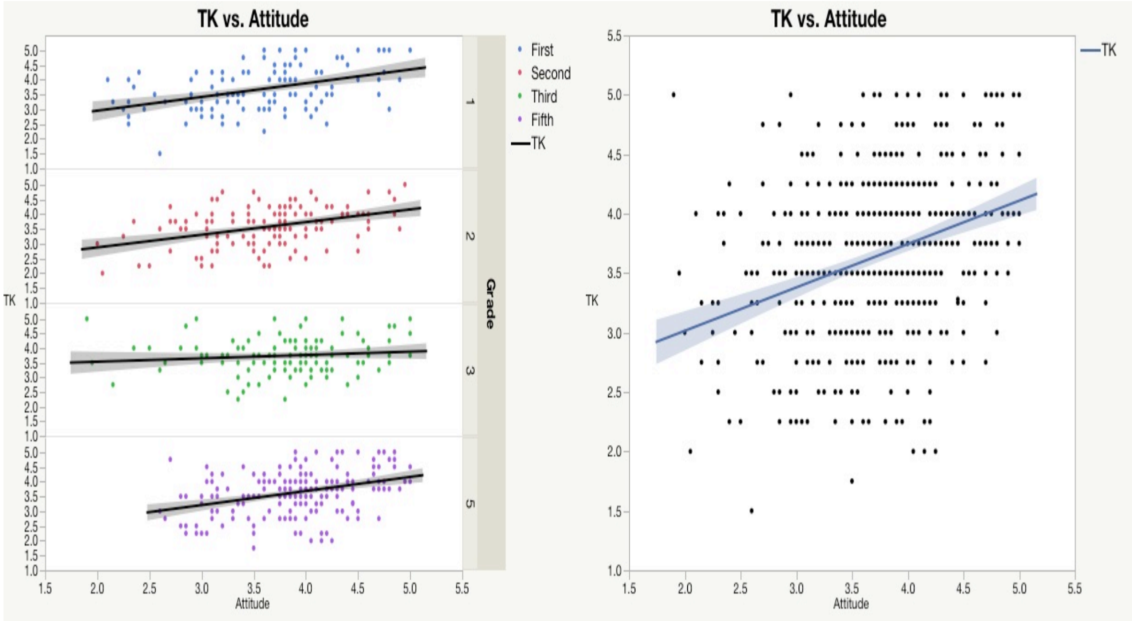
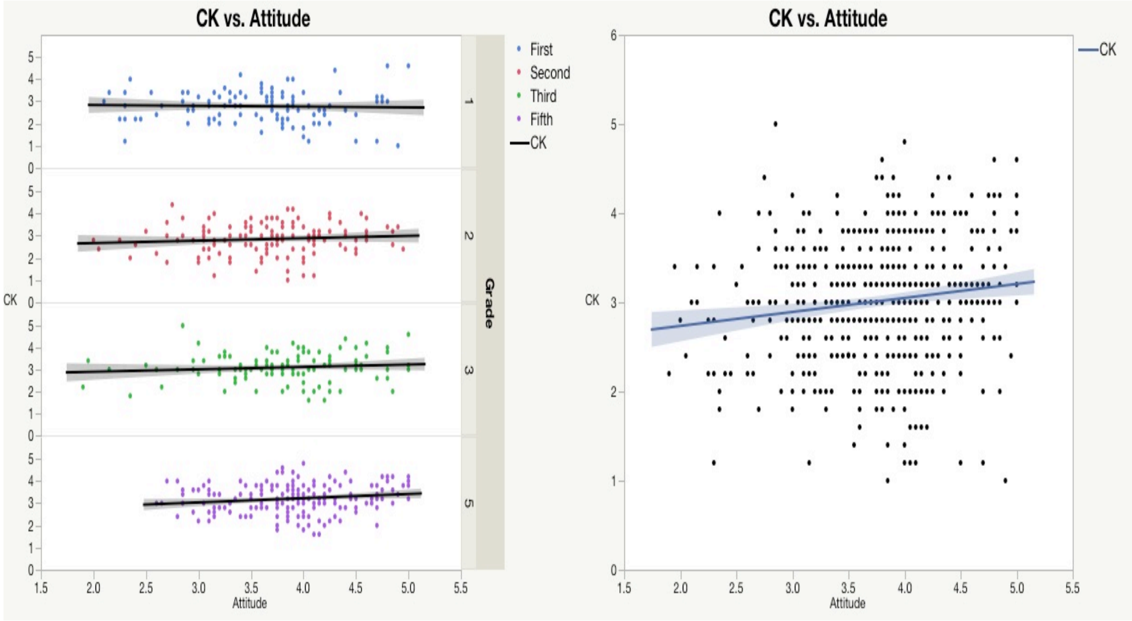
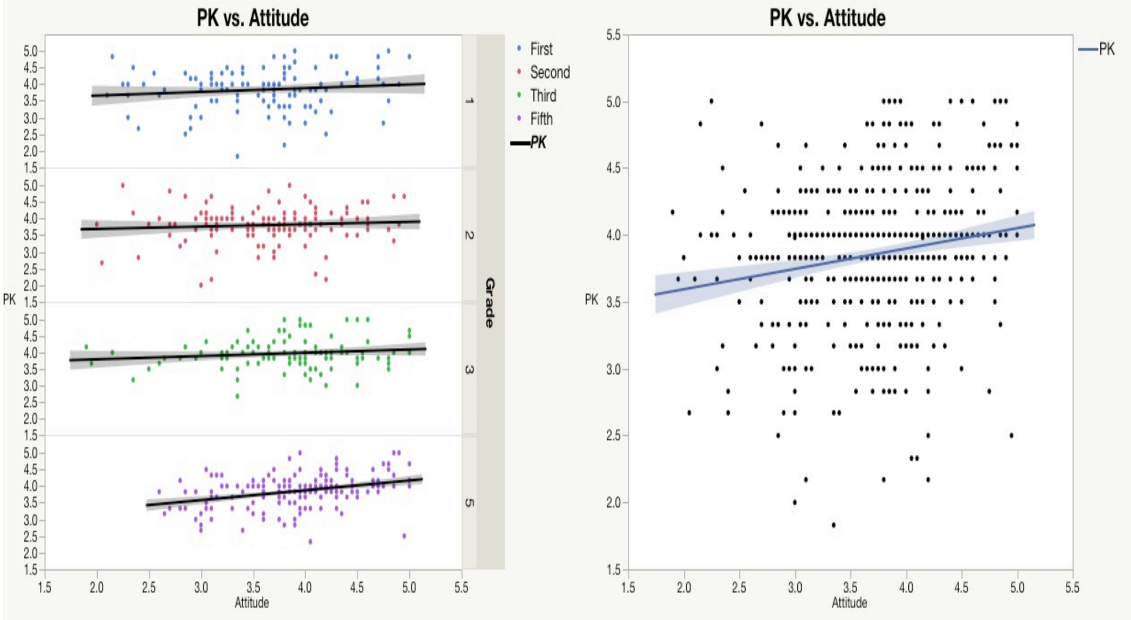
5.5
TPK vs. Attitude
TPK
TPK
Attitude



Year of Enrollment




CK vs. Attitude
First
Second
Third
Fifth
CK
Grade
1
2
3
5
CK
0
1
2
3
4
5
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Attitude
CK vs. Attitude
CK
CK
0
1
2
3
4
5
6
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Attitude


PK vs. Attitude
First
Second
Third
Fifth
PK
Grade
1
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PK
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3.5
4.0
4.5
5.0
5.5
Attitude
PK vs. Attitude
PK
PK
1.5
2.0
2.5
3.0
3.5
4.0
4.5
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3.0
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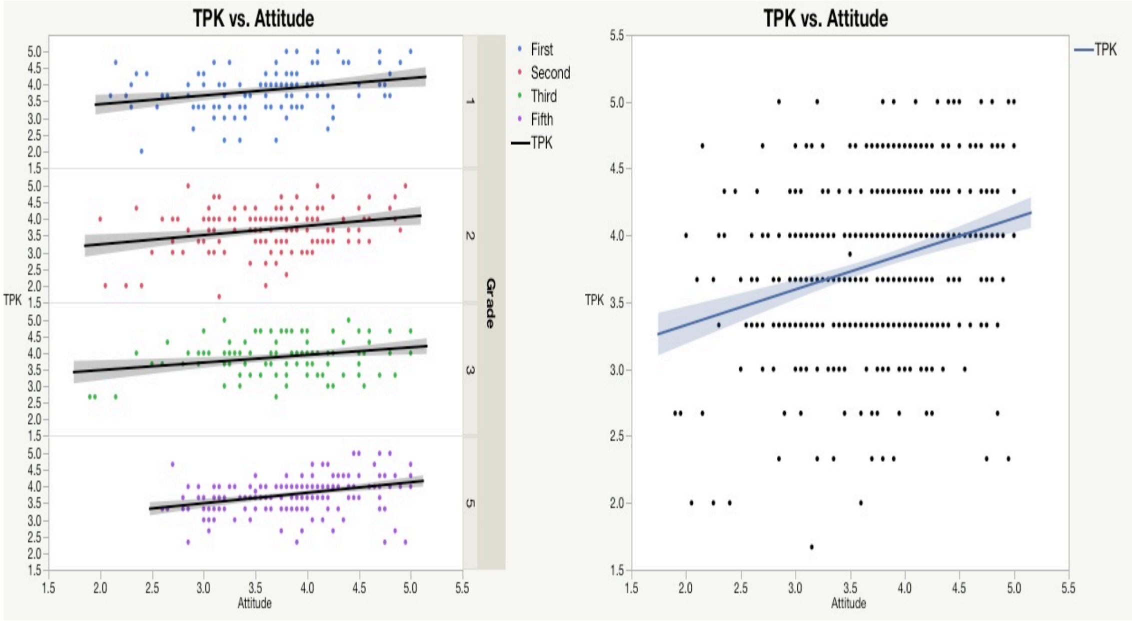
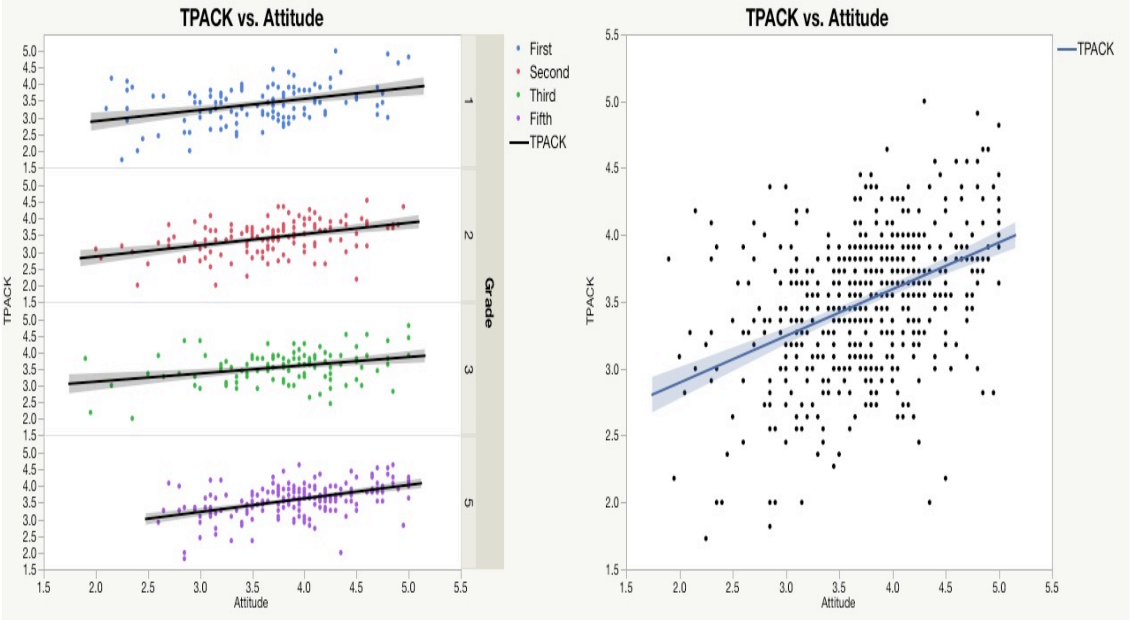
4.0
4.5
5.0
5.5
Attitude


TPK vs. Attitude
TPK
Attitude
Grade
1
2
3
5
● First
● Second
● Third
● Fifth
—TPK
TPK vs. Attitude
TPK
Attitude
—TPK


TPACK vs. Attitude
TPACK
Attitude
Grade
1
2
3
5
● First
● Second
● Third
● Fifth
—TPACK
TPACK vs. Attitude
TPACK
Attitude
—TPACK

Appendix R

Clemson University Institutional Review Board (IRB) Approval

Dear Dr. Tyminski,

The Clemson University Institutional Review Board (IRB) reviewed the protocol identified above using exempt review procedures and a determination was made on **September 20, 2016** that the proposed activities involving human participants qualify as **Exempt under category B2 and B4** based on federal regulations 45 CFR 46. **Your protocol will expire on August 31, 2017.**

Please find attached the approved consent document(s) to be used with this protocol.

The expiration date indicated above was based on the completion date you entered on the IRB application. If an extension is necessary, the PI should submit an Exempt Protocol Extension Request form, http://www.clemson.edu/research/compliance/irb/forms.html, at least three weeks before the expiration date. Please refer to our website for more information on the extension procedures,http://www.clemson.edu/research/compliance/irb/guidance/reviewprocess.html.

This approval is based on U.S. human subjects protections regulations (45 CFR 46) and Clemson University human subjects protection policies. We are not aware of any regulations that may be in place for the country you are planning to conduct research in that would conflict with this approval. However, you should become familiar with all pertinent information about local human subjects protection regulations and requirements when conducting research in countries other than the United States. We encourage you to discuss with your local contacts any possible human subjects research requirements that are specific to your research site, to comply with those requirements, and to inform this office of those requirements so we can better help other researchers prepare for international research in the future.

No change in this approved research protocol can be initiated without the IRB's approval. This includes any proposed revisions or amendments to the protocol or consent form. Any unanticipated problems involving risk to subjects, any complications, and/or any adverse events must be reported to the Office of Research Compliance immediately. All team members are required to review the IRB policies on "Responsibilities of Principal Investigators" and "Responsibilities of Research Team Members" available at http://www.clemson.edu/research/compliance/irb/regulations.html.

The Clemson University IRB is committed to facilitating ethical research and protecting the rights of human subjects. Please contact us if you have any questions and use the IRB number and title in all communications regarding this study.

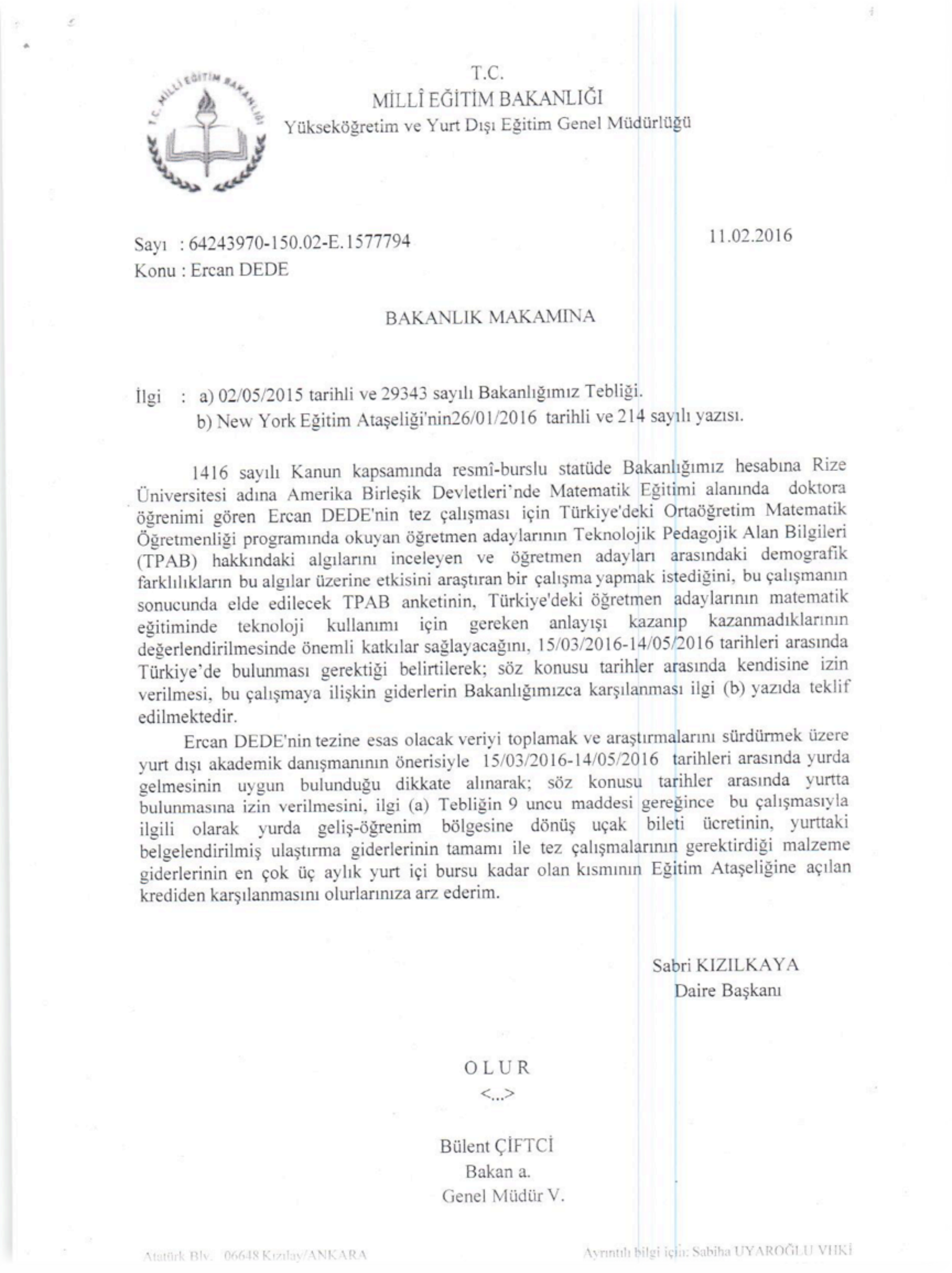
Sincerely,

Elizabeth

B. Elizabeth Chapman, MA, CACII
IRB Coordinator
Clemson University
Office of Research Compliance
Institutional Review Board (IRB)
Clemson Centre
391 College Avenue
Suite 406
Clemson, SC 29631
Voice: (864) 656-6460
E-mail: bfeltha@clemson.edu
Web site: http://www.clemson.edu/research/compliance/irb/

Appendix S

The Permission of Turkish Ministry of National Education for This Study



T.C.
MİLLÎ EĞİTİM BAKANLIĞI
Yükseköğretim ve Yurt Dışı Eğitim Genel Müdürlüğü

Sayı : 64243970-150.02-E.1577794 11.02.2016
Konu : Ercan DEDE

BAKANLIK MAKAMINA

İlgi : a) 02/05/2015 tarihli ve 29343 sayılı Bakanlığımız Tebliği.
b) New York Eğitim Ataşeliği'nin26/01/2016 tarihli ve 214 sayılı yazısı.

1416 sayılı Kanun kapsamında resmî-burslu statüde Bakanlığımız hesabına Rize Üniversitesi adına Amerika Birleşik Devletleri'nde Matematik Eğitimi alanında doktora öğrenimi gören Ercan DEDE'nin tez çalışması için Türkiye'deki Ortaöğretim Matematik Öğretmenliği programında okuyan öğretmen adaylarının Teknolojik Pedagojik Alan Bilgileri (TPAB) hakkındaki algılarını inceleyen ve öğretmen adayları arasındaki demografik farklılıkların bu algılar üzerine etkisini araştıran bir çalışma yapmak istediğini, bu çalışmanın sonucunda elde edilecek TPAB anketinin, Türkiye'deki öğretmen adaylarının matematik eğitiminde teknoloji kullanımı için gereken anlayışı kazanıp kazanmadıklarının değerlendirilmesinde önemli katkılar sağlayacağını, 15/03/2016-14/05/2016 tarihleri arasında Türkiye'de bulunması gerektiği belirtilerek; söz konusu tarihler arasında kendisine izin verilmesi, bu çalışmaya ilişkin giderlerin Bakanlığımızca karşılanması ilgi (b) yazıda teklif edilmektedir.

Ercan DEDE'nin tezine esas olacak veriyi toplamak ve araştırmalarını sürdürmek üzere yurt dışı akademik danışmanının önerisiyle 15/03/2016-14/05/2016 tarihleri arasında yurda gelmesinin uygun bulunduğu dikkate alınarak; söz konusu tarihler arasında yurtta bulunmasına izin verilmesini, ilgi (a) Tebliğin 9 uncu maddesi gereğince bu çalışmasıyla ilgili olarak yurda geliş-öğrenim bölgesine dönüş uçak bileti ücretinin, yurttaki belgelendirilmiş ulaştırma giderlerinin tamamı ile tez çalışmalarının gerektirdiği malzeme giderlerinin en çok üç aylık yurt içi bursu kadar olan kısmının Eğitim Ataşeliğine açılan krediden karşılanmasını olurlarınıza arz ederim.

Sabri KIZILKAYA
Daire Başkanı

O L U R
<...>

Bülent ÇİFTCİ
Bakan a.
Genel Müdür V.

Atatürk Blv. 06648 Kızılay/ANKARA Ayrıntılı bilgi için: Sabiha UYAROĞLU VHKİ

Appendix T

The Permission for Adapting TPACK Survey Instrument in Turkish

Date: 10/28/2015
To: Ercan Dede
From: Dr. Jeremy Zelkowski
Re: Permission for TPACK survey

No problem. This is published in the Journal of Research on Technology in Education.

https://www.iste.org/resources/Product?ID=2976

All items were published for the final instrument, as well as the initial items tested. My team and I whole-heartedly welcome translational studies, and other studies with this instrument.

We'll be interested in the outcomes of your dissertation work! I hope it helps!

Jeremy Zelkowski, PhD Associate Professor, Secondary Mathematics Education
T^3 National Instructor
President, Alabama Council of Teachers of Mathematics
Southern 2 Region Rep, NCTM Affiliates Services Committee
Co-PI, MSP - Project IMPACT
Co-PI, NSF UA NOYCE Scholars Program Department of Curriculum & Instruction Office of Research on Teaching in the Disciplines College of Education The University of Alabama 212-A Graves Hall Tuscaloosa, AL 35487-0232 205-348-9499 205-348-9863 (Fax)
Website: http://education.ua.edu/people/jeremy-zelkowski/

Appendix U

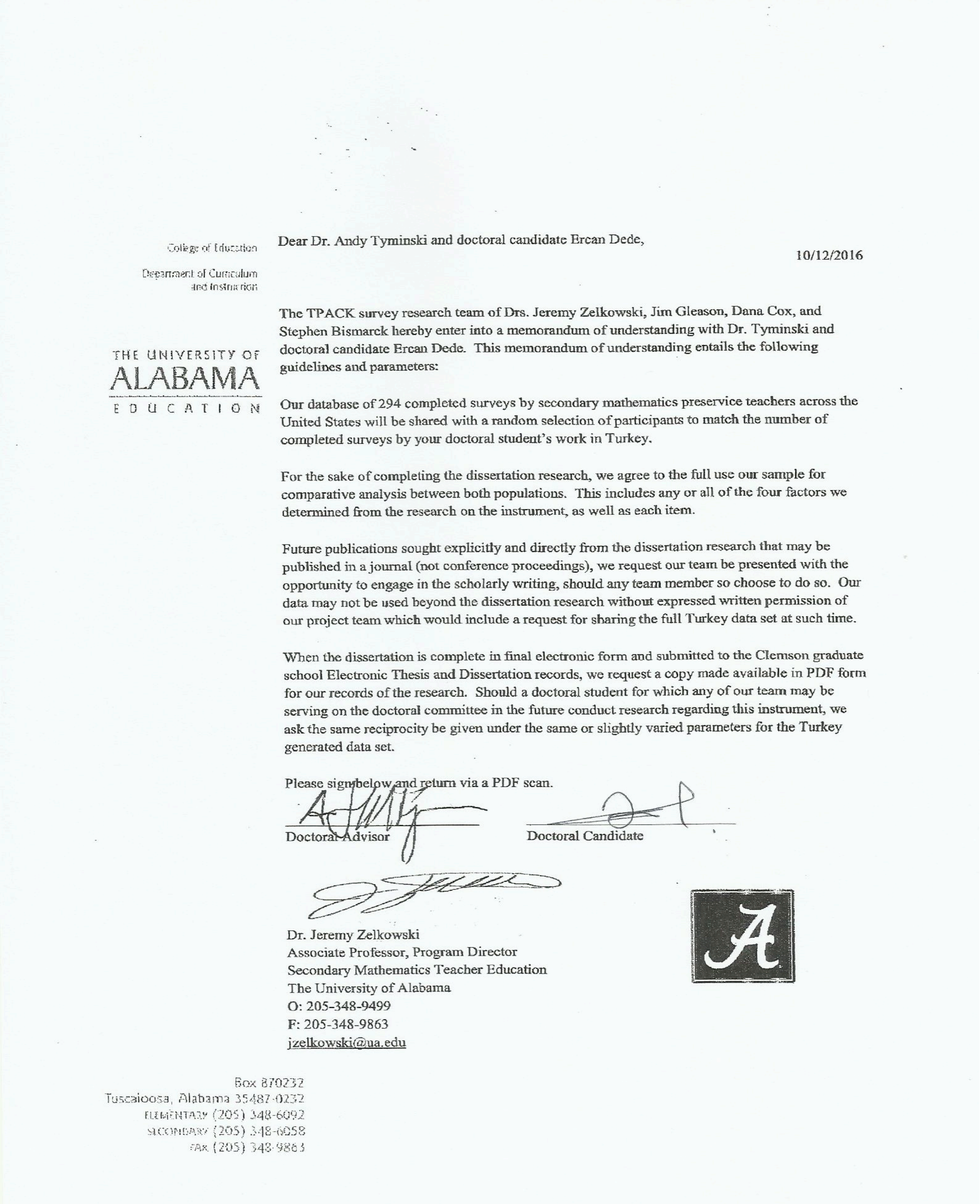
The Permission of use of the Attitude Scale for Computer-Aided Education

Date: 16/02/2016
To: Ercan Dede
From: Dr. Ali Arslan
Re: Permission to Use the Attitude Scale for Computer-Aided Education Survey Instrument

Ercan hocam merhabalar.
Ölçeği doktora çalışmanızda kullanabilirsiniz. İyi çalışmalar dilerim.

Appendix V

Memorandum of Understanding for the USA Sample Data Sharing



College of Education

Department of Curriculum
and Instruction

THE UNIVERSITY OF
ALABAMA
EDUCATION

Dear Dr. Andy Tyminski and doctoral candidate Ercan Dede,

10/12/2016

The TPACK survey research team of Drs. Jeremy Zelkowski, Jim Gleason, Dana Cox, and Stephen Bismarck hereby enter into a memorandum of understanding with Dr. Tyminski and doctoral candidate Ercan Dede. This memorandum of understanding entails the following guidelines and parameters:

Our database of 294 completed surveys by secondary mathematics preservice teachers across the United States will be shared with a random selection of participants to match the number of completed surveys by your doctoral student's work in Turkey.

For the sake of completing the dissertation research, we agree to the full use our sample for comparative analysis between both populations. This includes any or all of the four factors we determined from the research on the instrument, as well as each item.

Future publications sought explicitly and directly from the dissertation research that may be published in a journal (not conference proceedings), we request our team be presented with the opportunity to engage in the scholarly writing, should any team member so choose to do so. Our data may not be used beyond the dissertation research without expressed written permission of our project team which would include a request for sharing the full Turkey data set at such time.

When the dissertation is complete in final electronic form and submitted to the Clemson graduate school Electronic Thesis and Dissertation records, we request a copy made available in PDF form for our records of the research. Should a doctoral student for which any of our team may be serving on the doctoral committee in the future conduct research regarding this instrument, we ask the same reciprocity be given under the same or slightly varied parameters for the Turkey generated data set.

Please sign below and return via a PDF scan.

Doctoral Advisor

Doctoral Candidate

Dr. Jeremy Zelkowski
Associate Professor, Program Director
Secondary Mathematics Teacher Education
The University of Alabama
O: 205-348-9499
F: 205-348-9863
jzelkowski@ua.edu

Box 870232
Tuscaloosa, Alabama 35487-0232
ELEMENTARY (205) 348-6092
SECONDARY (205) 348-6058
FAX (205) 348-9863

REFERENCES

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Ball, D. L. (1990). Prospective elementary and secondary teachers' understanding of division. *Journal for research in mathematics education*, 132-144.

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