AN EXAMINATION OF IN-SERVICE SECONDARY MATHEMATICS TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE AND THEIR TECHNOLOGY INTEGRATION SELF-EFFICACY

by

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B.S., Elementary Mathematics Education, Middle East Technical University, 2012

Submitted to the Institute for Graduate Studies in
Science and Engineering in partial fulfillment of
the requirements for the degree of
Master of Science

Graduate Program in Secondary School Science and Mathematics Education

Boğaziçi University

2014

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DATE OF APPROVAL: 15.08.2014

Dedicated to days and nights
spent for this study

ACKNOWLEDGEMENTS

First of all, I would like to express my gratitude to those who supported me and encouraged me on a daily basis to continue to pursue my dreams. A special word of thanks goes to my supervisor Assist. Prof. Fatma Aslan Tutak. Her valuable guidance and support throughout my research has been tremendous. She always reminded me my potential to deal with the difficulties throughout the whole process of this research and encouraged me to complete my study in time.

I would also like to express sincere appreciation to my committee members, Assist. Prof. Fatih Çağlayan Mercan and Assoc. Prof. Hatice Akkoç who shared their valuable suggestions and assistance with me. This thesis became more qualified with their useful critiques, feedbacks and recommendations.

I would like to thank to all the faculty members that were a part of this graduate educational experience. Thanks to my respectful instructors Prof. Ayşenur Yontar Toğrol, Prof. Ali Baykal, Assist. Prof. Emine Adadan and Assoc. Prof. Buket Yakmacı Güzel for providing me numerous opportunities to grow as a researcher.

I would also like to thank my instructor from prep school Halil İbrahim Karabulut, my friend Emine Karadeniz and Kübra Okumuş for their invaluable support and feedbacks. I want to thank my colleagues at Private Yeni Nesil 2000 Schools for their support in my busy times throughout my study.

I would also like to my friends Rabia, Eray, Güneş, Nurseda, Pınar, Ayşenur and Hatice for their contributions and supports. My special thanks go to my lovely friend Özge and her baby Nehir. Whenever I needed their support they were always there for me.

During data collection process, administrators and teachers in all schools welcomed me and showed their hospitability. Without the help of them, this study could not be completed. I would like to express my appreciation to mathematics teachers who participated in the study for their valuable contribution.

The last but not least, a huge thank to my family who supported my academic dream. Thank to my parents, Hasan and Nimet for believing in and supporting me throughout my life. I always feel their endless love and support which give me perseverance to complete this study. I would also like to thank my aunt, Sebahat who always been there for me since I started to graduate program. I would also give grateful thanks to my brother, Cengiz for his understanding, patience, friendship and help. Although he was not near me physically most of the time, I always feel his support next to me. I always feel lucky to have such a family.

ABSTRACT

AN EXAMINATION OF IN-SERVICE SECONDARY MATHEMATICS TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE AND THEIR TECHNOLOGY INTEGRATION SELF-EFFICACY

The aim of this study was to identify perceived technological pedagogical content knowledge (TPACK) and technology integration self-efficacy (TISE) of secondary mathematics teachers. In addition, the purpose was to examine the relationship between TPACK and TISE variables. Moreover, possible gender, age and years of experience diversities related to TPACK and TISE were examined. The research conducted with 138 secondary mathematics teachers from 28 different FATIH project schools in six districts of Istanbul. Turkish translated versions of TPACK-M and TISE scales were used to collect data. The results indicated that secondary mathematics teachers' perception of TPACK and their TISE are moderate level. Moreover, there was a strong relationship between TPACK and TISE variables. According to demographic results, there was no significant difference in TPACK perception of male and female mathematics teachers while there was significant difference in TISE of mathematics teachers in favor of males. Also, small negative correlation was found between age and mathematics teachers' TPACK perception though strong negative correlation was found between age and mathematics teachers' TISE. Furthermore, there was no significant difference in TPACK perception and teaching experience of secondary mathematics teachers. However, there was significant difference in TISE and teaching experience of secondary mathematics teachers. More experienced mathematics teachers recorded lowest mean score for TISE. Based on the findings, it is recommended to provide professional development programs for teachers. It could be useful to use TPACK as a framework to understand what knowledge teachers must have to integrate technology into teaching and TISE as a belief to adopt current technologies.

ÖZET

ORTAÖĞRETİM MATEMATİK ÖĞRETMENLERİNİN TEKNOLOJİK PEDAGOJİK ALAN BİLGİLERİNİN VE TEKNOLOJİYİ ENTEGRETME ETME ÖZ YETERLİLİKLERİNİN İNCELENMESİ

Bu çalışmanın amacı ortaöğretim matematik öğretmenlerinin algıladıkları teknolojik pedagojik alan bilgilerini (TPAB) ve teknolojiyi entegre etme öz-yeterliliklerini (TEÖY) tanımlamaktır. Çalışmanın diğer bir amacı ise TPAB ve TEÖY arasındaki ilişkiyi incelemektir. Ayrıca bu çalışmada öğretmenlerin olası cinsiyet, yaş ve öğretmenlik deneyimi farklılıklarının TPAB ve TEÖY ile ilişkileri incelenmiştir. Bu çalışma İstanbul'daki 6 farklı ilçedeki FATIH projesi kapsamındaki okullarda çalışan 138 matematik öğretmeniyle yapılmıştır. Veri toplamak için Türkçeye çevrilmiş TPAB-M VE TEÖY ölçekleri kullanılmıştır. Çalışma sonuçlarına göre ortaöğretim matematik öğretmenlerinin TPAB algıları ve TEÖY orta seviyededir. Ayrıca TPAB ve TEÖY değişkenleri arasında güçlü bir ilişki bulunmuştur. Demografik sonuçlara göre, erkek ve bayan öğretmenlerin TPAB algılarında anlamlı bir fark yokken TEÖY lerinde erkeler lehine anlamlı bir fark vardır. Ayrıca TPAB ve yaş arasında zayıf negatif korelasyon bulunmasına rağmen TEÖY ve yaş arasında güçlü negatif korelasyon bulunmuştur. Buna ek olarak ortaöğretim matematik öğretmenlerinin TPAB ve öğretmenlik deneyimleri arasında anlamlı bir fark yoktur. Fakat ortaöğretim matematik öğretmenlerinin TEÖY ve öğretmenlik deneyimleri arasında anlamlı bir fark vardır. Daha deneyimli öğretmenler için TEÖY ortalama puanı en düşük olarak kaydedilmiştir. Bulgulara dayanarak öğretmenler için mesleki gelişim programlarının sağlanması tavsiye edilebilir. Öğretmenlerin teknolojiyi öğretime entegre edebilmesi için sahip olması gereken bilgileri anlayabilmek için TPAB sini bir çerçeve olarak kullanmak ve güncel teknolojileri benimseyebilmeleri için TEÖY bir inanç olarak kullanmak faydalı olabilir.

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LIST OF ACYRONYMS / ABBREVIATIONS

CK	Content Knowledge
ICT	Information and Communication Technologies
MoNE	Ministry of National Education
NCTM	National Council of Teachers of Mathematics
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
SMK	Subject Matter Knowledge
TCK	Technological Content Knowledge
TK	Technology Knowledge
TPCK	Technological Pedagogical Content Knowledge
TPK	Technological Pedagogical Knowledge

1. INTRODUCTION

"It is not the boards that are smart, it is the teachers"

(ERI, 2014, p.17)

Recent scientific and technologic developments in the world have forced educational institutions to change. According to Alkan (2005), education system must renew itself in the process of rapid social change. If an educational system that aims to go beyond the era, it should be receptive. Also, it should analyze the requirements of time and modernize itself in accordance with needs (Akkoyunlu *et al.*, 2008). Therefore, to be literate is not enough nowadays. The importance of information technology, especially computers and the Internet into everyday life has revealed new types of literacy. Being technologically literate is increasingly important.

From this point of view, technological opportunities of schools have increased in Turkey recently. Ministry of National Education (MoNE) has some attempts to integrate technology in schools. There are projects held by MoNE to improve the schools technologically such as FATIH, e-school, e-twinning (EĞİTEK, 2011). "Movement of Enhancing Opportunities and Improving Technology", known as FATIH, is among the most significant educational investments of Turkey. The FATIH project proposes that "Smart Class" project is put into practice in all schools around Turkey. With this project, 42.000 schools and 570.000 classes will be equipped with the latest information technologies and will be transformed into computerized classes (Smart Class). The aim of this project is to enable equal opportunities in education and to improve technology in schools for the efficient usage of information and communication technologies (ICT) tools in the learning-teaching processes through providing tablets and LCD Interactive Boards (MoNE, 2013). However, first results of the FATIH project reflect that policymakers assumed that the technology would be taught by itself without teacher (ERI, 2014).

The FATIH project proposes that schools in Turkey have been equipped with technological facilities over time starting from secondary schools. However, putting computers into the classrooms without well trained teachers is not really technology integration (Dockstader, 1999). The ratios of students to computers or the number of hours that computers used are not a measure of effective technology integration, neither (U.S. Department of Education, National Center for Education Statistics, 2002; Ertmer, 1999). Technology integration means to use technology in an educational context in a manner that enhance student learning (Harris, 2005). It can be achieved when technology is used *effectively* and *efficiently* in the different content areas to allow students to learn how to apply technology skills in meaningful ways.

Although technology has relationship with many domains, it has prominent place in mathematics education due to many reasons. In the last century, technology integration into mathematics education has brought many innovations in the mathematics classroom in terms of development as well as accessibility (Preiner, 2008). Research suggests that using technology in classrooms facilitates classroom activities and enhances productivity and quality of lessons (Chrysanthou, 2008). Technology tools facilitate and develop students‘ skills to solve problems and give students the chance to think about problems and their solution strategies when used *efficiently* (Altun, 2011; Baki, 2001; Lee and Hollebrands, 2008; Risser, 2011). According to National Council of Teachers of Mathematics (NCTM) which is one of the world‘s largest associations in mathematics education, technology is one of six principles for school mathematics. NCTM (2000) insists on technology-supported school mathematics and continues:

> ―The effective use of technology in the mathematics classroom depends on the teacher. Technology is not a panacea. As with any teaching tool, it can be used well or poorly. Teachers should use technology to enhance their students‘ learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well — graphing, visualizing, and computing (p.25).

Since teachers are responsible for adjusting the learning environment, new skills have aroused which a teacher should have for better technology integration (Cox, 2008). Therefore, integrating technology requires not just the technology knowledge but a complex mixture of technology, pedagogy and content knowledge (Koehler and Mishra, 2005). There is limited

study concerning the technology, pedagogy, and content knowledge of teachers in Turkey. FATIH project teachers' competencies in technology integration should be determined when putting the latest technologies into the classrooms. Moreover, MoNE in Turkey determined mathematics teachers' special area competencies for technology use. MoNE (2010) suggests that mathematics teachers should be able to use technology resources in mathematics education and know mathematics software. In addition to these competencies, mathematics teachers need to be technology literate and follow developments in ICT (MoNE, 2006; 2013).

The knowledge needed for teachers to use technology strategically in mathematics instruction is a topic that has recently gained much attention (Neiss *et al*., 2009; Mishra & Koehler, 2006). Technological Pedagogical Content Knowledge (TPACK), as described by Mishra and Koehler, "represents a thoughtful interweaving of all three key sources of knowledge – technology, pedagogy, and content" (2006, p. 14). The TPACK framework describes good teaching with technology by including the components of content, pedagogy, and technology. Shulman's (1986, 1987) idea of pedagogical content knowledge (PCK) is the basis for this framework with the inclusion of the domain of educational technology. Technological pedagogical content knowledge (TPACK) provides a useful framework for understanding teacher perceptions and practices of technology integration into curriculum and pedagogy. To integrate technology into their pedagogy and curriculum successfully, teachers must develop confidence in their abilities to integrate technology in the classroom because the integration of technology affects how students learn in the classroom (Bunch *et al*., 2012b).

However, the relationships between intrapersonal factors like technology integration self-efficacy and relationship of it with TPACK are not fully understood in mathematics education. Therefore, this study focused on determining in-service secondary mathematics teachers' perceived TPACK and the intrapersonal factors of technology integration self-efficacy (TISE) and also the relationship between TPACK and TISE. The term, perceived TPACK was used in this study to get the views of teachers' on their TPACK as a self-report. Also, technology related constructs technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPCK) were measured in this thesis study.

2. LITERATURE REVIEW

According to Bloom and his colleagues (1956), there are three domains (cognitive, affective and psychomotor) of educational activities. The cognitive domain involves knowledge and development of intellectual skill. This includes the recall or recognition of specific facts, procedural patterns and concepts that serve developing intellectual abilities and skills. The affective domain includes feelings, values, appreciation, enthusiasms, motivations and attitudes. The psychomotor domain includes physical movement, coordination and use of the motor skills areas. Educators often refer to these domains as KSA (knowledge, skills and attitude or self). Generally, more emphasis is given to the cognitive domain (knowledge) in teaching and learning processes. However, the affective domain (attitude or self) also plays a critical role in these processes.

The present study seeks to examine in-service teachers' knowledge as a dimension of cognitive domain and their self-efficacy as a dimension of affective domain. In accordance with technological developments in education, this study focuses on teachers' technological pedagogical content knowledge and their technology integration self-efficacy. Theoretical backgrounds of teachers' knowledge and self-efficacy for using technology and also relevant studies have been referred to throughout the chapter.

2.1. Teachers' Knowledge for Using Technology

The knowledge which is required for teachers has changed throughout the years. There were many studies on teachers' knowledge such as Ball (1990a; 1990b; 2000), Borko *et al*. (1992), Grossman (1990), Hill et al. (2008), Shulman (1986, 1987), Tamir (1988). One influential study, Shulman (1986) divided teachers' knowledge into three categories subject matter knowledge, pedagogical content knowledge (PCK) and curricular knowledge. Subject matter knowledge or content knowledge is teacher's knowledge that can be used to teach the structures of specific subject. Curricular knowledge is the full range of programs that are designed for teaching a particular subject. Furthermore, Shulman and his colleagues have focused on the intersection of content and pedagogical knowledge, which is known as

pedagogical content knowledge (PCK). After Shulman's study, Grossman (1990) extended Shulman's construct by describing four central components as general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge and knowledge of context. Shulman's (1986) and Grossman's (1990) frameworks were related to general teacher knowledge. They did not focus on any specific subject. However, Ball and his colleagues (2008) proposed a model for mathematics teachers' knowledge. In Ball and his colleagues' (2008) model, there are two dimensions, namely subject matter knowledge and pedagogical content knowledge. While subject matter knowledge consists of three subdomains as common content knowledge, specialized content knowledge and horizon content knowledge, pedagogical content knowledge (PCK) has been divided into three domains as knowledge of content and students, knowledge of content and teaching and knowledge of curriculum. However, these models did not provide much information about use of educational technologies. With developing technologies in the mid-1990s, integration of technology in teaching has taken place. So, many researchers proposed an expansion of Shulman's PCK framework by adding a new dimension (technology). Pierson (2001) worked on technology integration in PCK. She added technology knowledge to Shulman's PCK definition. According to Pierson (2001), effective technology integration requires extended content and pedagogical knowledge. So, technological pedagogical content knowledge means integrating technology *effectively*. As technology in life and education get more importance, it is vital to focus on technological pedagogical content knowledge.

One of the early contributions to TPACK in mathematics classroom showed that mathematics teachers with strong TPACK have six main characteristics (Grandgenett, 2008):

(i) Opening to experimentation with technological tools and willingness to experiment with new lessons using technology;
(ii) Staying on task and not being sidetracked when teaching mathematics topics with technology;
(iii) Offering clear pedagogical strategies by knowing where students are academically, what students need to know, and how the lesson should be taught;
(iv) Helping students understand why technology is important;
(v) Using technology for teaching, assessment, and classroom management; and

(vi) Being comfortable and optimistic about changes in technology.

2.1.1. Technological Pedagogical Content Knowledge (TPACK)

The concept of technological pedagogical content knowledge (TPACK) has emerged over the last decade. It was started with Pierson's (2001) initial articulation of the idea and followed by various other researchers suggesting similar conceptions of a more content-specific orientation to technology integration (Angeli and Valanides, 2005; Koehler and Mishra, 2005; Lee, 2005; Margerum-Leys and Marx, 2003, 2004; Niess, 2005; Wallace, 2004). The term TPACK began to gain widespread popularity in 2006 after Mishra and Koehler's seminal work outlining the model and describing each of the central constructs. TPACK was called "TPCK" in the literature until 2008, when some in the research community proposed using the more easily spoken term TPACK (Thompson, 2008).The TPACK framework builds on Shulman's (1986, 1987) conception of pedagogical content knowledge (PCK) by explicitly integrating the component of technological knowledge into the model. The TPACK framework is most commonly represented using a Venn diagram with three overlapping circles, each representing a distinct form of teacher knowledge (see Figure 2.1.). The framework includes three core categories of knowledge: pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK). The framework proposes that combining these three core types of knowledge results in four additional types of knowledge: pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). Often knowledge of context is also included as a part of the model (Akarasriworn and Ku, 2010; Mishra and Koehler, 2006). Many recent TPACK studies have used the current diagrammatic demonstration of TPACK framework developed by Koehler and Mishra (2005) after five years of ongoing research studies. Following Shulman's (1987) definitions of good teaching, in educational projects the teachers' perception of their knowledge is considered a critical success factor (Polly and Mims, 2009). In technology implementation projects this knowledge is described as a blend of technology, pedagogy and content knowledge (TPACK) (Mishra and Koehler, 2006) that teachers must master in order to use the technology effectively.

As a result, the TPACK framework was used in this study. Firstly, each type of teacher knowledge represented in the framework was briefly described below. Then, previous research studies with pre-service and in-service teachers on TPACK were explained.

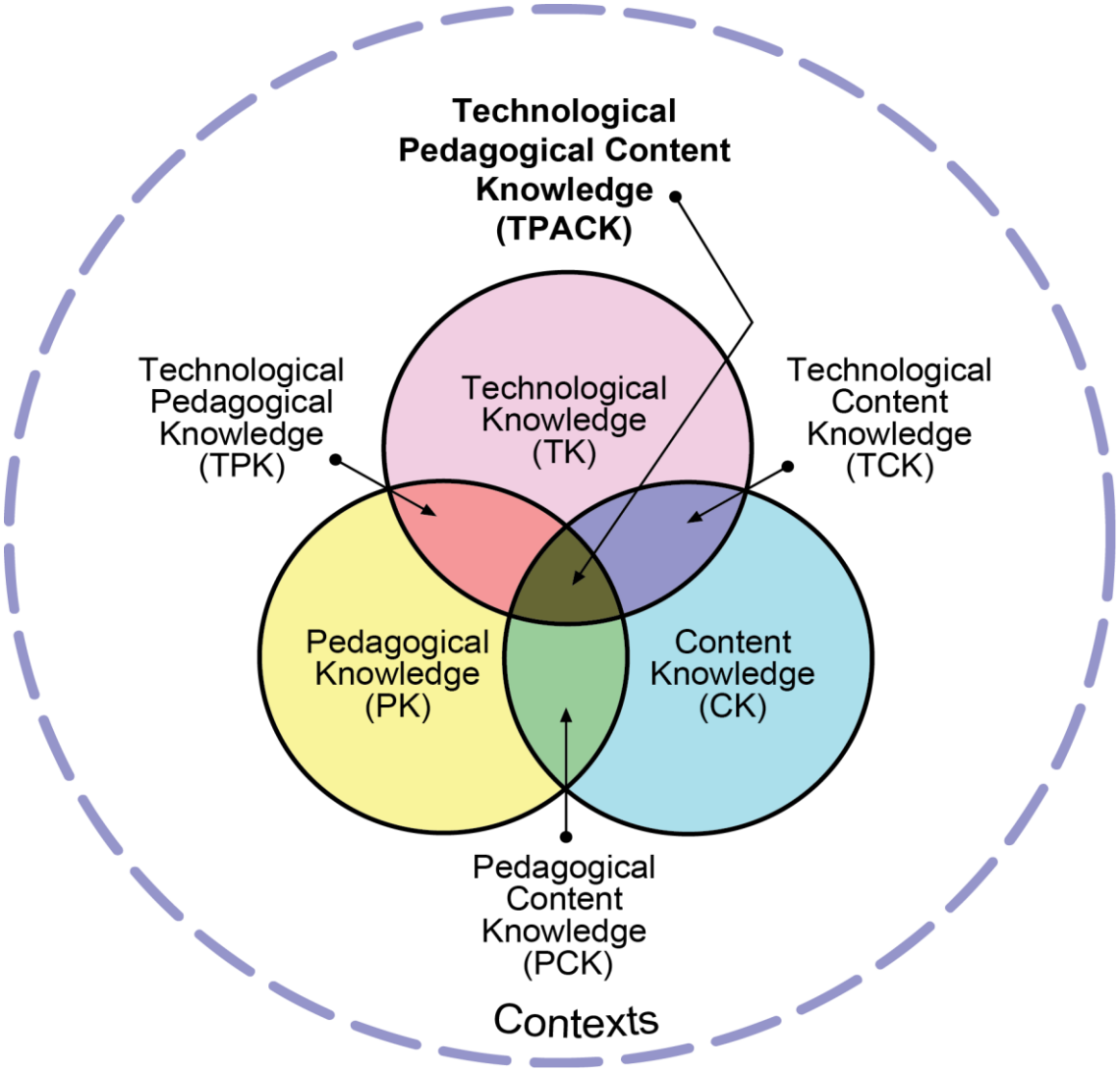


Figure 2.1. Technological Pedagogical Content Knowledge Framework, adapted from Koehler and Mishra (2009, p. 63).

2.1.1.1. Three Main Components of Teacher Knowledge. In order to explore TPACK framework, the three main components (types of knowledge) of TPACK –content knowledge

(CK), pedagogical knowledge (PK) and technological knowledge (TK) primarily should be understood. However, due to the overlapping nature of the framework, concerns about the confusion among constructs have been highlighted by researchers such as Cox and Graham (2009).

Content knowledge (CK), in other words subject matter knowledge, is knowledge about the actual subject matter that is to be taught (Mishra and Koehler, 2006). According to Shulman (1986), this knowledge would include knowledge of central facts, concepts, theories and procedures within a given field; knowledge of explanatory frameworks that organize and connect ideas; and knowledge of the rules of evidence and proof. The content knowledge regarding mathematics instruction includes knowledge of mathematical concepts, formulas, algorithms, postulates and theorems in addition to the procedures involved in their application such as problem solving and reasoning. For example, knowing the definition of functions and its applications is content knowledge of a mathematics teacher. Teachers who do not have these understandings can misrepresent those subjects to their students (Ball and McDiarmid, 1990). Content knowledge is about "what to teach," and it is as important as pedagogy knowledge, "how to teach" (Jiang, 2007).

Pedagogical Knowledge (PK) is the knowledge about the procedures, processes, practices, strategies, and methods of teaching and learning and how it encompasses among other things, overall educational purposes, values and aims (Koehler and Mishra, 2005; 2009). This type of knowledge includes classroom management skills, lesson planning, teaching and assessment strategies and also students' learning methods (Koehler and Mishra, 2009). According to Morine-Dershimer and Kent (1999) personal beliefs, practical experience, and reflection also play an important role in shaping pedagogical knowledge. Shulman (1987) stated that general pedagogical knowledge includes broad principles and strategies of classroom management and organization those appear to transcend subject matter. Similarly, extending this definition, Grossman and Richert (1988) commented that knowledge of theories of learning and general principles of instruction, an understanding of the various philosophies of education, general knowledge about learners, and knowledge of the principles and techniques of classroom management were involved in general pedagogical knowledge. Therefore, fundamental theories and methods of instruction and learning, as well as classroom management, can be defined as essential parts of general pedagogical knowledge (König *et*

al., 2011). A teacher who has deep pedagogical knowledge understands how students construct knowledge and acquires skills; develops habits of mind and positive dispositions towards learning (Koehler and Mishra, 2008). For example, knowing multiple representation methods and its' importance for high school students' learning is pedagogical knowledge of a mathematics teacher.

Technology knowledge (TK) can be defined as the knowledge about standard technologies, such as books, chalks and blackboard, and more advanced technologies, such as the Internet and digital technology (Koehler and Mishra, 2005). However, because of the changes in technology and its possible influence on use of technology in classroom, the definition of TK might be redefined over time. For example, Schmidt and his colleagues (2009) included interactive whiteboards and software programs in TK as well as the definition of Koehler and Mishra. Therefore, defining technology knowledge (TK) is more difficult than two main knowledge domains in the TPACK framework (pedagogy and content) since it is always in a *'state of flux'* (Harris *et al.*, 2009). Koehler and Mishra (2005) said that "any definition of technology knowledge is in danger of becoming outdated by the time this text has been published". Other definitions of TK highlight installing and removing peripheral devices, software programs (Mishra and Koehler, 2006) and use of computer technology (Cox, 2008). Technology knowledge regarding mathematics may include the use of computer software including word processing, spreadsheets, or content related software (Geometer's Sketchpad, TI-Interactive, and TI-Smart View), graphing calculators, calculator-based rangers (CBRs), and audio and video recordings.

2.1.1.2. Interactions between Main Components of Teacher Knowledge. In the TPACK framework (Figure 2.1), there are the three main components of knowledge represented by the three circles: technological knowledge, pedagogical knowledge, and content knowledge. Equally important in this framework are the intersections of these components of knowledge. The interactions between each pair of concepts can be represented as pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK).

In Mishra and Koehler's model, pedagogical content knowledge (PCK) is similar to Shulman's (1986) idea of knowledge of pedagogy that is applicable to the teaching of specific content. Shulman defines it as "subject matter knowledge for teaching*"* (Shulman, 1986). Also, he stated that PCK represents the blending of content and pedagogy. According to Shulman (1987), this means that teachers should organize particular topics, problems or issues, represent them, adapt to diverse interests and abilities of learners. It includes knowing which teaching approaches fit the content and knowing in which way elements of the content can be arranged for better teaching (Mishra and Koehler, 2007). Moreover, PCK is concerned with the one's ability to combine teaching methods and curricular understanding with knowledge about learners and learning. Also, it deals with an understanding of educational goals and assessment to communicate information *effectively* and *efficiently* to students (McCaughtry, 2005; Morine-Dershimer and Kent, 1999). According to Ball and his colleagues (2008), it is a kind of amalgam of knowledge of content and pedagogy that is central to the knowledge needed for teaching. A teacher with deep PCK can satisfy essential elements of effective teaching .For example, an awareness of common misconceptions and ways of looking at them, the importance of making connections among different context-based ideas, students' prior knowledge, alternative teaching strategies, and the flexibility that comes from exploring alternative ways of looking at the same idea or problem are all essential elements for effective teaching (Koehler and Mishra, 2009). In PCK, the knowledge of content-specific activities and the knowledge of representations are combined in order to facilitate student learning (Cox and Graham, 2009). That means a teacher with a good PCK presents a subject matter with appropriate instruction strategies for a group of learners. For instance, a ninth grade teacher who will design an instruction on functions would need to be aware of common alternative conceptions in order to deliver an effective instruction.

Secondly, Mishra and Koehler (2007) defined technological content knowledge (TCK) as an understanding of the connection between technology and content and how one affects the other. Cox (2008) extended Mishra and Koehler's definition. She said that TCK is knowledge of appropriate technologies that may be utilized in a specific discipline and how use of those technologies influences the content of that discipline through representation. Besides, being aware of technology, knowing how to use it and understanding the rationale for doing it in the context of specific subject matter are crucial for teachers. Teachers should

know which specific technologies are best suited for addressing a particular subject. For example, knowing which software program is more appropriate for teaching functions can be considered as an example of TCK for a mathematics teacher.

The last but not least, technological pedagogical knowledge (TPK) is an understanding of the relationship between technology and learning, particularly how learning changes when technologies are utilized. TPK can include knowledge of the constraints of technological tools as well as how they fit into pedagogy and strategies (Mishra and Koehler, 2007). It also includes the ability to creatively use available technology tools in a pedagogical context (Harris et al., 2007). Cox (2008) stated that understanding technological tools, which are available for teaching, and their weaknesses and strengths, are included in TPK. According to Koehler and Mishra (2009), TPK is particularly important for teachers because most popular software programs are not designed for educational purposes. However, they can be used for instructional practices. Software programs such as Microsoft Office Suite (Word, PowerPoint, Excel and MSN Messenger) are usually designed for business environment. Also, web-based technologies such as blogs are designed for purposes of environment, communication and social networking. So, teachers need to develop skills looking beyond most common uses for technologies and reconfiguring them for pedagogical purposes. In this line, teachers should be forward-looking, creative, and open-minded. Also, teachers should seek use of technology for advancing student learning and teaching. It may include such applications as how to use digital cameras and whiteboards in the classroom to support effective learning. Knowledge of tools for maintaining class records, attendance, and grading, and knowledge of generic technology based ideas such as web quests, discussion boards, and chat rooms can be considered as an example for TPK.

However, three main components of teacher knowledge (CK, PK, TK) individually and interactions between them (PCK, TCK, TPK) were not useful to transform for classroom instruction. Those are not sufficient for underlying truly meaningful and deeply skilled teaching with technology. Effective technology integration should bring fundamental changes in education instead of merely using technology to continue the old way of teaching and learning (Ertmer, 2005). So, learning can be most effective when pedagogical strategies are carefully developed, with computer technologies used as mediators of learning and

incorporated into the pedagogical strategy (Stoilescu and McDougall, 2009). Consequently, adequate pedagogical models are necessary in order to explicitly describe and support the use of technology. So, emphasis is placed on the "connections, interactions, affordances, and constraints" (Mishra and Koehler, 2006) between and among the three components. The intersection among all three components represents technological pedagogical content knowledge (TPACK). More than just the sum of technology, pedagogy, and content, the significance of the overlapping areas lies in the interaction between the three components, described by Mishra and Koehler (2006). TPACK model can be important and useful because it stresses the importance of technology knowledge and how to combine it with pedagogy and the content. If it is understood and implemented in the classroom, TPACK could be an effective framework to guide teachers' integration of technology (Franklin, 2004; Gunter and Baumbach, 2004; Hughes, 2003; Koehler and Mishra, 2008; Pierson, 2001).

2.1.1.3. Technological Pedagogical Content Knowledge. Technological Pedagogical Content Knowledge (TPACK) refers to the complex interrelationship between a teacher's technology use, instructional methods, and understanding of the subject matter (Mishra and Koehler, 2006). It is the knowledge required by teachers for integrating technology into their teaching in any content area. In TPACK, teachers should have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) when teaching content using appropriate pedagogical methods and technologies (Schmidt, *et al.* 2009). TPACK is not a simple combination of three independent domains; rather, content, pedagogy, and technology are interdependent, each one affecting the others (Harris *et al.*, 2007). Mishra and Koehler (2006) defined TPACK as

> the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones (p. 1029).

Similarly, Cox (2008) defined TPACK as knowledge of the 'dynamic, transactional' negotiation among technology, pedagogy, and content and how that negotiation impacts

student learning in a classroom context. Teachers should have an in-depth understanding of mathematics (the content), teaching and learning (the pedagogy), and technology to be prepared for teaching mathematics. More importantly, however, they should need an integrated knowledge of these different domains, the overlap and integration of these domains. TPACK for teaching with technology means that as teachers how particular mathematics concept might teach with technology. So, students understand the concept (Niess, 2006). For example, a mathematics teacher may have a difficulty to teach functions (content knowledge). Especially, making a connection between the definition of a function and graph of a function may be difficult only using chalk and board. However, using computer software (technology knowledge) such as Geogebra or Geometry Sketchpad for visualization and multiple representations (pedagogy knowledge) may contribute to better understand the particular topic.

2.1.2. Research Studies on TPACK

After Mishra and Koehler (2006) introduced their TPACK model, it was used in many researches. This framework has been widely adopted for the planning of teacher ICT education (Cox and Graham, 2009) and used as a theoretical underpinning for the development of surveys to measure teachers' TPACK. In terms of measurement, all of the instruments were focused on teachers' self-report, in other words their perception on use of technology. Also, conducting research about development and measuring of TPACK is an important and hard challenge. Since TPACK is complicated construct and comprised of many components. Measuring the effectiveness of TPACK depends on the relationships of these components with each other (Koehler *et al.*, 2011). As a result of complexity of TPACK, getting reliable and valid results after assessing the TPACK is an important process. Researchers encounter some problems while they are measuring the TPACK of teachers. They face different problems in each different measuring tool of TPACK. The main two problems living during the measurement process are that understanding the effects of teachers' domain knowledge on their current teaching practices and reliability, validity concerns of TPACK measurement methods (Abbitt, 2011). So, researchers tend to try different methods to measure TPACK because of the fact that dynamic characteristic.

According to Cox (2008), beyond Koehler and Mishra's studies (Koehler and Mishra, 2005a, 2005b; Koehler et al., 2004; Koehler *et al.*, 2007; Mishra and Koehler, 2005; Mishra, Koehler *et al.*, 2007), the body of research on TPACK is varied. Studies on TPACK were focus; in-service teachers (Archambault and Crippen, 2009; Graham *et al.*, 2009; Handal *et al.*, 2013) and pre-service teachers (Koh *et al.*, 2010; Niess, 2005; Schmidth *et al*, 2009). TPACK framework includes the descriptions of the three primary domains of knowledge (TK, PK and CK) as well as four blended domains (PCK, TCK, TPK, TPCK). In an effort to maintain clarity, this thesis study identifies the blended knowledge domain of technological pedagogical content knowledge using the acronym TPCK to distinguish the individual construct from the title of knowledge model identified using the acronym TPACK.

2.1.2.1. Research Studies with Pre-service Teachers. The definition of TPACK concept was settled but it continues to be studied on it. So, most of the studies focused on the definition of TPACK and developing instruments to measure it in literature. Also, many TPACK studies conducted with pre-service teachers. For example, Schmidt and his colleagues (2009a) developed an instrument to measure pre-service teachers' TPACK level. The researchers specifically designed the instruments for elementary education focusing on the content areas (literacy, mathematics, science and social studies). The instrument was constructed as 5 point Likert scale with 75 items which were based on Koehler and Mishra's (2005) TPACK framework. The survey was applied to one hundred twenty four pre-service teachers. The results showed that factor analysis (between .65 and .92) and reliability analysis (between .80 and .90) were good (Schmidt *et al.*, 2009a). With the modification and omission of some items, the survey became a reliable and valid instrument to assess pre-service teachers' development of TPACK. The survey of Schmidt and his colleagues (2009) was used in another study to examine pre-service teachers' related knowledge domains in TPACK framework. The participants of the study were 87 pre-service teachers enrolled in a required introductory instructional technology course. Pretest-posttest design was used in the study. Also, a series of paired samples t-tests were conducted and changes in variables were measured. The results revealed that there are significant gains in all seven TPACK components. Moreover, the largest gain was found in the areas of TK, TCK and TPACK.

Similarly, Koh, Chai and Tsait (2010) examined 1185 Singaporean pre-service teachers in terms of their TPACK level. The 5 point Likert scale designed by Schmidt *et al*. (2009b) was changed to 7 point Likert scale in this study. After suggested adaptations, the final survey with 29 questions was used to collect data. The differences of gender, age and teaching level on TPACK were examined. The results showed that male pre-service teachers' TPACK are generally higher than females. Moreover, male pre-service teachers had a more positive attitude, higher confidence and competency perceptions in terms of computer use. On the other hand, the findings showed that the participants of this study do not make conceptual distinctions between TPACK constructs such as TCK and TPK. There were not significant effects of age and teaching level on TPACK variables in the study.

Different from (Schmidt *et al.*, 2009) and (Koh *et al.*, 2010) quantitative studies, Niess (2005) conducted a qualitative study. The participants of the study were 22 pre-service science and mathematics teachers in a multi-dimensional science and mathematics context. The development of these teachers' PCK was investigated with respect to integrating technology. A one year teacher preparation program for this study focused on the preparation of science and mathematics teachers. All classes (technology, microteaching and content, technology and pedagogy) were observed and analyzed for this study. The data was coded using the four components of TPACK adapted from Grossman's (1988, 1989) PCK definition. The results revealed that participants were various degrees of progress in the development of TPACK. Niess (2005) explained that 14 of 22 students improved their TPACK for using technologies to engage students in learning science and mathematics. However, the remaining 8 students needed more work toward TPACK.

It can be concluded from these studies that all studies drew quantitative conclusions and selected pre-service teachers as participants because of easy access to them. Most of the studies developed an instrument to examine the TPACK level of pre-service teachers. The researchers also investigated pre-service teachers' related knowledge domains, demographic diversities and improvement after teacher preparation program in TPACK framework.

2.1.2.2. Research Studies with In-service Teachers. Although it is important to study with pre-service teachers, the TPACK level of in-service teachers should be examined because technology integration is experienced in the classroom. Koehler and Mishra (2005) designed a survey study to assess TPACK perceptions of instructors and graduate students. The study was conducted on 13 students (9 male and 4 female) and four faculty members (2 male and 2 female) to develop online courses. They designed a course called 'Learning Technology by Design' and they focused on observed changes between the beginning and end of the semester. Participants completed online survey four times throughout the semester. Each survey consists of 35 questions, 2 of them short answer questions and rest of them 7-point Likert scale from 'agree' to 'disagree'. The results of the study analyzed by using t-test and showed that there is a significant shift in their technology knowledge as well as their TPACK both as individuals and as a group. Moreover, the results revealed that learning by design can be an effective instructional technique to develop deeper understanding of the complex relationship between content, pedagogy and technology and its function in the context.

Similarly, Archambault and Crippen (2009) developed an instrument to measure teachers' TPACK consists of content, pedagogy and technology and the combinations of each of these parts. The researchers examined 596 K-12 online teachers in the United States. 5-point Likert-type survey which includes 24 items was developed and conducted online by researchers used TPACK definition based on Koehler and Mishra (2005). The findings of the study indicated that knowledge of teachers' in the domain of content knowledge (CK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK) are highest value among TPACK components. When technological knowledge (TK) has been considered, knowledge ratings of technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPCK) have reduced compared with CK, PK and PCK.

Furthermore, to measure in-service teachers' confidence related to four TPACK constructs that involve technology (TK, TPK, TCK and TPACK), Graham and his colleagues (2009) developed a pre-post questionnaire. He supported his decision with the idea that TPACK is an extension of PCK, TPK is an extension of PK, and TCK is an extension of CK. Their survey with thirty one items and two open-ended questions was applied to fifteen in-

service teachers who participated in professional development program. Eleven of the fifteen participants were elementary school teachers (10 females and 1 male); four were secondary school teachers (1 female and 3 male). The result of the study showed that there was a significant improvement of teachers' TPACK for all four constructs. While their level of confidence was highest in TK, their level of confidence was lowest in TCK.

In a recent study focusing on mathematics education, Handal and his colleagues (2013) conducted an empirical study to apply the TPACK framework in secondary mathematics education through technological pedagogical content knowledge in secondary mathematics (TPACK-M) questionnaire .The participants were 280 secondary mathematics teachers in Australia. The questionnaire consisted of two parts. The first part consists of 30-item 5 point Likert scale based on three technology related constructs: TCK, TPK and TPCK. The second part consists of open-ended responses to capture information about why teachers might find difficulty applying their TPCK skills in the classroom. The TCK results showed that teacher use mostly Excel spreadsheets, PowerPoint and Paint. On the other hand, TPK level of teachers generally lower than the TCK level of teachers. That means mathematics teachers prefer to use technology in mathematic specific task rather than pedagogical issues. The highest and most consistent response related to teachers' ability for using technology to support students' research skills. The highest score to the TPCK items were related to data analysis and problem solving. This shows that mathematics teachers use their TPCK mostly in data analysis and problem solving activities. Furthermore, teachers' answers on transferring their TPACK to practice revealed that instructional, curricular, and organizational factors seriously preventing the integration of technology into teaching and learning.

In another study focusing on ten mathematics teachers participating in a four-week summer professional learning experience designed to help them to develop their TPACK through the use of spreadsheets, Niess and her colleagues (2006) analyzed pre/post questionnaire responses, course assignments, journal entries, observation notes, and peer teaching feedback. The authors reported that the participants noted TPK development primarily. In only one case did a participant reference using TCK-related knowledge that resulted from participation in the professional development experience. In a similar study of two elementary mathematics teachers' learning from a 30-hour summer professional development experience, Polly (2011a) drew upon interviews and classroom observations to

examine the growth of teachers' TPACK. He reported that both teachers were confident in their CK, PCK and TPK, but that they reported needing additional TCK and TPACK development.

Another two studies studied teachers' existing practice regarding technology integration knowledge rather than differences that emerge following professional development or coursework. Richardson (2009) designed her dissertation study to determine how teachers draw upon their TPACK in planning and implementing technology-enhanced classroom lessons. In her study of twelve fifth, sixth, and seventh grade teachers, she determined that each domain of TPACK was evident in their practice. Through an analysis of interviews, observations, and planning documents, the author concluded that despite the evidence of each TPACK subdomain in the participating teachers' thinking, TPK took precedence, while TCK was "the weakest area of knowledge reported" (p. 133). Also seeking to understand veteran teachers' knowledge for technology integration, Hervey (2011) designed a two-phase dissertation study in which 81 secondary teachers first self-assessed their TPACK using Schmidt and his colleagues (2009) self-report survey. From these respondents, Hervey identified six teachers, two of whom reported particularly strong TCK, TPK and TPCK, respectively. She then developed case studies for each of the six teachers, using videotapes of classroom instruction, stimulated recall activities, semi-structured interviews, and observational field notes. Though the six participants reported drawing upon all three domains of knowledge in their instructional planning and implementation, analysis of their survey responses indicated slightly lower levels of self-reported TCK when compared with TPK and TPCK.

It can be concluded that most of the studies on in-service teachers' focused on developing instruments to measure TPACK or its components while only few studies on in-service teachers' focused on teachers' existing knowledge and practice regarding TPACK. The studies on TPACK showed that the definition of TPACK concept was settled. On the other hand, instruments have been developed and applied to both pre-service and in-service teachers. When TPACK-based studies of teachers' technology integration knowledge were examined by Hofer and Harris (2012), the majority of these studies have focused upon development of pre-service teachers' TPACK. Increasingly, however, researchers have begun

to explore how this knowledge develops with in-service teachers. For this reason, there should be done more studies focusing on in-service teachers to determine the TPACK level of teachers.

2.1.2.3. Research Studies with Teachers in Turkey. Similar to general trend in TPACK studies in international arena, in Turkey most of the studies focused on the measuring TPACK (adapting surveys or developing new ones). Three TPACK instruments have been used to adapt in Turkish setting. For example, Öztürk and Horzum (2011) adapted TPACK scale developed by Schmidt and his colleagues (2009) to Turkish. The participants of the research were 291 elementary school teachers. The scale consists of 47 items with seven factors. The study showed that the results of the factor analysis and reliability analysis were high. Therefore, the authors concluded that the Turkish version of the scale was reliable and valid. Moreover, the scale was used in another study Öztürk (2013) to examine classroom teacher candidates' TPACK. The participants of the study were 2nd, 3rd and 4th year students in the department of classroom teaching in Sakarya. The survey model was used in the study. Whether TPACK differs according to classroom teachers' gender, type of education, technology training they have received or not have been tested in the study. The findings revealed that there is not a statistically significant difference between technological knowledge (TK), content knowledge (CK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPCK). As a last part of the research, whether there is a difference between how competent pre-service teachers see themselves in the use of technology and TPACK was observed in this study. According to results, a statistically significant difference was found between how competent they see themselves in the use of technology and TK, CK, PCK, TCK, TPK, TPCK. In addition, Semiz and Ince (2012) used the survey (Schmidt *et al.*, 2009) to identify TPACK of 760 pre-service physical education teachers. The authors reported that TPACK perceptions of pre-service education teachers are at satisfactory level. It can be concluded that Schmidt and his colleagues' survey was not content specific and it may be used to measure teachers' TPACK from different fields such as social studies, mathematics, literacy and science (Schmidt *et al.*, 2009).

Moreover, Timur and Taşar (2011) adapted technological pedagogical content knowledge confidence scale (TPACKCs) developed by Graham and his colleagues (2009)

into Turkish. The scale was administered 393 science and technology teachers to determine its validity and reliability. The instrument consists of 31 items and four technology related dimensions (TK, TCK, TPK, and TPCK). The findings from factor analysis and reliability analysis were reported to be good. So, TPACKCs can be used in Turkey to measure TPACK confidence of in-service teachers.

In a recent study, Karadeniz and Vatanartıran (2013) adapted TPACK survey which was developed by Koh, Chai and Tsait (2010) to Turkish for secondary school teachers. 285 teachers from different subject areas at the secondary level in Edirne participated in the survey. Specialists did the translation equivalence, back translation and content validity. The confirmatory factor results showed that original 5 factor scale fitted with Turkish data. Cronbach Alpha coefficients, item total correlations and t-tests among upper and lower 27% group indicated high reliability. Authors stated that the findings revealed that the survey is a valid and reliable instrument to measure secondary school teachers' TPACK. Moreover, the findings from descriptive statistics showed that teachers had high level of TPACK perceptions.

In addition to adaptation of TPACK survey, some researchers attempted to develop a survey of TPACK in Turkey. For instance, Şahin (2011) developed a survey of TPACK with seven subscales forming the TPACK model. This study was conducted in five phases: item pool, validity and reliability, discriminant validity, test-retest reliability, translation of the TPACK survey. TPACK survey consists of 47 items five point Likert scale. Validity and reliability process of the survey were conducted with 348 pre-service teachers. Also, both Turkish and English versions of the survey were administered to pre-service teachers studying English language education to examine language equivalence. The results from this study supported that there are significant interactions among content, pedagogy and technology constructs. Moreover, findings revealed that TPACK survey is a reliable and valid instrument.

Furthermore, Yurdakul and her colleagues (2012) developed a TPACK scale based on the centered component of TPACK framework to measure pre-service teachers' TPACK. The scale called TPACK-deep consists of 33 items and has four factors; namely, design, exertion, ethics and proficiency. The scale developed in this study quite different from other TPACK scales in the literature because it was the first study focusing on the intersection of three main

components in the TPACK framework. The study carried out 995 Turkish pre-service teachers. The Cronbach's alpha coefficient for the whole scale was found to be .95, whereas the values of Cronbach's alpha coefficient for individual factors of the scale ranged between .85 and .92. The confirmatory factor analysis was used for the validity of the scale. In this way, this structure of the 4-factor scale was confirmed. Moreover, the test-retest reliability coefficient of the scale was calculated as .80. The findings revealed that the TPACK-deep scale is a valid and reliable instrument to measure TPACK.

It can be concluded that most of the studies in Turkey focused on the adaptation of international instruments. Adapted instruments used other studies with teachers from different department because the scales were not content specific. On the other hand, few of the study focused on developing scale in Turkish setting.

When the results of these and similar studies focusing on identifying teachers' TPACK competencies and perceptions were considered, researchers also worked on to design programs for pre-service teachers in the scope of project. For example, Akkoç (2008) studied TPCK in pre-service mathematics teachers about radian concept and Akkaya (2009) derivative concept in terms of 'knowledge of student difficulties'. In the same project, Uğurlu (2009) studied measurement and assessment issues in TPCK. The common objective of those studies was to determine how professional development programs influenced teachers' development of TPACK. In these studies, workshops helped teachers to improve their TPACK.

2.2. Teachers' Self-Efficacy for Using Technology

Not only TPACK is important as a part of cognitive domain for the process of technology integration in teaching and learning but also self-efficacy about technology integration is really important as a part of affective domain.

Based on the Bandura's (1977; 1986) social cognitive theory, the concept of self-efficacy can be defined as one's beliefs about his or her capabilities to learn, organize, implement, and perform actions or behaviors in specific situations to reach designated goal. According to Bandura (1997), perceived self-efficacy referred to "the belief in one's

capabilities to organize and execute the courses of action required to produce given attainment and this belief influenced decisions about what behaviors to undertake" (p.21). Moreover, teacher efficacy is generally defined as the "extent to which the teacher believes he or she has the capacity to affect student performance" (Brouwers and Tomic, 2003, p.67) and "a belief in one's capability to execute the actions necessary to achieve a certain level of performance" (Deemer and Minke, 1999).When adopting any new innovation it is important to study teachers' self-efficacy. Teacher's self-efficacy belief is critical to the effective use of technology in the classroom (McGrail, 2005; Penuel, 2005; Windschitl and Sahl, 2002). If teachers have confidence in their teaching, they can take greater risks in their instruction and be more inclined to integrate technology into their teaching. It is a factor that can help predict and explain how teachers will act on what they know and what they can do (Gibbs, 2002).

2.2.1. Teachers' Self-Efficacy

A teacher's self-efficacy plays a key role in how he/she defines tasks and selects strategies (Albion, 2001). It also can influence behavior in the classroom (Fives and Buehl, 2008). Pajares (1996) found "a strong relationship between teachers' self-efficacy beliefs and their planning, instructional decisions and classroom practices" (p. 326). High self-efficacy is a strong predictor of teacher effectiveness (Gibbs, 2002). According to Bandura (1997), a person's feeling of self-efficacy can influence his/her ability to learn new skills. Teachers with high self-efficacy are more confident, are greater risk takers, can tolerate failure, persist more at achieving their goals, give greater effort to challenging tasks, and think outside the box (Vannatta and Fordham, 2004). On the other hand, teachers with low self-efficacy are less confident, less committed to teaching, and allocate less time to instruction (Enochs et al., 1993; Gibson and Dembo, 1984). That is, individuals with lower self-efficacy beliefs feel as if they do not have necessary skills to carry out a given tasks (Bandura, 1994). Also, self-efficacy is one of the powerful concepts to predict the performance of students in academic settings (Bandura 1994; Pajares, 1996).

There are four main sources of information that help a person form beliefs about self-efficacy (Bandura, 1986; Ebmeier, 2003; Shaughnessy, 2004). The most influential source is

one's mastery experiences: the actual experiences individuals have and on which they base other experiences. Successful experience builds a person's sense of efficacy while failure undermines it, especially if failure occurs before efficacy is established (Bandura, 1994). Vicarious experiences, another source of efficacy information, are weaker than authentic mastery experiences, but can be valuable when people have no prior experience or are uncertain about their own abilities. In this type of role modeling experience, the more socially similar a person is to the role model, the stronger the influence he or she has on the person's self-efficacy beliefs. When the role model succeeds or fails, it will have an effect on the person's willingness to try the same type of activity. The third source of information, verbal persuasion, is less effective than mastery or vicarious experiences in helping to form self-efficacy beliefs. In some instances, people just need to hear positive verbal praise to increase their self-efficacy (Bandura, 1997). The last source of information is a physiological state, such as anxiety, stress, fatigue, and mood. A person's emotional state can have a powerful effect on his/her actions.

2.2.2. Technology Integration Self-Efficacy of Teachers

Teachers' beliefs are foundational to their sense of self-efficacy. Particular beliefs or attitudes about or toward a specific concept or idea will influence their behavior patterns when faced with that concept or idea. According to Loucks-Horsley, Hewson, Love, and Stiles as cited in Lumpe and Chambers, (2001) ―beliefs are the ideas people are committed to—sometimes called core values…They shape goals, drive decisions, create discomfort when violated, and stimulate ongoing critique (p. 93). Teachers' beliefs about technology may be formed through their own experiences with technology inside or outside of the classroom as a student or as a teacher. Lumpe and Chambers (2001) also addressed the need for focused efforts to examine teachers' beliefs about the use of technology in the formal school setting. It is more likely that teachers who believe technology can and will produce positive results for student learning will make the decision to integrate technology into their classrooms.

Previous research was conducted to identify factors that influence technology use (Compeau and Higgins, 1995; Kellenberger and Hendricks, 2003; Littrell *et al.*, 2005; Teo,

2009; Wang *et al.*, 2004). In these previous studies, self-efficacy, or people‘s beliefs in their capacity to carry out a given task, was identified as a significant factor influencing people‘s decisions to use technology (Karatas, 2014).

According to Bandura (1994), innovative achievements involve a resilient sense of efficacy because innovations pose risks, challenge existing preferences, and require a sustained investment of effort while not knowing what the final results will bring. Integrating technology into the classroom is considered to be an innovative concept because it is different from what has traditionally been done, it requires a shift from teacher-directed learning to student-directed learning, and one must be committed to learning how to use the various technologies now available for classroom use.

Littrell and his colleagues (2005) found in their study that teachers may not use instructional technology due to low levels of computer self-efficacy (p. 45). Because self-efficacy is connected to one‘s own beliefs about his or her capability, if one does not feel capable of performing a task or fears failing at the task, then one is less likely to attempt that task. Along the same line, people will exert a certain amount of effort in performing a task which is said to be congruent with the amount of success they expect to achieve in performing that task (Henson, 2002). In another study by Wang and his colleagues (2004), the authors discussed results from similar studies that indicated that teachers’ self-efficacy beliefs are useful indicators of levels of technology integration.

Similarly, Vannatta and Fordham (2004), in the introduction to their study, also discussed how teachers’ self-efficacy beliefs played an important role in their decision to integrate technology into their classrooms. According to Henson (2002), teachers with high efficacy tend to experiment with methods of instruction, seek improved teaching methods, and experiment with instructional materials (p.138). Therefore, teachers who may be unfamiliar with technology but have high teaching self-efficacy may take more risks to experiment with technology as a way to enhance their teaching practice.

2.2.3. Research Studies on Technology Integration Self-Efficacy

While many studies in educational research have focused on self-efficacy beliefs (Pajares, 1996; Pintrich and Schunk, 1995), few have investigated the relationship between self-efficacy and technology use (Albion, 2001; Enochs *et al.*, 1993; Riggs and Enochs, 1993; Wang et al., 2004). Studies have been conducted on subject matter specific self-efficacy–such as mathematics self-efficacy (Hacket, 1985; Hackett and Betz, 1989; Pajares and Miller, 1994, 1995) and computer self-efficacy with respect to actual usage of computers (Kukafka *et al.*, 2003; Pajaras and Kranzler, 1995; Zhao *et al.*, 2002). The findings suggested that teachers with low confidence used the computers less than those with higher confidence. A teacher's belief in his/her ability to use computers is directly related to his or her use of computers (Marcinkiewicz, 1994). Research also suggests that self-efficacy beliefs are related to instructional practices (Ashton and Webb, 1986).

Extending findings from studies of efficacy, it would be expected that teachers' belief in their ability to work effectively with technology would significantly impact their use of technology in teaching (Hill *et al.*, 1987). Teachers who performed better in computer-related tasks were found to have higher levels of computer self-efficacy (Harrison *et al.*, 1997). Albion (2001) states that teacher' self-efficacy beliefs "are important and measurable components of the beliefs that influence technology integration" (p. 2).

Furthermore, there are limited studies investigating the relationship between TPACK and technology integration self-efficacy. Lee and Tsai (2008) conducted a study to investigate teachers' perceived self-efficacy in terms of their TPACK-W. This study aimed to develop a new questionnaire, namely the Technological Pedagogical Content Knowledge-Web (TPACK-W) survey to explore teachers' self-efficacy in terms of their TPCK-W, and additionally to assess their attitudes toward Web-based instruction. The participants in this study were 558 teachers from elementary school to high school level in Taiwan. Both exploratory and confirmatory factor analyses indicated that the TPACK-W survey developed in this study has satisfactory validity and reliability characteristics. The results indicated a lack of general knowledge about Web-related pedagogy amongst the teachers surveyed. The correlations between teachers' self-efficacy in terms of their TPACK- W, their attitudes

regarding Web-based instruction, and their background variables were also examined. Correlations were found between self-efficacy and positive attitudes to web-based instruction. Older and more experienced teachers were found to have lower levels of self-efficacy with respect to TPACK-W, though teachers with more experience of using the web (including for instruction) had higher levels of self-efficacy with respect to TPACK-W.

Similarly, Abbitt's (2011) exploratory study investigated the relationship between measures of TPACK and the self-efficacy beliefs of 45 pre-service teachers about technology integration. Within a single-group, pretest-posttest design, a correlational analysis identified several knowledge domains in the TPACK model that the researcher found to have a significant and positive correlation with self-efficacy beliefs about technology integration. A multiple regression analysis of pretest and posttest data indicated a change over time in the predictive relationship between the measures of knowledge in TPACK domains and self-efficacy beliefs. Findings from the study illustrated the changing nature of the complex relationship between knowledge and self-efficacy beliefs and highlight the potential areas of knowledge in TPACK domains that influence pre-service teachers' beliefs about technology integration.

According to previous studies, effective technology integration depends on several factors: teachers' beliefs and attitudes (Becker, 2000; Chen, 2008; Jimoyiannisa and Komisb, 2007; Lee and Chai, 2008; Van Braak et al.,2004; Vannatta and Fordham, 2004; Wozney *et al.*, 2006); demographic characteristics of teachers, such as years of teaching (Bebell et al.,2004; Van Braak, 2001); access to technology and support (Hohlfeld *et al.*, 2008); pedagogical, content, and technology knowledge (TPACK; Koelher and Mishra, 2006; Pierson, 2001); ongoing professional development (Becker, 1994; 2000); and teaching models or mentors (Bitner and Bitner, 2002). Technology integration takes place at different levels depending on the teacher, the situation, and the aforementioned factors.

In Turkey, teachers do not have necessary skills using ICT tools in education and do not have enough knowledge about technology. For instance, Akbaşlı and his colleagues (2012), İşman (2002), Toker and Yılmaz (2007) expressed that primary school teachers cannot use technology effectively in their lessons. Moreover, Cüre and Özdener (2008)

indicated that teachers have serious deficiency concerning using ICT tools, and teachers rarely use computers in their classrooms (Seferoglu and Akbıyık, 2005). Ciftci, Taskaya and Alemdar (2013) also claim that inadequate in-service training about using ICT tools, deficient configuration about curriculum in terms of ICT and poor lessons' content regarding ICT can explain insufficient technology integration in education. Therefore, teachers should take in-service training regarding guidance for students and using technology in classroom (Altan and Tuzun, 2011). In order to be successful in the FATIH project, teachers should be technologically literate and take in-service training (Kayaduman *et al.*, 2011). In addition, teachers' opinions for the FATIH project showed that they need to be educated at first (Yuksel and Alemdar, 2012). So, teachers' in-service training is an important part of the FATIH project. However, Güven (2012) expressed that based on the pilot study of the project, in-service training programs are unsuccessful, since the opinions of the teacher, who took part in pilot study, as "…in in-service training, no one knows the aim of the training programs. We do not have any tools about the project. Even lecturers do not know how to integrate technology in classroom. They did not give the right answer in our questions. Shortly, this program is wasting our time…"

Another issue of the project is a lack of teacher confidence that is one of the main barrier integration of ICT (Bingimlas, 2009; Schoepp, 2004). Kurtluca and Ekici (2010) claimed that positive attitudes enhance students' learning, improve effectiveness of curriculum and increase students' and teachers' success. Therefore, teacher should feel confident in using all the different instruments of educational technology, and the more teachers are incorporated in the process of integration, the more they get motivated and believe the value of computers, tablets and projectors (Yuksel and Alemdar, 2012). On the other hand, the study of Ciftci, Taskaya and Alemdar (2013) indicated that 81 percent of teachers think that the FATIH project will not be carried out because teachers have low computer ability and negative attitude toward ICT usage. Moreover, teachers have anxiety about using tablets. Teachers also think that FATIH project causes laziness, computer addiction and being asocial personality for students. So, teachers' opinions regarding ICT should be changed in order to be successful in this project.

Based on the literature, integrating technology into classroom effectively, knowledge (TPACK) and self-efficacy beliefs (TISE) are important factors. Also, the adaptation studies in Turkey did not focus on any specific content. According to the results from pilot study of the FATIH project, teachers do not feel themselves adequate in their knowledge and confidence. So, TPACK (perceived) and TISE of secondary mathematics teachers at FATIH project schools was examined in this study by adopting mathematics specific scale (TPACK-M) and TISE. Perception is defined as the way one thinks about and one's idea of what it is like (Longman, 2012). In this study, perceptions on TPACK refer to how in-service secondary teachers perceive TPACK. Also, researchers interested in measuring teachers' self-reported perception of TPACK (Archambault and Barnett, 2010; Lee and Tsai, 2010).

3. SIGNIFICANCE OF THE STUDY

Technology plays an essential role in today's society and the integration of technology into the classroom is necessary for students to learn. Today's students are digital natives, who have grown up surrounded by digital media, and these generation Z bring with them a unique set of characteristics that educators must consider in order to maximize student learning (Karatas, 2014). For this reason, integration of technology into teaching and learning process is among the principles of the disciplines. According to technology principle of National Council of Teachers Mathematics (2000), "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. " (p. 11). Moreover, the effective use of information and communication technologies is strongly emphasized in Turkish mathematics education curriculum (MoNE, 2006, 2013). From this point of view, mathematics teachers' role in the integration of technology into instruction is crucial. They need to acquire the ability to use technology resources effectively. On the other hand, integrating technology is not just adding technological knowledge in curriculum; it needs a complex mixture of technology, pedagogy and content knowledge (Koehler and Mishra, 2009) .To effectively integrates technology into instruction, teachers should have an adequate technological pedagogical content knowledge (TPACK) (Mishra and Koehler, 2006).

Recently, in Turkey there have been some important changes in education. One of them is FATIH project (Increasing Opportunities and Improvement of Technology Movement), announced in November 2010, is a joint project of MoNE and Ministry of Transport and Communications. The purpose of the FATIH project is to increase the success of the students by using technology effectively in classrooms. It is planned to be completed in three years. The project has been implemented in secondary, elementary, primary schools and pre-school levels. The FATIH project should be examined in many ways to ensure the expected success. However, the most important aspect of this examination can be investigating the status of teachers using technology in classroom. Teachers have an active role in the implementation process of FATIH project when using offered technology. Therefore, attaining the goals of projects substantially depends on teachers. This is why; comprehension of TPACK is a necessity to teachers for successful implementation of ICT integration. At this point, Dilworth

et al. (2012) stated that the most effective uses of technology necessitate an understanding of content and pedagogical strategies at the same time. Thus; it is really important to consider TPACK, by that teachers can become more confident and willing to integrate technology into educational activities effectively.

Moreover, it is important to study teachers' self-efficacy when adopting any new innovation. Teacher's self-beliefs are critical to the effective use of technology in the classroom (McGrail, 2005; Penuel, 2005; Windschitl and Sahl, 2002). Teachers who are more efficacious are more likely to take the risks necessary to use technology in their classrooms (Ivers, 2002). For this reason, examining teachers' technology integration self-efficacy is important. Hence, this study attempts to determine TPACK level and technology integration self-efficacy of secondary mathematics teachers in FATIH project.

There have been some problems in FATIH project according to the first report prepared by MoNE (2012). The problems may stem from the ineffective in-service training programs. The first reason behind the failure is the training programs being not able to improve the teacher's TK level even though the main goal of training programs was to improve that skill. In a study, Kayaduman, Sirakaya and Seferoglu (2011) stated that teachers take training programs to improve their computer literacy. Within the scope of these training programs; basic operations about computer literacy are just taught to in-service teachers. It could be said that the training programs in scope of ICT project, generally focus on Technological Knowledge (TK) rather than TPACK. Considering that teachers already have PK and CK, TPACK level should have been focused for the success. Referring to the in-service teacher training programs, TPACK model can positively contribute to integrate the technology into educational settings. While teachers are in the training programs, they may learn not only about using technology but also how technology can be used as a tool for learning and teaching. In this way, teachers may see the benefit of technology and how they can support their educational activities by the help of TPACK rather than only learning how to use them. Hence; this study can contribute to designing in-service mathematics teacher training programs based on TPACK.

The TPACK theoretical framework has been adopted by different researchers in many educational areas, and is considered to have shown promising results. In mathematics education, there are limited numbers of studies in Turkey related to TPACK because it has been studied in last few decades. Also, most of the TPACK studies (Öztürk and Horzum, 2011; Timur and Tasar, 2011; Karadeniz and Vatanartıran, 2013) are instrument adaptation studies and focused on pre-service mathematics teachers. Therefore, the results of the study can contribute to the literature by adapting TPACK-M and TISE scale and examining TPACK and TISE level of secondary mathematics teachers.

4. STATEMENT OF THE PROBLEM

The present study aimed to determine technological pedagogical content knowledge (TPACK) and technology integration self-efficacy (TISE) of high school mathematics teachers in FATIH project schools. Also, the relationship between their TPACK and TISE was investigated. For this purpose, TPACK-M and TISE survey adapted to Turkish.

4.1. Variables

The variables of this study are technological pedagogical content knowledge, technology integration self-efficacy, gender and years of experience. The definitions of these variables are as follows:

- *Technological Pedagogical Content Knowledge (TPACK)* is defined as teachers' technological pedagogical content knowledge in secondary mathematics based on TPACK framework (Mishra and Koehler, 2006). It will be measured by TPACK-M scale.
- *Technology Integration Self-efficacy (TISE)* is defined as participants' perception of their ability for technology integration (Wang *et al.*, 2004) .It will be measured by TISE scale.
- *Gender* is defined as being male or female. It will be measured by self-reports of the participants on the demographic survey.
- *Years of experience* is defined as how many years participants' are currently teaching. It will be measured by self-reports of the participants on the demographic survey.
- *Age* is defined as length of time that a person has lived.

4.2. Research Questions

The following research questions investigated in the study:

(i) What are the levels of secondary mathematics teachers' TPACK as measured by TPACK-M scale?

(ii) Is there a significant difference in perception of Turkish secondary mathematics teachers' TPACK in terms of gender?

(iii) Is there a significant relationship between TPACK and age of secondary mathematics teachers?

(iv) Is there a significant difference in perception of Turkish secondary mathematics teachers' TPACK in terms of years of experience?

(v) What are levels of secondary mathematics teachers' technology integration self-efficacy (TISE) as measured by TISE scale?

(vi) Is there a significant difference in Turkish secondary mathematics teachers' TISE in terms of gender?

(vii) Is there a significant relationship between TISE and age of secondary mathematics teachers?

(viii) Is there a significant difference in Turkish secondary mathematics teachers' TISE in terms of years of experience?

(ix) Is there a significant relationship between TPACK and TISE variables?

4.3. Statement of the Research Hypotheses

In this study it is hypothesized that:

(i) There is a significant difference in perceptions of Turkish female and male secondary mathematics teachers' technological pedagogical content knowledge

(ii) There is a significant relationship between Turkish secondary mathematics teachers' technological pedagogical knowledge and their age.

(iii) There is a significant difference in perceptions of Turkish secondary mathematics teachers' technological pedagogical content knowledge in terms of their years of experience.

(iv) There is a significant difference in Turkish female and male secondary mathematics teachers' technology integration self-efficacy.

(v) There is a significant relationship between Turkish secondary mathematics teachers' technology integration self-efficacy and their age.

(vi) There is a significant difference in Turkish secondary mathematics teachers' technology integration self-efficacy in terms of their years of experience.

(vii) There is a significant relationship between TPACK and TISE variables.

5. METHOD

The goal of this chapter is to give information about the research design and procedures used in this study. This chapter has five parts. The first part explains the overall research design; the second part explains participants of the study; the third part explains the data collection instruments; the fourth part explains the data collection procedures and the last part explains the analyses of the data.

5.1. Design of the Study

The main goals of the present study were (i) to identify mathematics teachers' technological pedagogical content knowledge (TPACK) levels, (ii) to examine the relationship between their TPACK level and possible demographic differences, (iii) to identify their technology integration self-efficacy (TISE), (iv) to examine the relationship between their TISE and possible demographic differences and (v) to examine the relationship between their TPACK and TISE.

Survey research methodology was used to study teachers' perceived TPACK and TISE levels. According to Creswell (2012), survey study provides "a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population" (p.376). Furthermore, other purposes of the study were to examine the relationship of teachers' possible demographic differences with TPACK and TISE levels and also to examine the relationship between their TPACK and TISE level. Creswell (2012) stated that the degree of relationship between two or more variables is investigated in correlational research designs (p.338). Therefore, correlational research methodology was used in the study All the purposes were considered, it was stated that this study contains the combination of survey and correlational research methodology.

5.2. Sampling and Participants

In this study, all secondary mathematics teachers at FATIH (Increasing Opportunities and Improvement of Technology Movement) project schools in Istanbul were identified as the

target population. The reason why FATIH projects teachers determined as participants in this study is that they have already equipped with technological devices such as interactive board and tablets. However, it was not practical to visit all schools to meet teachers. So, FATIH project schools in Istanbul were considered as clusters. Six districts (three from Anatolian side and three from European side) were chosen from 39 districts. When selecting each district, the ratio of students per teacher and school size in all districts were considered. Firstly, all districts ranged according to ratio of student per teacher. Then, those districts separated into three groups (low, middle and high). Six districts were chosen from each group considering one from Anatolian side and one from European side purposefully. In addition, the school size interval was determined between 1500 and 5500 excluding extreme points. The interval was divided by eight equal groups and then six districts were selected among these groups. Therefore, three districts from a side of Istanbul are similar to other three districts from the other side of the city in terms of student and teacher data. In multistage cluster sampling, the researcher chooses a sample in two or more stages because either the researchers cannot easily identify the population or the population is extremely large (Creswell, 2012). So, multistage cluster sampling method was used in this study.

Data were collected from all volunteered mathematics teachers at FATIH project schools in those sampled districts. All type of high school (Anatolian, Vocational and Special Education) which were determined as FATIH project schools were included in those districts. It should be noted that two of the schools were determined as pilot schools for using tablets by MoNE. However, data were gathered only 28 schools among 51 schools in six districts. One of the reasons is that there were no mathematics teachers in special education schools. The other reason is that at some schools there were no mathematics teachers at the time of researcher's visit. Also, some of the teachers did not complete the survey despite the researcher's several visits to schools. So, those were excluded from the study. In addition, many teachers in district C and D were not willingly participated the study because they said that they overused in studies throughout the year.

Sample of the study consisted of one hundred thirty eight (138) mathematics teachers from fifty one different schools in Istanbul. Some demographic characteristics of participants are presented in Table 5.1.

Table 5.1. Some demographic characteristics of participants.

District	Side	School Size	Ratio of students per teacher	The Number of Participants
A	Anatolian	3833	Middle	39
B	European	4846	High	17
C	European	1633	Low	19
D	European	2156	Middle	14
E	Anatolian	5408	High	20
F	Anatolian	3036	Low	29

Demographic characteristics of the participants included gender, age, and department of graduation, highest graduation degree and years of teaching experience. Among the participants, 62 (44.9 %) of them were male and 76 (55.1 %) of them were female aged between 29 and 62 years of age (*M= 41.1, SD=6.04).* All participants in this study graduated from mathematics related departments. Among the 133 responses, 71.4 % was graduated from mathematics department, 27.1 % was graduated mathematics education and the rest 1.5 % graduated from mathematics engineering. Moreover, 112 of them have bachelor's degree, 25 of them have master degree and 1 of them have doctoral degree. When teaching experience of teachers was considered, majority of the teachers have teaching experience between 11 and 15 years. Table 5.2 shows numbers of teachers according to teaching experience.

Table 5.2. Number of teachers according to teaching experience.

Less than 5 years	3
6-10 years	5
11-15 years	58
16-20 years	40
21-25 years	23
26-30 years	4
More than 30 years	4

Furthermore, teachers were asked about their teaching load (hours per week) for grade levels. The mean number of lesson hours in each week they give was 21.4. Among the participants, 73.9 % give lessons for 9^{th} grade level, 69.6 % give lessons for 10^{th} grade level, 79.0 % give lessons for 11^{th} grade level and 69.6% give lessons for 12^{th} grade level.

As demographic information, it was also asked participants to indicate whether they had their personal electronic devices (desktop, laptop, tablet and smartphone). The majority of teachers have their own laptop (76.1%), smartphone (73.9%) and tablet (70.3 %), while teachers showed lower percentages of desktop ownership (42.8%).

The last demographic information was about whether they took in-service training related to using technology in education and using technology in mathematics teaching. While 92.8% teachers took in service training related to using technology, only 49.9 % teachers took in service training related to using technology in mathematics teaching.

5.3. Instruments

Two surveys were used after an adaptation and validation study for secondary mathematics teachers. These are (i) Survey of Technological Pedagogical Content Knowledge of Secondary Mathematics Teachers (TPACK-M) (Handal, *et al.*, 2013), (ii) Survey of Technology Integration Self-Efficacy (TISE) (Wang *et al.*, 2004).

5.3.1. TPACK-M Scale

The TPACK-M questionnaire was designed by (Handal *et al.*, 2013) to identify teachers' technological pedagogical content knowledge in terms of technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPCK). It focuses on secondary mathematics teachers and involves three parts. A Likert type scale contains a total of 30 items. TK was not included in the questionnaire because of the research emphasis on discipline related technology (Handal *et al.*, 2013). The instrument measures only technology related constructs except TK so PCK was not included in this thesis study. The participants were asked to rate their level of agreement (from 1-strongly disagree to 5-strongly agree) to given statements. The questionnaire deliberately focused on the concept of ability as a measure of a respondent's capacity to carry out a particular task, rather than focusing on the enactment itself. Hence the item stems were, "I am able to use technology to ..." (for part 1and 3), and, "I am able to ..." (for part 2). Such an approach assumed that respondents' ability might be either potential or effective. Taking the latent approach to ability left open the possibility that the stated capability may have never been enacted for various reasons (Handal *et al.*, 2013). According to Handal and his colleagues (2013), the "'I am able to" rather than the "What I do in the classroom" approach had two obvious benefits over simply holding skills. First, it enabled the instrument to collect data on both potential and effective ability. Handal and his colleagues (2013) discussed that professional learning programs and policy-making would benefit more from data on teachers already acquired skills.

The reliability and validity of the TPACK-M questionnaire was assessed by (Handal *et al.*, 2013). Reliability was assessed through Cronbach's alpha, resulting in reliability coefficients of 0.944 for the whole instrument. Also, 0.845, 0.867, and 0.924 for three parts, respectively. These coefficients suggested fairly high internal consistency reliability. In addition, an exploratory factor analysis results showed confirming the structurally soundness of the instrument in terms of validity and reliability (Handal *et al.*, 2012). For the sample of this study, the reliability coefficients were calculated. Internal consistency coefficients (Cronbach's alpha) for three parts were found .942 for TCK, .903 for TPK, .954 for TPCK and lastly .975 for whole instrument. The alpha value of 0.6-0.7 indicates acceptable

reliability, and 0.8 or higher indicates good reliability (Cronbach, 1951). Therefore, it can be concluded that the instrument of this study has a good reliability. Based on this, Turkish TPACK scale for secondary mathematics teachers is a reliable survey to assess the related characteristics of the population. Turkish TPACK survey is presented in Appendix A.

The reason for selecting Handal and his colleagues (2013) survey is that it is the most appropriate survey serving the purpose of this study. The reason is that it focuses on high school mathematics teachers' TPACK with high validity and reliability results. Also, the items were drawn from the current literature and from previous TPACK-related instruments (Archambault and Crippen, 2009; Archambault and Barnett, 2010; Lee and Tsai, 2010; Schmidt *et al.*, 2009). Moreover, the term, perceived TPACK was used for this thesis study based on the literature and some research studies such as Koh *et al.* (2010), Lee and Tsai (2010) and Schmidt *et al.* (2009). Since the technological pedagogical content knowledge (TPACK) of teachers' cannot be measured only items of the survey and based on the self-report, perceived TPACK term was preferred to use for this thesis study.

5.3.2. TISE Scale

Computer technology integration survey (CTIS) measuring participants' self-efficacy belief for technology integration was developed by Wang *et al.* (2004). A Likert-style survey included 21 items. The participants were asked to rate their levels of agreement (from 1-strongly disagree to 5-strongly agree) with statements related to their self-efficacy beliefs regarding technology integration. (e.g..," I feel confident that I understand computer capabilities well enough to maximize them in my classroom." "I feel confident I can regularly incorporate technology into my lessons, when appropriate to student learning.").

During the development of CTIS, Wang *et al.* (2004) evaluated a 21-item version of the survey and reduced the instrument to include 16 items. Cronbach's alpha coefficients were calculated for both pre-survey data and post-survey data to determine the reliability of the instrument. Alpha coefficients of .94 (for pre-survey) and .96 (for post-survey) indicated that the instrument was highly reliable. Thus, the obtained factor solution and resulting reliability coefficients for the self-efficacy for technology integration scale suggests that the instrument

exhibited construct validity and reliability. Also, the reliability coefficient was calculated for the sample of this study. Cronbach's alpha coefficient was found .98 for TISE survey. According to Cronbach (1951), the Turkish version of the instrument has a good reliability. Turkish TISE survey is presented in Appendix A.

The reason for selecting Wang *et al.*'s (2004) study is that their instrument was used in most of the technology integration self-efficacy studies (Abbitt, 2011; Perkmen, 2008; Semiz, 2012) in the literature due to high validity and reliability results. 21-item version of the survey was chosen for this study because it fits the aim of the study.

5.3.3. Adaptation of Instruments

For the adaptation studies, the above mentioned TPCK-M (Handal, *et al.*, 2013) and TISE (Wang, 2004) were translated into Turkish using a standard protocol (Vallerand, 1989) Firstly, for TISE survey, the items (1, 2, 5, 6, 7 and 18) containing "computer" changed with "technological tools". The items of both survey were translated from English to Turkish by the researcher .The translated documents were reviewed by an expert in mathematics education and a professional translator. Also, Turkish versions of scales were reviewed by mathematics teacher with twenty six years of experience and Turkish teacher with twenty one years of experience. After the translations were compared and the differences were identified, a final Turkish version was prepared with the consensus of the translators. Then, the Turkish versions of scales were translated back into English by two English language experts separately. It was seen that the back-translated items and the original English items were similar to each other in TPCK-M scale. However, some minor changes were made in the items 7, 16 and 19 of TISE scale.

Furthermore, the original English tests were applied a group of pre-service secondary mathematics teachers who are native in Turkish and fluent in English. The same group took the translated versions of tests after 4 weeks. The instrument implemented in college courses to the participants in the adaptation study. The approximate time of completing the scale was 10-15 minutes. Before implementing the survey, all informed about the purpose of the study and the content of the survey. Volunteered students participated in this study. Moreover, in

order to make their participation anonymous, participants asked to use a code rather than their names. In the first implementation, 41 pre-service teachers from three courses completed the tests. For the second implementation, the translated versions of the tests were administered at same three courses and 46 pre-service teachers completed the tests. When both implementations were considered, 25 pre-service teachers completed both English and Turkish version of tests.

After scoring the items and evaluating all participants' results, their total scores for English and Turkish version of tests were compared by using Statistical Package for Social Sciences (SPSS). The assumptions of normality for Pearson correlation coefficient were violated because of few participants. So, Spearman correlations were used. The Spearman correlation is .347 ($p < .01$) for TPACK-M scale as shown in Table 5.3 which is not statistically significant whereas .556 ($p < .01$) for TISE scale as shown in Table 5.4 which is statistically significant.

Table 5.3. Correlations for TPACK scale.

			TPACK_ENGLISH	TPACK_TURKISH
Spearman's rho	TPACK_ENGLISH	Correlation Coefficient	1.000	.347
		Sig. (2-tailed)	.	.090
		N	25	25
	TPACK_TURKISH	Correlation Coefficient	.347	1.000
		Sig. (2-tailed)	.090	.
		N	25	25

Table 5.4. Correlations for TISE scale.

			TISE_ENGLISH	TISE_TURKISH
Spearman's rho	TISE_ENGLISH	Correlation Coefficient	1.000	.556**
		Sig. (2-tailed)	.	.004
		N	25	25
	TISE_TURKISH	Correlation Coefficient	.556**	1.000
		Sig. (2-tailed)	.004	.
		N	25	25
**. Correlation is significant at the 0.01 level (2-tailed).				

Moreover, items that the most of the students answered differently in English and Turkish versions of tests were reviewed in order to investigate linguistic or conceptual errors in translation. Some participants reported that they do not know the meanings of words such as “appraise”, “cyber safety” and “wikis”. So, some of the phrases such as wikis and spreadsheet were exemplified to prevent the linguistic errors.

Furthermore, exploratory factor analysis was conducted for construct validity. Before performing principal components analysis, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence all coefficients of .3 and above. The Kaiser-Meyer–Oklin value was .95, exceeding the recommended value of .6 (Kaiser, 1974) and Barlett’s Test of Sphericity (Barlett, 1954) reached statistical significance, supporting the factorability of the correlation matrix (Pallant, 2007).

Based on the criteria of Kaiser (1960), eigenvalues should be 1 or more to consist of factors. The 30 items were factor analyzed, and three factors emerged with eigenvalues greater than 1. Table 5.5 shows these eigenvalues.

Table 5.5. Initial Eigenvalues of the Factors.

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	17.603	58.676	58.676
2	1.703	5.676	64.352
3	1.194	3.979	68.331

In factor analysis, there are three factors that have eigenvalue higher than 1 and these explains about 68.3% of the variance. It is claimed that the higher the variability explained by the factor analysis, the stronger the factor structure of the scale is. In order to interpret three factors, rotated component matrix table (see Appendix B), which shows the factor loadings of each of variables, has been used. The order of factors and number of loading items are determined based on the rotated component matrix. The loaded factors names are that first factor is TCK, second factor is TPK and third factor is TPCK.

5.4. Data Collection

First of all, necessary permissions to use surveys were taken from the authors of the original surveys. After all the necessary permissions have been taken, adaptation study of the instrument was conducted. Then, data collection process for the main study has been completed. The data collection period started at April, 2014 and lasted until July, 2014.

For this study, necessary permissions to administer surveys to secondary mathematics teachers were taken from Ministry of National Education (MoNE). The list of FATIH project schools in all districts of Istanbul were taken from MoNE. The researcher contacted with those schools. Each school visited by the researcher. Firstly, necessary permissions were taken from each of school administrators showing legal document of Istanbul Provincial Directorate of National Education before conducting the surveys. Upon the approval of principals, the researcher went to teachers' lounge or branch room to inform all teachers about the purpose of the study and the content of the survey. Then, volunteer mathematics teachers participated in the study. The approximate time of completing the survey was 15 minutes. All

data were collected by the researcher. The researcher remained in the teachers' lounge while teachers completed the surveys to answer the further questions. Moreover, in order to make them feel comfortable, no question was asked to identify the identity of participants. In addition to the instruments mentioned above, a short interview was conducted with volunteered teachers. So, more detailed information was gathered from the participants to support the findings.

5.5. Data Analysis

Data were gathered from secondary mathematics teachers at FATIH project schools in six districts. In order to answer research questions, quantitative data analysis technique was utilized. Prior to data analysis, data were examined trough SPSS 20 program for accuracy of data entry and missing values. Firstly, the minimum and maximum values, means, and standard deviations of each survey item were inspected for plausibility (Tabachnick and Fidell, 2007). All values were deemed reasonable. Next, the quantity and patterns of missing data were analyzed. According to Tabachnick and Fidell (2007), if missing data represent less than 5 % of the total and is missing in a random pattern from a large data set, " almost any procedure for handling missing values yields similar results" (p.63). Among 138 participants, none of them has missing values more than 5 percent. Therefore, analysis was carried out with 138 subjects. In the survey, the statement of 'strongly disagree' was valued with 1 whereas the statement of 'strongly agree' was valued with 5. Demographic parts of the survey was coded as value of 0 and 1, and the highest graduation degree was coded the value from 0 to 3 corresponding to associate degree to doctoral degree, respectively.

In data analysis both descriptive and inferential statistics were applied. All statistical analysis was carried out by SPSS 20 software program. In terms of descriptive statistics, central tendency, frequency distributions and variability was performed to organize and to demonstrate the demographic characteristics of the participants by gender, age and years of experience. Also, inferential statistics was used to interpret the results from surveys.

More specifically, descriptive statistics methods including mean and standard deviation were used to describe the TPACK and TISE levels of mathematics teachers as a group and the

level of effect for each TPACK item. In other research questions, whether males and females differ in terms of their level of TPACK and TISE was investigated.

There are some general assumptions; namely, level of measurement, random sampling, independence of observations, normal distribution and homogeneity of variance (Pallant, 2007) to apply all the parametric techniques. Secondary mathematics teachers' TPACK and TISE were measured by using a continuous scale so level of measurement assumption is ensured. It is assumed that each measurement in this study is not influenced by any other measurement. In order to check for normal distribution, Kolmogorov-Smirnov Test was applied as shown in Table 5.3. However, the normality assumption was violated and so non-parametric Mann-Whitney test was used to answer these research questions. Also, for the question whether there is a difference in TPACK and TISE levels across five teaching experience levels was examined using non parametric Kruskal-Wallis test. Teaching experiences of teachers were categorized as less than 10 years, 11-15 years, 16-20 years, 21-25 years and more than 25 years.

Table 5.6. Tests of normality for TPACK and TISE.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TPACK	.106	119	.002	.944	119	.000
TISE	.111	132	.000	.943	132	.000

Furthermore, correlation between mean scores of TPACK and TISE tests for participants was examined. In order to examine it, appropriate statistical testing method was used. According to Pallant (2007), there were five assumptions for correlational analysis, namely measurement, related pairs, independence of observations, normality, linearity, and homoscedasticity. This study has two dependent variables as TPACK and TISE. Both of them are continuous at interval level. Thus, the level of measurement assumption is ensured. Pallant (2007) stated that all scores of the variables for each participant are necessary. Missing data from tests were eliminated so the assumption of related pairs is provided. As mentioned before, it is assumed

that the participants have not influenced each other during the implementation process. To ensure normality, Kolmogorov- Smirnov statistics was used. The results of the tests of normality are shown in Table 5.3. A non-significant result (Sig. value of more than .05) indicates normality. In this case, the Sig. value is .000 for TISE and .002 for TPACK, suggesting violation of the assumption of normality.

Linearity and homoscedasticity were checked via the scatterplot (Pallant, 2007). Visual examination of the scatterplot in Figure 5.1 and 5.2 reveals that most of distributions are linear shape not in curve shape Thus they indicated that there is no violation in linearity assumption. In addition, scatterplot indicates the strength of the relationship among variables (Pallant, 2007). If the relationship is weak, the shape of scatterplot resembles a blob-type arrangement. However, in strong relationship, the shape of scatterplot resembles a vague cigar shape (Pallant, 2007). In order to check the assumption of homoscedasticity, scatterplots, histograms and normality plots have been examined. Visual examinations showed that scatterplots look like cigar shape. Based on the examinations, it can be stated that there is violation in normality assumption. So, Spearman rho correlation coefficient was used to find whether there is a relationship between TPACK and TISE variables. Similarly, correlation between participants' age and TPACK and participants' age and TISE were examined using Spearman rho correlation coefficient.

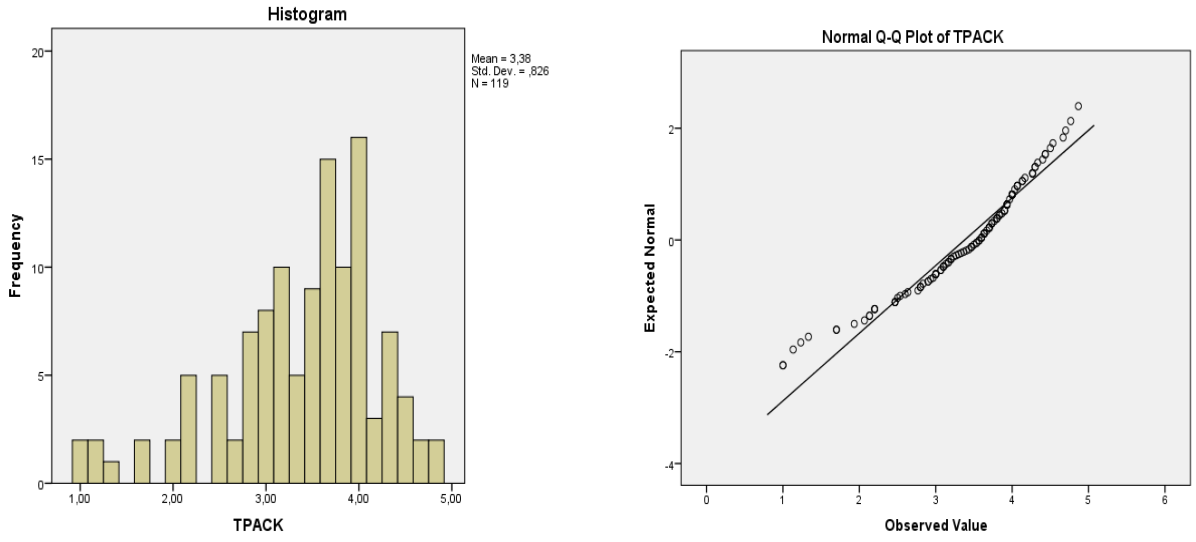


Figure 5.1. Histogram and Q-Q plot of TPACK.

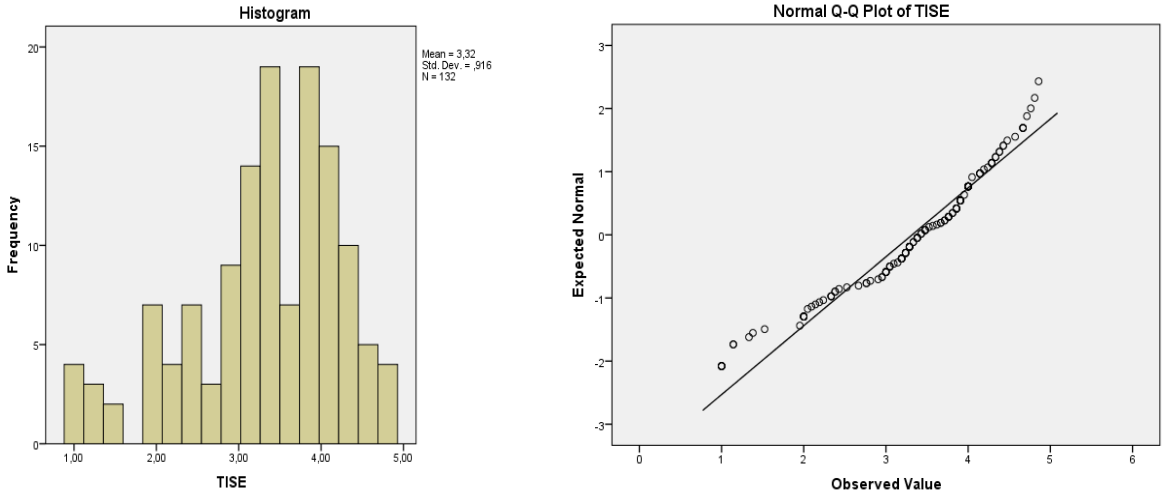


Figure 5.2. Histogram and Q-Q plot of TISE.

6. RESULTS

In this section, the findings of the research are presented. This chapter has five parts. The first part explains mathematics teachers' TPACK level; the second part explains demographic diversities and teachers' TPACK level; the third part explains the TISE level of teachers; the fourth part explains demographic diversities and the teachers' TISE level and the last part explains relationship between TPACK and TISE level of the teachers. The findings for each question have been explained respectively.

6.1. Secondary Mathematics Teachers' TPACK Level

First of all, individual scores of participants were calculated for three constructs; technological content knowledge (TCK), technological pedagogical knowledge (TPK) technological pedagogical knowledge (TPK), technological pedagogical content knowledge (TPCK) and for whole instrument (TPACK). Then, each item of three constructs was considered by itself in this part of the section.

The aim of the first research question was to explore the levels of secondary mathematics teachers' technological pedagogical content knowledge (TPACK). In order to answer this question, descriptive analysis including mean, standard deviation and frequency was conducted. Table 6.1 indicates mean values and standard deviations of participants' TPACK level for three constructs TCK, TPK, TPCK and for whole instrument (TPACK). The sample sizes are different because of some missing data for three constructs and whole instrument.

Table 6.1. Mean TPACK scores.

	N	Mean	Std. Deviation
TCK	127	3.48	.92
TPK	131	3.28	.77
TPCK	134	3.39	.90
Whole instrument	119	3.38	.83
Valid N (listwise)	119		

According to Table 6.1, whole TPACK mean score is 3.38 *(SD=.83)* in a range of 1 to 5. When three components of scale are examined, the highest mean subscale score belongs to technological content knowledge (*M= 3.48, SD= .92*) while the lowest mean subscale belongs to technological pedagogical knowledge *(M=3.28, SD= .77).* The results of data were reported based on the range interval of (5-1) / 3 (Yurdakul, 2011). In other words, three dimensions as low, moderate and high were determined to interpret the findings. If mean scores of tests are between 1 and 2.33, the level of perception is considered as "low". If mean scores of tests are between 2.34 and 3.67, the level of perception is considered as "moderate". If mean scores of tests are between 3.68 and 5.00, the level of perception is considered as "high" (Yurdakul, 2011). Considering these values, it may be inferred that secondary mathematics teachers' perception on their TPACK level is moderate. Also, their perception level for three constructs (TCK, TPK and TPCK) can be considered as moderate. The distributions of the mean TPACK score is illustrated in Figure 6.1.

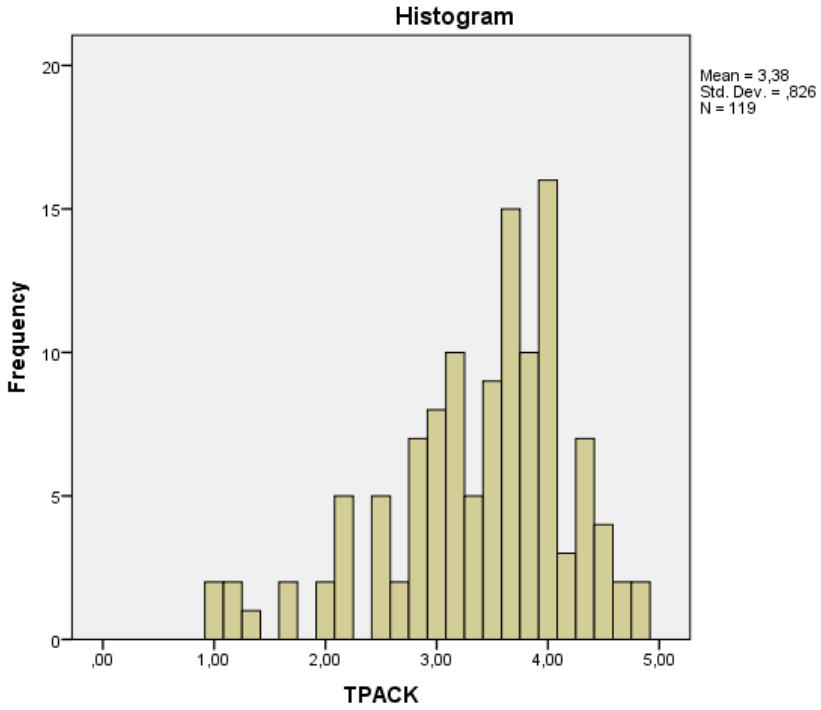


Figure 6.1. Distributions of TPACK Mean Scores

Moreover, each item of the TPACK questionnaire was examined to compare responses of participants. Descriptive statistics including mean and standard deviation was calculated for each item. As shown in Table 6.2, if mean score of the item less than 3.0 were examined on a continuum ranging through very low, low, moderately low to slightly below average, while mean score of the item greater than 3.0 represented a continuum ranging from slightly above average to very high. A mean score of 3.0 would indicate an orientation that lies midway at a particular ability level (Handal *et al.*, 2013). So, the level of effect for each question was determined.

Table 6.2. TPACK questionnaire mean range.

Mean Range	Level of effect
$1.0 \leq x < 1.5$	Very low
$1.5 \leq x < 2.0$	Low
$2.0 \leq x < 2.5$	Moderately low
$2.5 \leq x < 3.0$	Slightly below average
3.0	Average
$3.0 < x \leq 3.5$	Slightly above average
$3.5 < x \leq 4.0$	Moderately High
$4.0 < x \leq 4.5$	High
$4.5 < x \leq 5.0$	Very High

Table 6.3 shows the mean scores for the TCK items. The mean scores of all TCK items are above average. Five of them (A1, A2, A3, A6 and A10) are moderately high mean scores and the rest of them are slightly above average mean scores .The highest mean score *(MD=3.84)* for the TCK items related to Paint/Photoshop while lowest mean scores *(MD=3.12)* for the TCK items related to using dynamic geometry software and constructing multimedia objects.

Table 6.3. Mean scores for TCK items.

I am able to use technology to …	N	Mean	Std. Deviation
A1:Create a PowerPoint presentation	138	3.76	1.11
A2:Create and edit simple images (e.g. Microsoft Paint or Photoshop)	138	3.84	1.11
A3:Make calculations on a spreadsheet	137	3.61	1.14
A4:Create charts/graphs using a spreadsheet	137	3.50	1.13
A5:Use a graphic calculator	137	3.33	1.16
A6:Locate and evaluate maths online applications and tools (e.g., learning objects, apps, simulators)	136	3.51	1.19
A7:Use dynamic geometry software (e.g., GeoGebra, Geometer's Sketchpad, Autograph, Cabri)	135	3.12	1.18
A8:Use computer algebra software (e.g., Derive, Mathematica)	137	3.20	1.16
A9: Construct multimedia objects embedding pictures, sound and animations	138	3.12	1.18
A10: Network with other colleagues and professional associations through online forums, Facebook, etc	136	3.60	1.18
Valid N (listwise)	127		

The TPK scale items have generally lower mean scores among all three constructs as shown in Table 6.4. There are some items (B3, B5 and B7) have slightly below average mean scores for whole scale. The highest mean score *(MD=3.94)* for the TPK items and for the whole test related to interactive whiteboard while the lowest mean score *(MD=2.71)* for the TPK items and for the whole test related to cyber safety issues in the school.

Table 6.4. Mean scores for TPK items

I am able to ...	N	Mean	Std. Deviation
B1: Use technology to develop students' research skills	138	3.72	1.07
B2: Teach a concept using an interactive whiteboard	138	3.94	1.00
B3: Create a web quest to deliver a curriculum unit	137	2.99	1.12
B4: Use mobile devices (e.g. iPad, smartphone) in teaching	138	3.58	1.09
B5: Engage students in collaborative learning through wikis	135	2.98	.98
B6: Guide students in creating their own multimedia presentations	136	3.23	1.03
B7: Deal with cyberbullying and cyber safety issues in the school	138	2.71	1.04
B8: Use technology to provide students with alternative forms of assessment	137	3.28	1.08
B9: Engage students in critically analyzing online texts or images	135	3.18	1.04
B10: Appraise educational websites and software for usefulness and quality	137	3.18	1.10
Valid N (listwise)	131		

The means and standard deviations for TPCK as shown in Table 6.5 had the narrowest range of any of the three constructs in the survey, with the means scores ranging from 3.10 to 3.59 and standard deviations ranging from 1.02 to 1.13. Also, the mean scores of all items in TPCK can be evaluated as above average (Handal *et al.*, 2013). Two of them (C1 and C6) are moderately high means scores and the rest of them are slightly above average mean scores. The highest means score *(MD=3.59)* for the TPCK items related to mathematics problem solving skills and the lowest means score *(MD=3.10)* for TPCK items related to identifying trends and patterns.

Table 6.5. Mean scores for TPCK items.

I am able to use technology to ...	N	Mean	Std. Deviation
C1: Assist students to develop their maths problem-solving skills	138	3.59	1.02
C2: Represent maths problems linking symbolic, numerical and graphical data	138	3.41	1.11
C3: Demonstrate mathematical models or concepts through learning objects (e.g., animations, simulations, online applications)	137	3.33	1.11
C4: Identify trends and patterns to predict possibilities	136	3.10	1.05
C5: Explore or present mathematical content in a variety of different ways	138	3.37	1.08
C6: Collect, analyze and interpret data to make informed judgments	138	3.51	1.08
C7: Incorporate authentic tasks in the learning of mathematics	138	3.48	1.04
C8: Promote substantive student communication in a maths lesson (e.g., class discussion on multiple methods of solving a problem)	137	3.44	1.05
C9: Integrate the study of maths with content from other Key Learning Areas (e.g, English, Arts, Science,History)	138	3.17	1.05
C10: Support students' mathematical investigations with digital tools (e.g., audio/video recording, measuring devices, etc)	138	3.42	1.13
Valid N (listwise)	134		

6.2. Demographic Diversities and the Teachers' TPACK

The aim of the second and third research questions is to explore possible demographic differences (gender and years of experience) of secondary mathematics teachers' technological pedagogical content knowledge. The normality assumption was violated when Kolmogorov-Smirnov test was applied to check normality as shown in Table 5.3. Non parametric Mann-Whitney U test was used because of the violation of normality assumption. A Mann-Whitney U test results as shown in Table 6.6 revealed no significant difference in the TPACK levels of male mathematics teachers and female mathematics teachers *(U=1557, z= -1.11, p=. 27).* The r value was calculated as .1. This can be considered a very small effect size using Cohen (1988) criteria.

Table 6.6. Mann Whitney U test for gender and TPACK.

	Sex	N	Mean Rank	Sum of Ranks	U	Z	p
TPACK	male	56	63.71	3567.50	1556.5	-1.105	.269
	female	63	56.71	3572.50			
	Total	119					

Furthermore, the relationship between participants' age and TPACK perceptions were examined using appropriate correlational statistics. After conducting the preliminary analysis for checking the assumptions, the normality assumption was violated. So, Spearman rho correlation was used. The strength of the relationship was interpreted according to guidelines of Cohen (1988). The negative sign refers only to the direction of the relationship, not the strength. As shown in Table 6.7, there were small negative correlation between age and technological pedagogical content knowledge of teachers (r_s = - .16, p > .05)

Table 6.7. Correlations between age and TPACK.

			Age	TPACK
Spearman's rho	Age	Correlation Coefficient	1.000	-.157
		Sig. (2-tailed)	.	.087
		N	138	119
	TPACK	Correlation Coefficient	-.157	1.000
		Sig. (2-tailed)	.087	.
		N	119	119

In order to answer research question whether there is a difference in TPACK levels across five teaching experience levels, Kruskal-Wallis test was used. The Kruskal-Wallis test is a non-parametric alternative to a one-way between-groups analysis of variance. It allows comparing the scores on some continuous variable for three or more categories. Teaching experiences of teachers were categorized as less than 10 years, 11-15 years, 16-20 years, 21-25 years and more than 25 years. Chi-square value, the degrees of freedom (df) and the significance level are shown in Table 6.8. So, there is not a significant difference in TPACK levels of mathematics teachers across five different teaching experience groups ($X^2(4) = 6.56, p = .16$).

Table 6.8. Kruskal- Wallis test for TPACK and teaching experience.

	TEACHINGEXP	N	Mean Rank	χ^2	df	p
TPACK	Less than 10	7	51.86	6.560	4	.161
	11-15	53	67.71			
	16-20	32	55.69			
	21-25	19	52.53			
	More than 25	7	41.36			
	Total	118				

6.3. Secondary Mathematics Teachers' TISE Level

The aim of the fifth research question is to describe the technology integration self-efficacy (TISE) levels of secondary mathematics teachers. In order to answer this research question, descriptive analysis including mean and standard deviation was used. According to the results, secondary mathematics teachers' mean TISE score is 3.32 (*SD*= .*92*). The distributions of the mean TISE score is illustrated in Figure 6.2.

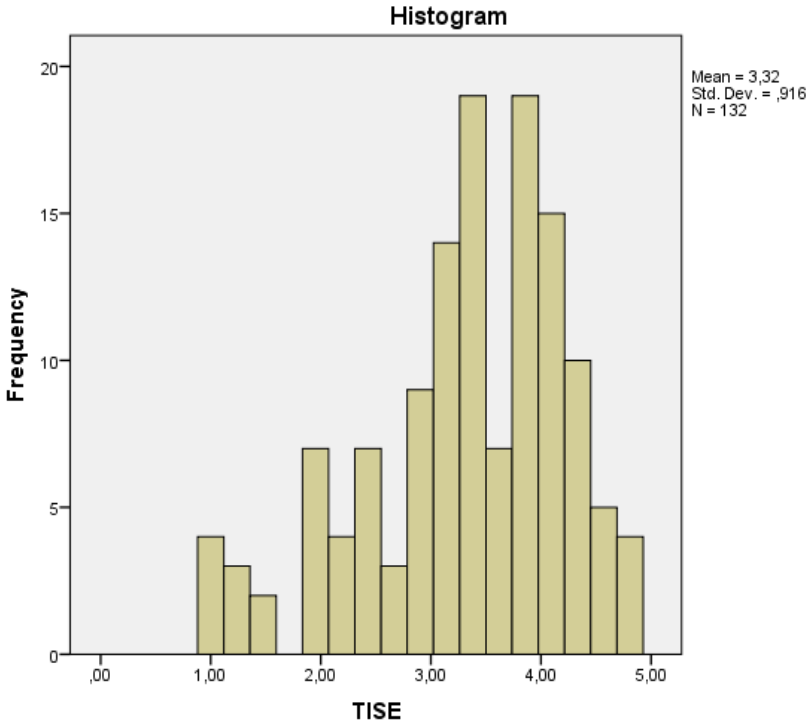


Figure 6.2. Distribution of TISE Scores.

The TISE levels of secondary mathematics teachers were evaluated according to Yurdakul (2011) categorization. It can be inferred that technology integration self-efficacy levels of mathematics teachers is moderate. Moreover, mean scores for TISE items were evaluated according to Handal and his colleagues (2013) categorization. The mean scores of all TISE items were above average. Three of them (Item 12, 13 and 19) are moderately high mean scores and the rest of them are slightly above average mean scores. The highest mean

scores *(MD=3.55)* are related to regularly incorporating technology into their lessons when appropriate to student learning, selecting appropriate technology for instruction based on curriculum goals and as time goes by their ability to address their students' technology needs will continue to improve while the lowest mean score *(MD=3.14)* is related to developing creative ways to cope with system constraints.

Table 6.9. Mean scores for TISE items.

	N	Mean	Std. Deviation
1. I feel confident that I understand capabilities of technological tools well enough to maximize them in my classroom	137	3.18	1.119
2. I feel confident that I have the skills necessary to use technological tools for instruction	137	3.39	1.101
3. I feel confident that I can successfully teach relevant subject content with appropriate use of technology	136	3.49	1.095
4. I feel confident in my ability to evaluate software for teaching and learning.	137	3.36	1.034
5. I feel confident that I can use correct technology terminology when directing students' technology use.	137	3.22	1.048
6. I feel confident I can help students when they have difficulty with technological tools.	137	3.15	1.068
7. I feel confident I can effectively monitor students' use of technological tools for project development in my classroom.	136	3.25	1.073
8. I feel confident that I can motivate my students to participate in technology-based projects.	136	3.31	1.072
9. I feel confident I can mentor students in appropriate uses of technology.	136	3.16	1.013
10. I feel confident I can consistently use educational technology in effective ways.	137	3.23	1.073
11. I feel confident I can provide individual feedback to students during technology use.	137	3.24	1.026
12. I feel confident I can regularly incorporate technology into my lessons, when appropriate to student learning.	138	3.55	1.047
13. I feel confident about selecting appropriate technology for instruction based on curriculum goals.	138	3.55	1.033
14. I feel confident about assigning and grading	137	3.23	1.073

Table 6.9. Mean scores for TISE items (cont.)

technology-based projects.			
15. I feel confident about keeping curricular goals and technology uses in mind when selecting an ideal way to assess student learning.	138	3.35	.979
16. I feel confident I can help students when they have difficulty with technological tools.	138	3.42	1.093
17. I feel confident that I will be comfortable using technology in my teaching.	138	3.45	1.121
18. I feel confident I can be responsive to students' needs during the use of technological tools.	136	3.32	1.120
19. I feel confident that, as time goes by, my ability to address my students' technology needs will continue to improve.	138	3.55	1.074
20. I feel confident that I can develop creative ways to cope with system constraints (such as budget cuts on technology facilities) and continue to teach effectively with technology.	137	3.14	1.044
21. I feel confident that I can carry out technology-based projects even when I am opposed by skeptical colleagues.	138	3.25	1.121
Valid N (listwise)	132		

6.4. Demographic Diversities and the Teachers' TISE

The aim of this research question is to explore possible demographic differences (gender and years of experience) of secondary mathematics teachers' technology integration self-efficacy. The assumptions for using parametric tests were checked. However, normality assumption was violated when Kolmogorov-Smirnov test was applied to check normality as shown in Table 5.3. So, non-parametric Mann-Whitney U test was used to test the difference between male and female mathematics teachers' TISE levels. According to Table 6.9, p value is less than .05 so the result *(U=1663, z= -2.27, p=. 02)* is significant. There is a statistically significant difference in technology integration self-efficacy of males and females. After statistically significant difference between groups was found, the direction of groups was determined by using Mean Rank. So, it can be inferred that male mathematics teachers have higher technology integration self-efficacy than female mathematics teachers. The r value calculated as .2. So, it can be considered as small effect size according to Cohen (1988).

Table 6.10. Mann Whitney U test for gender and TISE.

	Sex	N	Mean Rank	Sum of Ranks	U	Z	p
TISE	male	60	74.78	4487.00	1663	-2.273	.023
	female	72	59.60	4291.00			
	Total	132					

Moreover, appropriate correlational statistics was used to examine the relationship between participants' age and TISE. After conducting the preliminary analysis for checking the assumptions, the normality assumption was violated. So, Spearman rho correlation was used. According to the results shown in Table 6.10, there were a strong negative correlation between secondary mathematics teachers' age and technology integration self-efficacy (r_s = *-.18, p < .05*).

Table 6.11. Correlations between age and TISE.

			Age	TISE
Spearman's rho	Age	Correlation Coefficient	1.000	-.178*
		Sig. (2-tailed)	.	.041
		N	138	132
	TISE	Correlation Coefficient	-.178*	1.000
		Sig. (2-tailed)	.041	.
		N	132	132
*. Correlation is significant at the 0.05 level (2-tailed).				

In the other research question, whether there is a difference in technology integration self-efficacy levels of mathematics teachers across five teaching experience categories was analyzed. Non parametric Kruskal-Wallis test was used to compare the scores on TISE for five groups because normality assumption violated. According to the results as shown in

Table 6.11, there is a statistically difference in TISE levels of teachers across five teaching experience groups. An inspection of the mean ranks for the groups in Table 6.11 suggests that mathematics teachers who have 11-15 years teaching experience recorded a highest mean score *(MD= 76.5)* among the other groups. Also, more experienced mathematics teachers recorded a lowest mean score *(MD= 43.3)* among the groups.

Table 6.12. Kruskal- Wallis test for TISE and teaching experience

	TEACHINGEXP	N	Mean Rank	χ^2	df	p
TISE	Less than 10	8	48.00	9.880	4	.043
	11-15	57	76.46			
	16-20	37	61.19			
	21-25	21	61.57			
	More than 25	8	43.31			
	Total	131				

6.5. The Relationship between TPACK and TISE of the Teachers

In last research question, the relationship between TPACK and TISE variables was investigated. The normality assumption was violated. So, Spearman rho correlation coefficient was used to find whether there is a relationship between TPACK and TISE variables. To determine the strength of the relationship, Cohen (1988) suggests the following guidelines: if the values of the correlation coefficient range from .10 to .29, there is a small relationship between variables. If the values of the correlation coefficient range from .30 to .49, there is a medium relationship between variables. If the values of the correlation coefficient range from .50 to 1.0, there is a strong relationship between variables. Therefore, Table 6.12 indicates that there is a strong relationship between TPACK and TISE variables (r_s = .83, p < 0.01). It can be inferred that for mathematics teachers in this sample high levels of TPACK of mathematics teachers associated with high levels of TISE of mathematics teachers. Also, scatter plot diagram for TPACK and TISE variables is illustrated in Figure 6.3.

Table 6.13. Spearman rho correlations between TPACK and TISE.

			TPACK	TISE
Spearman's rho	TPACK	Correlation Coefficient	1,000	,829**
		Sig. (2-tailed)	.	,000
		N	119	116
	TISE	Correlation Coefficient	,829**	1,000
		Sig. (2-tailed)	,000	.
		N	116	132
**. Correlation is significant at the 0.01 level (2-tailed).				

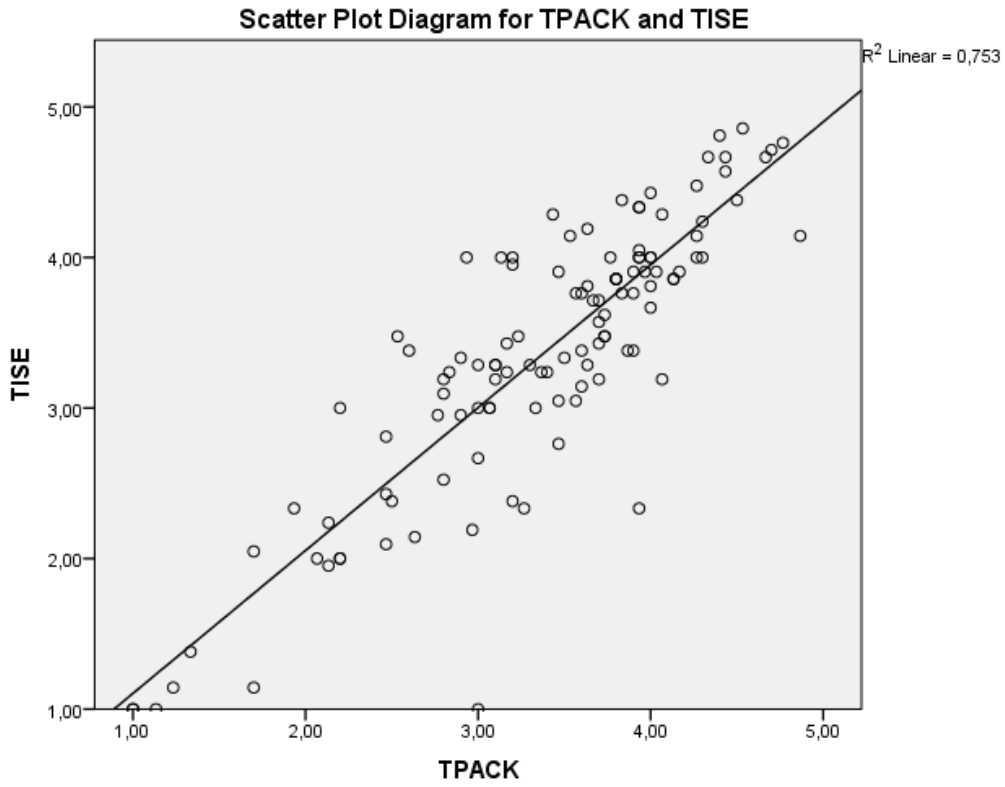


Figure 6.3. Scatter Plot Diagram for TPACK and TISE.

7. CONCLUSION AND DISCUSSION

In the present study, it was aimed to describe high school mathematics teachers' perception on their technological pedagogical content knowledge (TPACK) and technology integration self-efficacy (TISE) levels, and to investigate some possible diversity that can be explained by their demographic profiles. Another purpose of the study was to examine the relationship between teachers' TPACK and TISE. This chapter starts to discuss the findings of this research. Then, it continues with limitations of the study and suggestions for future research.

Turkey's FATIH project (Increasing Opportunities and Improvement of Technology Movement) is a controversial issue whether it is a plan to conquer the digital divide, or a technological leap of faith. Even for those closest to FATIH (at the MoNE, in schools and in academia), perceptions of the program vary widely between those who optimistically see this as an inevitable step to coming up to European "schools of the future" (Smith *et al.*, 2005), to those who see this as a catastrophic waste of resources (ERI, 2014). Up to now, there has no comparable example of national tablet and interactive whiteboard (IWB) use at this scope, but there can be made inferences from other large-scale laptop and tablet programs in the USA (Maine, Texas), Europe (Portugal) and South America (Peru, Uruguay), as well as more than a decade of IWB use in the United Kingdom (ERI, 2014). Despite this nearly ubiquitous access to computer technology, however, there is a significant gap between the presence of technology and its usage in the USA classrooms. While some type of technology is present in nearly every classroom in the country, it is rarely used to its fullest potential (Royer, 2002). The Berkshire Wireless Learning Initiative evaluation found that poor implementation is linked to lack of teacher knowledge and lack of support for innovations, and concluded 'Each teacher has a decisive role in the success or failure of technology implementation' (Bebell and Kay, 2010). The FATIH project also has evidence from the pilot study that teachers were the key factor in how the technology was used. If the teacher did not use the technology the students either did not use them or use it improperly. For example, without guidance students used the tablets to take notes (ERI, 2014). Therefore, it was important to study teachers' TPACK and TISE. For this study, secondary mathematics teachers' TPACK and TISE was examined and they will be discussed in the scope of the FATIH project.

7.1. Secondary Mathematics Teachers' TPACK

In order to identify secondary mathematics teachers' technological pedagogical content knowledge (TPACK) in terms of technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPCK), TPACK-M scale (Handal *et al.*, 2013) was adapted to Turkish. Secondary mathematics teachers' technological pedagogical content knowledge (TPACK) was identified in terms of TCK, TPK and TPCK in this study. The combinations of the three constructs form the TPACK perception of teachers' for the present study. Secondary mathematics teachers at the FATIH projects schools in Istanbul were chosen as a sample for this study.

According to the results, the mean score of each construct and whole instrument showed that secondary mathematics teachers generally rated themselves as moderate. These findings supported the results of the studies (Koh *et al.*, 2010) and (Karadeniz and Vatanartıran, 2013). Participants in those studies overall felt very well about their technological pedagogical content knowledge. Considering the specific subscale mean scores, the highest mean value of the teachers' perception corresponds to technological content knowledge (TCK). This means that mathematics teachers feel more competent in content-related technology. According to the report of 2000 National Survey of Science and Mathematics Education, high school mathematics teachers are significantly more likely than middle school teachers to report feeling qualified to teach a number of mathematics topics (Weiss *et al.*, 2001). Therefore, mathematics teachers may prefer to use technology mostly in their good-at construct, content.

Furthermore, the participants' ratings by items for TCK construct in this study were examined to provide more explanation about construct. The highest mean score for the TCK items related to Paint/ Photoshop were not unexpected. Participants of the study reported that they mostly use Paint/ Photoshop (A2) to edit questions in the preparation of mathematics exams. Also, drawing geometric shapes or writing mathematical formula by hand is a difficult process for the teachers. So, such programs were preferred by teachers to facilitate their task. Moreover, publishing companies prepared available materials for the use of interactive whiteboard. Some mathematics teachers regulated those materials for their own use with the

help of Paint/ Photoshop. The other moderately high mean score for PowerPoint (A1), Excel spreadsheets (A3, A4), networking with other colleagues through online forums and locating mathematics online applications (A6). The reason can be due to the fact that Excel and PowerPoint tools are available in most personal and school computers. Mathematics teachers are mostly use spreadsheet to record and calculate students' grades. Also, PowerPoint is used widely in schools for students' project presentations or for teaching 3D shapes. Comparing the Handal *et al.* (2013) results, the mean scores for Turkish mathematics teachers' use internet to network with other colleagues through online forums and Facebook are higher than that. The result may be explained by the use of Facebook in Turkey which takes place near the top in the world (AA, 2013). Moreover, there are so many online forums and Facebook groups to communicate with colleagues. Some teachers reported that they use such forums to discuss mathematics questions they cannot solve. So, it may be suggested that in EBA system, discussion boards may be created for mathematics teachers to share their activities and documents in the scope of FATIH project. Also, locating online applications (A6) item reflects the fact that teachers are becoming increasingly knowledgeable in using the internet as a source of teaching resources. For example, wolframalpha.com, computational engine was used by teachers to find the results of some computations. The overall TCK items in the instrument was considered, it may be suggested that more content specific questions take place in the survey.

When the lowest mean scores were considered, the items related to using dynamic geometry software (A7) and constructing multimedia objects (A9). The average age of participants for this study is about 40 so they most probably did not take any course related to use of software programs. If a teacher is interested in the use of technology in mathematics he or she may learn, otherwise the teacher might not feel need to learn software. Also, constructing multimedia objects requires high level technology skills. So, these results indicate that secondary mathematics teachers' knowledge of technology related to mathematics is limited because they can use only basic computer programs and online forums instead of mathematics teaching specific software. The other slightly above average means is for using graphing calculator (A5) and computer algebra software (A8). The results of this study may indicate that mathematics teachers were not feeling confident to use these resources too.

The mean scores for TCK items were compared with Handal and his colleagues (2013) study, the mean score for each item except using computer algebra software is higher than this study. Although Turkish Secondary Mathematics Curriculum (MoNE, 2013) recommended the use of information and communication technologies (ICT) in mathematics education, mathematics teachers are not familiar with the use of ICT tools especially educational technology software. According to the report of 2000 National Survey of Science and Mathematics Education (Weiss *et al.*, 2001), the distribution of high school mathematics teachers according to age is skewed toward older teachers which is parallel with the results of this study. These results may point out that in-service training focusing on using educational technologies in classroom should also provide content related portions prepared for mathematics teachers. Effectiveness of content specific programs was reported in some studies (Akkoç, 2008; Fennema and Franke, 1992). So, mathematics teachers' perception to use technology in mathematics may get higher by practices such as workshops or content specific training which teachers discuss students difficulties with various mathematical concepts and how these difficulties could be handled using technological tools (Akkoç, 2008).

On the other hand, among the TPACK sub-constructs, the least mean value of the teachers' perception corresponds to technological pedagogical knowledge (TPK). It can be concluded that mathematics teachers do not feel themselves sophisticated pedagogical use of technology as well as in other constructs. According to the report of 2000 National Survey of Science and Mathematics Education, high school mathematics teachers reported well prepared to use various instructional technologies in their teaching. As yet another lens on teachers' perceptions of pedagogical preparedness, they are least likely to feel prepared in technology-related areas (Weiss *et al.*, 2001). This result may stem from teachers' lack of general knowledge about technology-related pedagogy.

Moreover, the mean scores for each TPK item were examined in order to determine the level of contribution of the item. The TPK scale items generally scored lowest among all three subscales. This indicates that participants feel themselves least competent and sophisticated in TPK. The highest mean score for TPK items and for the whole test is related to interactive whiteboard (B2). The reason for this situation may be that interactive whiteboards are becoming available in the FATIH project schools. Also, most of the teachers

took in-service training on the general use of interactive whiteboard. So, they may feel competent in themselves in the use of interactive whiteboard. The other moderately high mean score was found regarding teachers' ability to use technology to support students' research skills (B1) and using mobile devices (B4). The distribution of tablets in the scope of the FATIH project and the use of it in students' project assignments might be an indicator of these results.

In addition, the slightly above average mean scores for alternative assessment tasks (B8) probably reflects the general lack of alternative assessment in secondary mathematics rather than teachers' technology use (Baki and Birgin, 2002). Similarly above average mean scores for online texts and images (B9) and multimedia presentations (B6) may indicate that these information and communication technology (ICT) tools do not fit with typical pedagogical approaches for secondary mathematics. Also, appraising educational websites and software (B10) ranked just above average, representing the quality and usefulness of educational websites and software may not be considered so much.

On the other hand, the lowest response for the whole instrument regarding cyber safety issues in school may simply reflect that many mathematics teachers do not deal with this type of incidents. The remaining two items relating to wikis (B5) and web quest (B3) also have the lowest mean scores for the entire survey, suggesting that teachers have not confident enough to work with those tools. Developing or using wikis and web quest may be seen as advanced technological skills. So, this result is parallel with teachers reported technological pedagogical content knowledge (TPACK) results. Lastly, the results of this construct were similar to Handal *et al*. (2013) study.

It may be inferred that secondary mathematics teachers generally have difficulty to integrate technology and pedagogy. So, the need for professional development programs is quite obvious, not only for the mastery of the tools but also for their integration to use it in instruction.

Compared with other two constructs, responses of participants for TPCK items were more consistent with narrowest mean scores. Examining each item of the construct may provide explanation for TPCK results' consistency. The highest mean scores were related to the items for collecting, analyzing and interpreting data to make informed judgments (C6) and

assisting students to develop their mathematical problem solving skills (C1). These results are not surprising for a secondary mathematics teacher sample (Handal *et al.*, 2013). The remaining items have slightly above average mean scores. The results were similar for linking symbolic, numerical, and graphical data (C2), mathematical content (C5), substantive student communication (C8) and authentic tasks (C7). These items are all generic so the midrange responses are not unexpected. Moreover, these tasks may be commonly delivered in classroom through either spreadsheets for making calculations or creating graphs and charts or PowerPoint for presenting content in a variety of ways. These mathematical capabilities also scored highly in technological content knowledge (TCK) items (TCK: A1, A3 and A4). Similarly, being knowledgeable in using online mathematics applications and tools scored highly in TCK may contribute to effects of the items related to digital learning objects (TPCK) and supporting students' mathematical investigations with digital tools (TPCK).

The lowest mean score in TPCK construct was to the general statement regarding identifying trends and patterns to predict possibilities (C4). This may reflect that secondary mathematics teachers do not prefer to use technology in statistics and probability topics. Difficulties in teaching statistics and probability in Turkey were recently noticed by Kaynar and Halat (2012). Secondary mathematics teachers already have difficulty with these topics without technology. However, using statistical software and technology tools can be an opportunity for teachers to teach important statistical ideas and skills and to prevent or overcome typical misunderstandings and misconnections about these concepts (Garfield and Everson, 2009).

The other low mean score is related to integration with other key learning areas (C9). Although secondary mathematics curriculum in Turkey mostly emphasizes the importance of integration with other fields, this may be not the case in enactment of the curriculum according to results. Teachers have difficulty with an integrating teaching knowledge to foster science, technology, engineering, and mathematics (STEM) education in Turkey (Çorlu, 2014). However, with the help of technology, Turkey may have qualified STEM workforce which will contribute to increasing country's innovation capacity.

The TPACK ratings by items are drawn from this study are generally consistent with Handal and his colleagues (2013) study. However, it may be claimed that there were

confusion among constructs in some part of the instrument. The moderate mean score in TPACK (and three constructs) may be explained by familiarity with technology in daily life and in-service training on using technology. Overall, the participants reported using various technologies in their personal life to communicate or obtain information. According to study conducted by Menzi, Çalışkan and Çetin (2012), teachers who have personal technological devices see themselves more competent in the field of technology than who do not have. So, this may explain why participating teachers' perception is moderate in technology related knowledge in this study. However, as shown in other studies (Harris *et al.*, 2009; Lei, 2009), use of technology for communication and information does not necessarily translate into technology integration in the classroom. Teachers used technology to communicate daily but lacked expertise or vision to translate this technology knowledge into use in instruction. Moreover, in the scope of the FATIH project, teachers took in-service training related to technology use in education. Training is focusing mainly on functionality of the hardware and software, but not on content (choice of appropriate media, functionality of the media) or pedagogical integration of the content in strategic ways, including interaction between the tablets, IWB, teacher and student (ERI, 2014). Teachers are somewhat subject to use technology. So, this may be the reason of teachers' moderate perception on technology related knowledge. However, how and in what degree they use technology is a questionable issue. Teachers' answers to such questions were given by item responses in this study. Based on the results, it may be inferred that teachers added technology component to already acquired skills such as problem solving and data analysis. So, teachers may still think pedagogical knowledge, content knowledge and technological knowledge separately. This does not mean technology integration. Earle (2002) defined integrating technology as not by the amount of technology used, but by how and why it is used. Moreover, Timur and Tasar (2011) found high relationship between the general TPACK and technological pedagogical knowledge (TPK), technological content knowledge (TCK), technological pedagogical content knowledge (TPCK) constructs. This study also shows that TPK, TCK and TPCK may not be independent constructs. Since related items in TCK and TPK scored consistently with TPCK items, it can be inferred that TPCK interact with TCK and TPK.

If the FATIH project aims to reach the determined goals (enabling equal opportunities in education and improving technology in schools for the efficient usage of ICT tools in the

learning and teaching processes), mathematics teachers should be encouraged to use technology integration of content and pedagogy. Before that, they need professional development in teaching mathematics with technology especially using computer algebra software, dynamic geometry software and graphic calculator and also in pedagogical issues such as web quest and wikis. So, teachers can enrich their lessons integrating technology, pedagogy and technology. Previous studies indicated positive influence of intervention programs on the technological pedagogical content knowledge of in-service and pre-service teachers (Angeli and Valanides, 2009; Mishra and Koehler, 2006). Also, it can be implied that if qualified in-service training programs are prepared for integration of technology in mathematics education, secondary mathematics teachers TPACK perception level can be improved even at a higher level.

To sum up, equipping classrooms with latest technology, providing teachers to easily access to technology and developing positive attitudes toward technology are not guaranteed the integration of technology (Perkmen and Tezci, 2011). Content knowledge, pedagogical knowledge and technology knowledge is not sufficient individually to ensure technology but also integration of these is important. If mathematics teachers know how to teach which mathematics topics using technology, they can successfully integrate technology (Niess, 2005; Schmidt *et al.*, 2009).

Based on the existing literature on teachers integration of technology into classroom, teacher self-efficacy and teacher knowledge play a significant role in predicting technology use (Mishne, 2012). Specifically, understanding teachers' knowledge and beliefs about educational technology can provide insight into how they use technology in a classroom environment. So, there is a need to examine teachers' self-efficacy for technology integration.

7.2. Secondary Mathematics Teachers' TISE

The current study was carried out to discuss secondary mathematics teachers' technology integration self-efficacy. Albion (1999) stated that teachers' beliefs, specifically self-efficacy beliefs, "are an important, and measurable, component of the beliefs that influence technology integration." According to the results of this thesis study, teachers'

technology integration self-efficacy (TISE) was at moderate level. Similarly, Gökçek and her colleagues (2013) investigated technological self-efficacy of primary school teachers and found that technology self-efficacy of teachers were at moderate level.

The overall theme in research regarding teacher self-efficacy and technology integration is that teachers who have high levels of self-efficacy are more willing to try new things and experiment more with educational innovations in the classroom (Evers *et al.*, 2002). Teacher beliefs toward technology use play an integral role in the development of a positive self-efficacy toward technology use. Positive self-efficacy toward technology use can lead to more practices of technology use (Ottenbreit-Leftwich, 2012).

TISE items in the study may provide explanation about teachers' TISE. So, it is likely to say that teachers considered themselves more efficient in regularly incorporating technology into their lessons when appropriate to student learning and selecting appropriate technology for instruction based on curriculum goals. Also they feel confident that, as time goes by; their ability to address students' technology needs will continue to improve. However, self-efficacy concerning skills that require expertise; for example, helping students when they have difficulty with technological tools and developing creative ways to cope with system constraints such as budget cuts on technology facilities was lower compared to other items. It may be inferred that teachers have a high technology integration self-efficacy on curricular activities while have a low technology integration self-efficacy on technical support. Although they feel unconfident to deal with students' technological difficulties at present, they believe that their ability to use technology will improve. In-service program in the scope of the FATIH project on the use of interactive whiteboard may contribute this result. The literature supports it that teachers who took training on ICT have higher self-efficacy for technology use than who did not take (Brown and Warschauer, 2006; Lee *et al.*, 2008).

Ertmer and Ottenbreit-Leftwich (2010) advocate for a change in teacher practice that higher levels of technology use for instruction would be required for 21st century teaching and learning. Perhaps the beliefs of teachers in this dataset have not caught up with this time. So, the results indicate that the teachers need professional development that allows teachers to learn the technology through the context of mathematics and helped to build the teachers'

self-efficacy (Hardy, 2012). As noted by An and Reigeluth (2011), professional development needs to go beyond teaching the technical skills but how to integrate technology within the core subject area. The development of a teacher's self-efficacy helps the teacher to integrate technology fully into their classroom. Confidence developed through "small successful experiences" and "working with knowledgeable peers" (Ertmer and Ottenbriet-Leftwich, 2010, pp.261-262). ERI (2014) reported that the level of in-service training in the FATIH project is not enough and functional. This thesis study also supports it that mathematics-specific training should be developed to integrate technology into the teaching of mathematics. So, teachers may have high self-efficacy and knowledge to integrate technology into their instruction.

7.3. The Relationship between Secondary Mathematics Teachers' TPACK and TISE

Pajares (1992) discusses the relationship and distinctions between knowledge and beliefs and the influence these might have on the teaching practices. Among his many assertions concerning beliefs, Pajares states that "knowledge and beliefs are inextricably intertwined" and that "beliefs are instrumental in defining tasks and selecting the cognitive tools with which to interpret, plan, and make decisions regarding such tasks" (1992, p. 325). Knowledge of teaching and learning, as well as evolving attitudes and beliefs, are among the attributes of teachers that inform and influence the decisions they make and behaviors they exhibit as professional educators.

Furthermore, Ertmer and Ottenbreit-Leftwich (2010) described the influence of self-efficacy beliefs, knowledge, pedagogical beliefs, and cultural contexts on technology integration and specifically address the connection between knowledge and self-efficacy beliefs by stating that "although knowledge of technology is necessary, it is not enough if teachers do not also feel confident using that knowledge to facilitate student learning" (Ertmer and Ottenbreit-Leftwich, 2010, p. 261). Measures of both knowledge and beliefs separately can yield unique and informative insights into the preparation of teachers to use technology to create engaging and effective classroom environments. However, examining the relationship between knowledge about technology integration and self-efficacy beliefs can provide a unique connection between these two areas of research. Also, the TPACK framework has also

been used to frame other constructs believed to influence technology integration, such as self-efficacy (Albion *et al.*, 2010; Graham *et al.*, 2009). So, the relationship between secondary mathematics teachers' perceived knowledge, as represented by TPACK framework and self-efficacy beliefs about integrating technology into classroom were discussed.

According to results from this study, there was a strong relationship between TPACK and TISE. The TPACK framework suggests that integrated knowledge of technology, pedagogy, and content is an essential condition to effective and innovative classroom teaching using technology. Further, self-efficacy beliefs regarding abilities to integrate technology into teaching are also considered a factor influencing decisions a teacher would make about the use of technology in the classroom. Bandura's theory of self-efficacy would suggest that increasing teacher knowledge would lead to increased self-efficacy beliefs and, potentially, to an increase in technology use in the classroom as well as an increased likelihood that this technology use will be based on knowledge of pedagogy and content. So, the relationship between TPACK and TISE in this study may suggest that efforts to improve teacher TPACK may result in increased self-efficacy beliefs about technology integration. Therefore, these two variables can be considered as crucial understanding teachers' technology integration perception in their teaching. Similarly, Nathan (2009) found moderate relationships between TPACK and TISE of pre-service teachers in four different subject areas (Mathematics, Science, Literacy and Social Studies). In another study conducted with pre-service physical education teachers, a considerably high relationship was found between these variables (Semiz, 2012). It may be concluded that the relationship between TPACK and TISE was found by different authors not only in mathematics education but also in other educational fields.

Moreover, Abbitt (2011) reported that self-efficacy beliefs about technology integration are more strongly related to specific knowledge domains where technology is blended with pedagogy and content knowledge (TPK, TCK, TPCK) than other constructs. In thesis study, TPACK construct is based only technology related constructs TPK, TCK and TPCK. So, the strong relationship between TPACK and TISE in this study may be explained based on the Abbitt (2011) study.

When considering how to design professional development programs that will develop skilled and knowledgeable teachers who use technology to create engaging and effective classroom environments, both knowledge and beliefs may be useful in understanding the processes. Also, providing technology integration experiences at multiple points (technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPCK) may lead to a more complex and deeper understanding of the interaction among these types of knowledge as well as increased beliefs in teachers' effectively use technology to improve teaching and learning.

7.4. Demographic Diversities of TPACK and TISE

Based on the existing literature on teacher integration of technology into classroom, gender, age and teaching experience were possible predictors of technology integration. So, demographic diversities of TPACK and TISE were discussed in terms of gender, age and teaching experience in this study.

Within the sample studied, there were no significant difference between secondary mathematics teachers' TPACK and gender. This finding is consistent with previous studies (Chai *et al.*, 2011; Öztürk, 2013). North and Noyes (2002) suggested that the prevalence of computers in schools could provide both males and females with equal opportunities for computer use, thereby equalizing their perceived differences with respect to computer use. Therefore, if the FATIH project reaches the aim of providing equal technological opportunities to schools, the impact of gender differences on TPACK may become less significant on teachers. Also, teachers in the FATIH project school took in-service training which was constructed on similar content. This may be the reason why male and female teachers' perceive themselves similar in terms of TPACK. On the other hand, there was significant difference in the mean TISE scores of the male and female mathematics teachers in favor of male participants. Literature on gender and TISE supports the finding that males tend to have higher TISE than females (Akkoyunlu and Orhan, 2003; Cassisdy and Eachus, 2002). The reason for these diversities in favor of males may be the conception of technology as masculine in nature. Dakers *et al.* (2009) and Sanders (2006) assert that females are less

interested in technologies than males. Therefore, the level of interest may be an indicator of such difference. Males can be more interested in technological devices and may use more complex technology than females. So, males can be considered themselves as more efficient than females in technology integration.

Furthermore, weak negative correlation was found between TPACK and age in this study consistent with previous studies (Koh *et al.*, 2010; Öztürk, 2013) while strong negative correlation was found between TISE and age for this sample. Also, there are other studies showing that TISE declines depending on the age (Korobili *et al*., 2010; Tella and Ayeni, 2006). The reason for this result may be older sample of this study. So, it may not be inferred that older teachers have low TISE while younger teachers have high TISE. Since few young teachers in this study, the results from correlation between age and TISE may not be generalized.

When teaching experience of participants was considered, there was no significant difference in TPACK levels of teachers across five teaching experience groups. However, there was a significant difference in TISE levels of teachers across the groups. More experienced teachers recorded low level of TISE in this study. Yaghi (2001) suggested that teachers with more years of teaching had lower levels of confidence in using computers. So, the results of this study may infer that teachers with more teaching experience tend to have a lack of TISE suggested by their lower confidence. This is parallel with the results for age and TISE. So, it may be inferred that older teacher have more teaching experience. Moreover, in at least one study, teaching experience as a factor in technology use decreases in significance after five years and levels off completely between five and seven years (Forssell, 2009). In this study, the respondents had an average of seventeen years of teaching experience and the categorization was centered on 11-20 years of teaching experience. Therefore, the results of this study may not be generalized because of few numbers of teachers in some teaching experience categories.

Previous study showed that age, gender and teaching experience all affect the teacher's response to implementing new ideas in the classroom (Fullan, 2001). Since FATIH project is a new implementation, such demographic information of teachers which can be effect on technology integration was discussed in the present study.

7.5. Limitations and Suggestions for Future Research

In this part, the limitations of the current study and suggestions for further research are presented. First limitation of the study is that the sample was limited to secondary mathematics teachers at FATIH project schools (public schools) in six districts of Istanbul. Also, participants were not selected randomly because of practical reasons. Frankel and Wallen (2006) stated that using non random sampling method limits the generalizability of the research. So, the results of this study may not be generalized to all mathematics teachers in Istanbul. Teachers' age and teaching experience was not normally distributed so this also limits the generalizability of the results. In addition, all mathematics teachers in those schools were invited to participate in the survey. However, the responses of those participated the study may be different than those who did not participate. In order to be able to generalize the results to the targeted population, the study can be conducted in a larger scope. Moreover, researchers can conduct studies to compare mathematics teachers at the FATIH project schools with private schools which already equipped with technological tools.

Second limitation of the study is that the findings from this study were based on self-reported data of teachers. The results were limited by the accuracy of teacher characterization. Self-reported data can be subject to bias, either on the part of the researcher or participants. Bias can be due to social desirability, when participants respond in a way their reflection would be viewed as socially acceptable or they think the researcher wants to that answer. Ertmer (2005) noted that teachers sometimes answer questions as they ideally want instruction to appear in their classroom, which is not always representative of what they are doing in the classroom. A possible way to overcome this limitation would be to use qualitative data in the forms of interview questions (Sarac, 2012). Accordingly, interviews were conducted with volunteered participants to explain the data results. However, this does not reflect all of the participants' explanations, feelings, motivations, and concern. Face to face interviews can be conducted to capture participants' actual perceived TPACK and TISE.

Moreover, the term perceived TPACK was used for this study based on literature (Koh *et al.*, 2010; Lee and Tsai, 2010; Schmidth *et al.*, 2009a) because the items in the instrument cannot measure teachers' TPACK. However, mathematics teachers' TPACK on some topics can be observed in real classroom setting. The high relationship between TPACK

and TISE may stem from the use of self-report especially for TPACK. Also, some items in TPACK scale may parallel with the TISE scale. So, it is recommended that future research make an observation to identify TPACK and TISE and also whether there are any disparities exist between teachers' self-report and their actual implementation in terms of technology integration. In addition, some demographic information (age, gender and years of experience) was identified as influencing teachers' TPACK and TISE in this study. However, additional factors that influence teachers' TPACK and TISE can be revealed by classroom observations for future researches.

APPENDIX A: TURKISH VERSION OF TPACK-M AND TISE SCALE

Sayın katılımcı,

Bu çalışmanın amacı sizlerin teknolojik pedagojik alan bilgisini (TPAB) ve teknolojiyi entegre etme öz-yeterliliğini (TEEÖ) incelemektir. Teknolojik bilgi, pedagojik bilgi ve alan bilgisini birbirine bağlayan ve bu bilgilerin kesiştiği noktada bulunan TPAB, teknolojinin konuya ve düzeye göre öğretim sürecinde nasıl kullanılması gerektiği konusunda öğretmenlerin sahip olması gereken bir bilgidir.

Üç bölümden oluşan anketin birinci bölümünde kişisel bilgilerinizin belirlenmesi için hazırlanmış 11 madde, ikinci bölümünde 30 maddeden oluşan "Teknolojik Pedagojik Alan Bilgisi(TPAB) Ölçeği" ve üçüncü bölümde 21 maddeden oluşan "Teknolojiyi Entegre Etme Öz-yeterlilik Ölçeği" bulunmaktadır.

Vereceğiniz samimi cevaplar, araştırmanın geçerliliğini ve güvenirliliğini olumlu yönde etkileyeceğinden son derece önemlidir. Katılım, gönüllük esasına dayanır, istediğiniz zaman çalışmayı bırakabilirsiniz. Cevaplarınız gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir; elde edilecek bilgiler bilimsel yayınlarda kullanılacaktır. Çalışmanın sonuçlarını öğrenmek ya da bu araştırma hakkında daha fazla bilgi almak isterseniz aşağıdaki iletişim adresini kullanabilirsiniz. Araştırmaya katıldığınız için teşekkür ederim.

Lütfen tüm bölümleri cevaplayınız.

BÖLÜM 1

Bu bölüm kişisel bilgilerinizden oluşmaktadır. Lütfen ilgili yerleri işaretleyiniz ve doldurunuz.

1. Okulunuzun adı: ……
2. Cinsiyetiniz: ☐ Kadın ☐ Erkek
3. Yaşınız: .....
4. Öğretmenlikteki hizmet süreniz: ……
5. Mezun olduğunuz bölüm:…….
6. En son mezun olduğunuz eğitim düzeyi:

   ☐ Önlisans ☐ Lisans ☐ Y.Lisans ☐ Doktora
7. Haftada kaç saat dersiniz var?.....
8. Girdiğiniz sınıf seviyeleri: ☐ 9.sınıf ☐ 10.sınıf ☐ 11.sınıf ☐ 12.sınıf
9. Kendinize ait hangi teknolojik araçlara sahipsiniz?

   ☐ Masaüstü bilgisayar ☐ Dizüstü bilgisayar ☐ Tablet ☐ Akıllı telefon
10. Hizmet içinde eğitimde teknoloji kullanımı ile ilgili kurs aldınız mı?

    ☐Evet ☐ Hayır
11. Matematik dersinde teknoloji kullanımı ile ilgili kurs, ders ya da eğitim aldınız mı?

    ☐Evet ☐ Hayır

Bu araştırmada **teknoloji** kelimesi ile dijital teknolojiler ifade edilmektedir. Dijital teknolojilere örnek olarak bilgisayarlar, diz üstü bilgisayarları, iPadler, Internet, bilimsel/grafik hesap makinaları, interaktif tahtaları, yazılım programları, çevrimiçi uygulamalar, iPodlar ve öğrenme yönetim sistemleri (Moodle, MyClasses) verilebilir.

Lütfen arkadaki sayfalarda yer alan soruları cevaplayınız. Eğer yanıtınızdan emin değilseniz ya da karar veremiyorsanız **'Kararsızım'** ifadesini işaretleyiniz.

BÖLÜM 2

TEKNOLOJİK PEDAGOJİK ALAN BİLGİSİ ÖLÇEĞİ

Aşağıdaki ifadelerden size uygun olanı işaretleyiniz.

Kesinlikle Katılmıyorum 1 | **Katılmıyorum 2** | **Kararsızım 3** | **Katılıyorum 4** | **Kesinlikle Katılıyorum 5**

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Bir PowerPoint sunusu oluşturmak için teknolojiyi kullanabilirim	1	2	3	4	5
2. Basit görüntüleri oluşturmak ve düzenlemek (örn: Microsoft Paint veya Photoshop) için teknolojiyi kullanabilirim.	1	2	3	4	5
3. Elektronik tablo(spreadsheet) üzerinde hesaplamalar yapmak için teknolojiyi kullanabilirim.	1	2	3	4	5
4. Elektronik tabloyla (spreadsheet) çizelge/grafik oluşturmak için teknolojiyi kullanabilirim.	1	2	3	4	5
5. Grafik hesap makinası için teknolojiyi kullanabilirim.	1	2	3	4	5
6. Çevrimiçi matematik uygulamalarını ve araçlarını (örn: öğrenme nesneleri, uygulamalar, simülasyonlar) bulmak ve onları değerlendirmek için teknolojiyi kullanabilirim.	1	2	3	4	5
7. Dinamik geometri yazılımları kullanımı (örn: Geogebra, Geometer's Sketchpad, Autograph, Cabri) için teknolojiyi kullanabilirim.	1	2	3	4	5
8. Bilgisayar cebir yazılımı (örn: Derive, Mathematica) için teknolojiyi kullanabilirim.	1	2	3	4	5
9. Resim, ses ve animasyonları yerleştirilmiş çoklu ortam nesneleri oluşturmak için teknoloji kullanabilirim.	1	2	3	4	5
10. Çevrimiçi forumlar, Facebook vb. aracılığıyla diğer meslektaşlarla ve profesyonel birliklerle bağlantı kurmak için teknolojiyi kullanabilirim.	1	2	3	4	5
11. Öğrencilerin araştırma becerilerini geliştirmek için teknolojiyi kullanabilirim.	1	2	3	4	5
12. Etkileşimli beyaz tahta kullanarak bir kavramı öğretebilirim.	1	2	3	4	5
13. Bir müfredat ünitesini sunmak için ağ araştırması (webquest) oluşturabilirim.	1	2	3	4	5

	Kesinlikle katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle katılıyorum
14. Öğretimde mobil cihazlar (örn: iPad, akıllı telefonlar) kullanabilirim.	**1**	**2**	**3**	**4**	**5**
15. Öğrencilerin vikiler (örn:vikipedi,vikispaces) yoluyla işbirlikçi öğrenime katılmalarını sağlayabilirim.	**1**	**2**	**3**	**4**	**5**
16. Öğrencilere kendi çoklu ortam sunularını oluştururken yol gösterebilirim.	**1**	**2**	**3**	**4**	**5**
17. Okuldaki sanal zorbalık ve sanal güvenlik sorunlarıyla başa çıkabilirim.	**1**	**2**	**3**	**4**	**5**
18. Öğrencilere alternatif değerlendirme biçimleri sağlamak için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
19. Öğrencilerin eleştirel olarak çevrimiçi metinleri veya görüntüleri analiz etmelerini sağlayabilirim.	**1**	**2**	**3**	**4**	**5**
20. Eğitim sitelerinin ve yazılımlarının kullanışlılığını ve kalitesini değerlendirebilirim.	**1**	**2**	**3**	**4**	**5**
21. Öğrencilerin matematiksel problem çözme becerilerini geliştirmeye yardımcı olmak için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
22. Sembolik, sayısal ve grafiksel veri bağlantılarını kurduran matematik problemlerini göstermek için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
23. Öğrenme nesneleri (animasyonlar, simülasyonlar, çevrimiçi uygulamalar) aracılığıyla matematiksel modelleri veya kavramları göstermek için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
24. Olası durumları tahmin etmek amacıyla eğilimleri ve modelleri belirlemek için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
25. Matematiksel içeriği farklı yollarla keşfetmek veya sunmak için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
26. Bilinçli karar verebilme amacıyla veri toplamak, analiz etmek ve yorumlamak için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
27. Özgün etkinlikleri matematik öğrenimine dâhil etmek için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
28. Matematik dersinde anlamlı öğrenci iletişimini teşvik etmek (örn: birden fazla yöntemle problem çözme üzerine sınıf tartışması) için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
29. Matematik çalışmalarını diğer temel öğrenme alanlarının (İngilizce, Sanat, Fen, Tarih) içeriğine entegre etmek için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**
30. Öğrencilerin matematiksel araştırmalarını dijital araçlar (örn: ses/video kayıtları, ölçüm araçları vb.) ile desteklemek için teknoloji kullanabilirim.	**1**	**2**	**3**	**4**	**5**

BÖLÜM 3

TEKNOLOJİYİ ENTEGRE ETME ÖZ- YETERLİLİK ÖLÇEĞİ

Aşağıdaki ifadelerden size uygun olanı işaretleyiniz.

Kesinlikle Katılmıyorum	**Katılmıyorum**	**Kararsızım**	**Katılıyorum**	**Kesinlikle Katılıyorum**
1	**2**	**3**	**4**	**5**

	Kesinlikle katılmıyorum	**Katılmıyorum**	**Kararsızım**	**Katılıyorum**	**Kesinlikle Katılıyorum**
1. Sınıfımdaki teknoloji araçlarının kapasitelerini en üst düzeye çıkarmak için bu araçları yeterince iyi anlayabilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
2. Teknolojiyi öğretim amacı ile kullanabilmek için gerekli olan becerilere sahip olma konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
3. İlgili ders içeriğini uygun teknolojiyi kullanarak başarılı bir şekilde öğretebilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
4. Öğretme ve öğrenme için yazılımları değerlendirme yeteneğim konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
5. Öğrencilerin teknoloji kullanımını yönetirken doğru teknoloji terminolojisini kullanabilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
6. Teknoloji araçları ile ilgili zorlandıklarında öğrencilerime yardım edebilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
7. Sınıfımda proje geliştirebilmeleri için öğrencilerin teknoloji araçlarını kullanımını etkili bir biçimde izleyebilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
8. Öğrencilerimin teknoloji tabanlı projelere katılmalarını motive edebilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
9. Uygun teknoloji kullanımında öğrencilerime danışmanlık yapabilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
10. Eğitim teknolojilerini sürekli bir şekilde, etkili yollarla kullanabilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
11. Öğrencilerin teknoloji kullanımları sırasında onlara bireysel geri bildirim sağlayabilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**

	Kesinlikle katılmıyorum	**Katılmıyorum**	**Kararsızım**	**Katılıyorum**	**Kesinlikle Katılıyorum**
12. Öğrencilerin öğrenmesine uygun olduğunda, teknolojiyi düzenli olarak derslerime dâhil edebilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
13. Müfredattaki öğrenme hedefleri için öğretime uygun teknolojiyi seçebilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
14. Teknoloji tabanlı projeler verebilme ve bu projeleri notlandırma konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
15. Öğrencilerin öğrenme süreçlerini değerlendirmede ideal bir yol seçerken müfredat öğrenme hedeflerini ve teknoloji kullanımını dikkate alma konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
16. Öğretimi geliştirmek için öğrenci sınavlarını ve ürünlerini derlemekte ve analiz etmekte teknoloji kaynaklarını (elektronik tablo, elektronik belgeler vb.) kullanabilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
17. Öğretmenliğimde teknolojiyi kullanırken rahat olabilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
18. Teknoloji araçlarının kullanımı sırasında öğrencilerin ihtiyaçlarına cevap verebilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
19. Zaman geçtikçe, öğrencilerimin teknoloji ihtiyaçlarına hitap edebilme yeteneğimin gelişmeye devam edeceği konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
20. Sistem kısıtlamaları (örn: teknoloji olanakları üzerine bütçe kesintileri) ile başa çıkmak için yaratıcı yollar geliştirebilme ve teknolojiyle etkili bir şekilde öğretmeye devam edebilme konusunda kendime güvenirim.	**1**	**2**	**3**	**4**	**5**
21. Teknoloji tabanlı projeler yürütebilme konusunda şüpheci meslektaşlarım tarafından karşı çıkılsam bile kendime güvenirim.	**1**	**2**	**3**	**4**	**5**

APPENDIX B:ROTATED COMPONENT MATRIX FROM FACTOR ANAYSIS

Rotated Component Matrix[a]

	Component		
	1	2	3
TCK3	,839		
TCK2	,794		,309
TCK1	,771		
TCK4	,769		,300
TCK6	,630	,325	,485
TPK2	,622	,472	
TPK1	,616	,544	
TCK5	,603		,462
TCK9	,587		,484
TPCK3	,549	,537	,420
TPCK7		,748	
TPCK8		,732	,458
TPK9		,706	,440
TPCK9		,694	,324
TPCK6	,486	,685	
TPCK1	,338	,677	
TCK10	,473	,588	
TPCK5	,502	,583	,389
TPK10		,568	,454
TPK4	,449	,456	,387
TPK6			,790
TPK7		,320	,721
TPK8		,526	,658
TCK7	,493		,643
TPK5		,371	,609
TPCK4	,428	,417	,606
TCK8	,469	,362	,583
TPCK2	,499	,439	,506
TPCK10	,441	,438	,502
TPK3	,333		,462

REFERENCES

Abbitt, J. T., 2011, "An Investigation of the Relationship between Self-Efficacy Beliefs about Technology Integration and Technological Pedagogical Content Knowledge (TPACK) among Pre-service Teachers", *Journal of Digital Learning in Teacher Education*, Vol. 27, No. 4, pp. 134-143.

Akarasriworn, C., and H.Y., Ku, 2010, "Mathematics Faculty Members' Roles, Skills, and Teaching Experiences in a Hybrid Environment", In D. Gibson, & B. Dodge (Eds.), *Proceedings of Society for information technology & teacher education International conference 2010*, pp. 258–263, Chesapeake, VA: AACE.

Akbaşlı, S., S. M., Taşkaya, A., Meydan and M., Şahin, 2012, "Teachers and Computer Technology: Supervisiors' Views", *International Journal of Research in Social Sciences*, Vol. 2, No. 2, pp. 113-124.

Akkaya, E., 2009, *Matematik Öğretmen Adaylarının Türev Kavramına İlişkin Teknolojik Pedagojik Alan Bilgilerinin Öğrenci Zorlukları Bağlamında İncelenmesi*, M.S. Thesis, Marmara University, 2009.

Akkoç, H., 2008, "Pre-service Mathematics Teachers' Concept Images of Radian", *International Journal of Mathematical Education in Science and Technology*, Vol. 39, No. 7, pp. 857-878.

Akkoç, H., M.F., Özmantar, E., Bingölbalı, S., Baştürk and İ. Yavuz , 2011, " Matematik Öğretmen Adaylarına Teknolojiye Yönelik Pedagojik Alan Bilgisi Kazandırma Amaçlı Program Geliştirme ", *TÜBİTAK Sosyal ve Beşeri Bilimler Grubu (SOBAG)*, Proje No: 107K531, İstanbul.

Akkoyunlu, B. and F. Orhan, 2003, "Bilgisayar ve Öğretim Teknolojileri Eğitimi (BÖTE) Bölümü Öğrencilerinin Bilgisayar Kullanma Öz Yeterlik İnancı ile Demografik Özellikleri Arasındaki İlişki", *The Turkish Online Journal of Educational Technology (TOJET)*, Vol. 2, No. 3, pp. 86-93.

Akkoyunlu, B., A., Altun and M. Y., Soylu, 2008, *Öğretim Tasarımı [Instructional Design]*, Maya Akademi, Ankara.

Albion, P. R., 2001, "Some Factors in the Development of Self-Efficacy Beliefs for Computer Use among Teacher Education Students", *Journal of Technology and Teacher Education*, Vol. 9, No. 3, pp. 321-347.

Albion, P. R., R., Jamieson-Proctor and G. , Finger, 2010, "Auditing the TPACK Confidence of Australian Pre-Service Teachers: The TPACK Confidence Survey (TCS)", In C. Maddux, D. Gibson and B. Dodge (Eds.), *Research Highlights in Technology and Teacher Education 2010*, pp. 303-312, Chesapeake, VA: Society for Information Technology in Teacher Education.

Alkan, C., 2005, *Eğitim Teknolojisi*, Anı Yayınevi, Ankara.

Altan, T., and H. Tüzün, 2011, "Teknoloji-Zengin Bireysel Öğrenme Ortamlarının FATIH Projesindeki Yeri (Contextualizing technology-rich learning environments in Fatih project", Akademik Bilişim '11 Bildirimler Kitabı, Malatya.

Altun, M., 2011, *Eğitim Fakülteleri ve Sinif Öğretmenleri için Matematik Öğretimi*, Aktüel Alfa Akademi, Bursa.

An, Y.J., and C.M., Reigeluth, 2011, Creating Technology-Enhanced, Learner Centered Classrooms: K-12 Teacher Beliefs, Perceptions, Barriers, and Support Needs. , *Journal of Digital Learning in Teacher Education*, Vol. 28, No. 2, pp. 54-62.

Anadolu Ajansı, 2013, "Türkiye Sosyal Medya Kullanımında Kaçıncı?", http://www.aktuel.com.tr/medya/2013/11/08/turkiye-sosyal-medya-kullaniminda-kacinci, [Accessed August 2014].

Angeli, C., and N. Valanides, 2005, "Pre-service Elementary Teachers as Information and Communication Technology Designers: An Instructional Systems Design Model Based on An Expanded View of Pedagogical Content Knowledge", *Journal of Computer Assisted Learning*, Vol. 21, No. 4, pp. 292–302.

Archambault, L**.,** and J.H., Barnett, 2010, "Revisiting Technological Pedagogical Content Knowledge: Exploring the TPACK Framework", *Computers & Education,* Vol. 55, No. 4, pp. 1656-1662.

Archambault, L., and K., Crippen, 2009, "Examining TPACK among K-12 Online Distance Educators in the United States", *Contemporary Issues in Technology and Teacher Education,*

Vol. 9, No. 1, pp. 71-88, http://www.citejournal.org/vol9/iss1/general/article2.cfm.

Ashton, P. T., and R. B., Webb, 1986, *Making a difference: Teachers' Sense of Efficacy and Student Achievement*, New York, NY: Longman.

Baki, A., 2001, "Bilişim Teknolojisi Işığı Altında Matematik Eğitiminin Değerlendirilmesi", *Milli Eğitim Dergisi, 149*, pp. 26-31.

Baki, A., and O., Birgin, 2002, "Matematik Eğitiminde Alternative Bir Değerlendirme Olarak Bireysel Gelişim Dosyası Uygulaması", 5.Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, 16-18 Eylül 2002, ODTU Kültür ve Kongre Merkezi, Ankara.

Ball, D. L., 1990a, "Prospective Elementary and Secondary Teachers' Understanding of Division", *Journal for Research in Mathematics Education*, Vol. 21, No. 2, pp. 132-144.

Ball, D. L., 1990b, "The Mathematical Understandings That Prospective Teachers Bring to Teacher Education", *The Elementary School Journal,* Vol. 90, No. 4, pp. 449-466.

Ball, D. L., 2000, "Bridging Practices: Intertwining Content and Pedagogy in Teaching and Learning to Teach", *Journal of Teacher Education,* Vol.51, No. 3, pp. 241-247.

Ball, D. L., and G. W. , McDiarmid, 1990, "The Subject Matter Preparation of Teachers", In R. Houston (Ed.), *Handbook of research on teacher education,* pp. 437-449, Macmillan, New York.

Ball, D. L., M.H., Thames, and G., Phelps, 2008, "Content Knowledge for Teaching, What Makes It Special?" *Journal of Teacher Education,* Vol. 59, No. 5, pp. 389-407.

Bandura, A., 1986, *Social foundations of thought and action: A social cognitive theory,* Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A., 1977, "Self-Efficacy: Toward a Unifying Theory of Behavioral Change", *Psychological Review,* Vol. 84, No. 2, pp. 191-215.

Bandura, A., 1994, "Regulative Function of Perceived Self-Efficacy", In M. G. Rumsey, C. B. Walker, and J. H. Harris (Eds.), *Personal selection and classification,* pp. 261-271, Hillsdale, Erlbaum, NJ.

Bandura, A., 1997, *Self-efficacy: The Exercise of Control*., New York, NY: W. H. Freeman.

Bebell, D., M., Russell, and L., O'Dwyer, 2004, "Measuring Teachers' Technology Uses: Why Multiple-Measures Are More Revealing", *Journal of Research on Technology in Education*, Vol. 37, No. 1, pp. 45-63.

Bebell, D. , and R. E. Kay, 2010, " One to One Computing: A Summary of the Quantitative Results from the Berkshire Wireless Learning Initiative", *Journal of Technology, Learning, and Assessment,* Vol. 9, No. 2.

Becker, H. J., 1994, "How Exemplary Computer-Using Teachers Differ From Other Teachers: Implications for Realizing the Potential of Computers in Schools", *Journal of Research on Computing in Education,* Vol. 26, No. 3, pp. 291-321.

Becker, H. J., 2000, "Findings from the Teaching, Learning, and Computing Survey: Is Larry Cuban right?" *Education Policy Analysis Archives,* Vol. 8, No. 51, pp. 1-31.

Bingimlas, K.A., 2009, "Barriers to the Successful Integration of ICT in Teaching and Learning Environments: A Review of Literature", *Eurasia Journal of Mathematics, Science and Technology Education*, Vol. 5, No. 3, pp. 235-245.

Bitner, J., and N., Bitner, 2002, " Integrating Technology into the Classroom: Eight Keys to Success", *Journal of Technology and Teacher Education, 10*, pp. 95-100.

Bloom, B. S., 1956, *Taxonomy of Educational Objectives*, Handbook I: The Cognitive Domain, New York: David McKay Co Inc.

Borko, H., M., Eisenhart, C.A., Brown, R. G., Underhill, Jones, D., and P.C., Agard, 1992, "Learning to Teach Hard Mathematics: Do Novice Teachers and Their Instructors Give up Too Easily?", *Journal for Research in Mathematics Education,* Vol. 23, No. 3, pp. 194-222.

Brouwers A. and W., Tomic, 2003, "A Test of the Factorial Validity of the Teacher Efficacy Scale", *Research in Education, 69,* pp. 67-79.

Brown, D., and M., Warschauer, 2006, "From the University to the Elementary Classroom: Students' Experiences in Learning to Integrate Technology in Instruction", *Journal of Technology and Teacher Education, 14*, pp. 599–621.

Bunch, J. C., J. H., Whisenhunt, J. S., Robinson, and M. C. Edwards, 2012b, "Oklahoma Teachers' Use of Interactive Whiteboards (IWBs) in the Secondary Agricultural Education Classroom: Measures of Teacher Innovativeness", *Proceedings of the 2012 Southern Region AAAE Conference,* Birmingham, AL.

Cassidy, S., and P., Eachus, 2002, "Developing the Computer User Self-Efficacy (CUSE) Scale: Investigating the Relationship between Computer Self-Efficacy, Gender and Experience with Computers", *Journal of Educational Computing Research,* Vol. 26, No. 2, pp. 133-153.

Chai, C. S., J. H. L., Koh, and C.-C.,Tsai, 2011,"Exploring the Factor Structure of the Constructs of Ttechnological, Pedagogical, Content Knowledge (TPACK)", *The Asia-Pacific Education Researcher,* Vol. 20, No. 3, pp. 607-615.

Chen, C. H., 2008, "Why Do Teachers Not Practice What They Believe Regarding Technology Integration? ", *Journal of Educational Research,* Vol. 102, No. 1, pp. 65-75.

Chrysanthou, I., 2008, *The Use of ICT in Primary Mathematics in Cyprus: The Case of GeoGebra* , M.S., University of Cambridge, UK.

Compeau, D. and C. Higgins, 1995, "Computer Self-Efficacy: Development of a Measure and Initial Test", *MIS Quarterly, June,* pp. 189-211.

Cohen, J., 1988, *Statistical Power Analysis for the Behavioral Sciences (2nd ed.),* New Jersey: Lawrence Erlbaum.

Corlu, M. S., 2014, "FeTeMM Eğitimi Araştırmaları: Alanda Merak Edilenler, Fırsatlar ve Beklentiler [STEM education research: Latest trends, opportunities, and expectations]" *Turkish Journal of Educational Research,* Vol. 3, No. 1, pp. 4-10.

Cox, S., 2008, *A Conceptual Analysis of Technological Pedagogical Content Knowledge,* Ph.D. Thesis, Brigham Young University, 2008.

Cox, S., C.R., Graham, J., Browne, and R. Sudweeks, (in review). *How Do We Measure TPACK? An Attempt to Create and Validate an Instrument,* manuscript submitted for publication.

Creswell, J. W., 2012, *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*, 4th ed. Boston: Pearson.

Cronbach, L. J., 1951, Coefficient Alpha and the Internal Structure of Tests, *Psychometrika,* Vol. 16, No. 3, pp. 297-334.

Cüre, F., and N. Özdener, 2008, "Teachers' Information and Communication Technologies (ICT) Using Achievement and Attitudes towards ICT*", Hacettepe University Journal of Education*, 34, pp. 41-53.

Çiftçi, S., S.M, Taşkaya, and M., Alemdar, 2013, "The Opinions of Classroom Teachers about Fatih Project", *Elementary Education Online*, Vol. 12, No. 1, pp. 227-240.

Dakers, J. R., W., Dow, and L., McNamee, 2009, "De-Constructing Technology's Masculinity. Discovering a Missing Pedagogy in Technology Education", *International Journal of Technology & Design Education, 19*, pp. 381-391.

Deemer, S.A., and K.M, Minke, 1999, "An Investigation of the Factor Structure of the Teacher Efficacy Scale", *Journal of Educational Research*, 93.

Dilworth, P., A., Donaldson, M., George, D., Knezek, Searson, M., Starkweather and S., Robinson, 2012, Editorial: "Preparing Teachers for Tomorrow's Technologies", *Contemporary Issues in Technology & Teacher Education*, Vol. 12, No. 1, pp. 1-5, http://www.citejournal.org/vol12/iss1/editorial/article1.cfm.

Dockstader, J., 1999, "Teachers of the 21st Century Know the What, Why, and How of Technology Integration" *THE Journal (Technological Horizons in Education), 26*.

Earle, R.S., 2002, "The Integration of Instructional Technology into Public Education: Promises and Challenges", *ET Magazine*, Vol. 42, No.1, pp. 5-13.

Ebmeier, H., 2003, "How Supervision Influences Teacher Efficacy and Commitment: An Investigation of a Path Model", *Journal of Curriculum and Supervision*, Vol. 18, No. 2, pp. 110-141.

Education Reform Initiative (ERI), 2014, Eğitim İzleme Raporu 2014 [Education Monitoring Report 2014], Istanbul:

ERI,http://erg.sabanciuniv.edu/sites/erg.sabanciuniv.edu/files/ERG-ERI2014-egitim-izleme-raporu-2014-pdf, [Accessed April 2014].

EGİTEK, 2011, Egitim *Teknolojileri Genel Müdürlügü Elektronik Dergisi,* http://egitek.meb.gov.tr/elektronikdergi.

Enochs, L. G., I. M., Riggs, and J.D., Ellis, 1993, "The Development and Partial Validation of Microcomputer Utilization in Teaching Efficacy Beliefs Instrument in A Science Setting", *School Science and Mathematics,* Vol. 93, No. 5, pp. 257-263.,

Ertmer, P. A., 1999, "Adressing First- and Second- Order Barriers to Change: Strategies for Technology Integration", *ETR&D,* Vol. 47, No. 4, pp. 47-61.

Ertmer, P. A., 2005, "Teacher Pedagogical Beliefs: The Final Frontier in Our Quest for Technology Integration?", *Educational Technology Research and Development,* Vol. 53, No. 4, pp. 25-39.

Ertmer, P. A., and A.T., Ottenbreit-Leftwich, 2010, "Teacher Technology Change: How Knowledge, Beliefs, and Culture Intersect", *Journal of Research on Technology in Education,* 42, pp. 255–284.

Evers, W., A., Brouwers, and W. Tomic, 2002, "Burnout and Self-Efficacy: A Study on Teachers' Beliefs When Implementing An Innovative Educational System in the Netherlands", *British Journal of Educational Psychology, 72,* pp. 227-243.

Fennema, E., and M.L., Franke, 1992, "Teachers' Knowledge and Its Impact", In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning,* pp. 147-167, NewYork: Macmillan.

Fives, H., and M.M., Buehl, 2008, "What Do Teachers Believe? Developing a Framework for Examining Beliefs about Teachers' Knowledge and Ability", *Contemporary Educational Psychology, 33,* pp. 134-176.

Forssell, K.S.**,** 2009, "The Roles of Expertise and Experience on Teachers' Technology Use in the Classroom", In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2009,* pp. 4074-4080, Chesapeake, VA: AACE.

Fraenkel, J. R., and N.E., Wallen, 2006, *How to Design and Evaluate Research in Education,* New York: McGraw Hill.

Franklin, C., 2004, "Teacher Preparation as a Critical Factor in Elementary Teachers: Use of Computers", In R. Ferdig et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2004,* pp. 4994-4999, Chesapeake, VA: AACE.

Fullan, M., 2001, Leading *in A Culture of Change,* San Francisco, CA: Jossey-Bass.

Garfield, J., and M., Everson, 2009, "Preparing Teachers of Statistics: A Graduate Course for Future Teachers", *Journal of Statistics Education*, Vol. 17, No. 2.

Gibbs, C., 2002, "Effective Teaching: Exercising Self-Efficacy and Thought Control of Action*", Annual Conference of the British Educational Research* Association, University of Exeter, England.

Gibson, S., and M.H., Dembo, 1984, "Teacher Efficacy: A Construct Validation", *Journal of Educational Psychology, 76*, pp. 569-582.

Gökçek, T., G., Güneş, and E., Gençtürk, 2013, "Evaluation of Primary School Teachers' Technological Self-Efficacy", *International Online Journal of Educational Sciences*, Vol. 5, No. 1, pp. 42-51.

Graham, C. R., Burgoyne, N., Cantrell, P., Smith, L., Clair, L. S., and R. Harris, R 2009, *TPACK Development in Science Teaching: Measuring the TPACK.*

Graham, R. C., N., Burgoyne, P., Cantrell, L., Smith, L., St. Clair, and R. Harris, 2009, "Measuring the TPCK Confidence of In-service Science Teachers", *Tech Trends,* Vol. 53, No. 5, pp. 70-79.

Grandgenett, N.F., 2008, "Perhaps a Matter of Imagination: TPCK in Mathematics Education", In AACTE Committee on Innovation and Technology (Ed.), *The Handbook*

of Technological Pedagogical Content Knowledge (TPCK) for Educators, New York: American Association of Colleges of Teacher Education and Routledge.

Grossman, P. and A., Richert, 1988, "Unacknowledged Knowledge Growth: A Re-Examination of the Effects of Teacher Education", *Teaching & Teacher Education*, Vol. 4, No. 1, pp. 53-62.

Grossman, P., 1989, "Learning to Teach without Teacher Education", *Teachers College Record*, 91, pp.191-207.

Grossman, P. L., 1990, *the Making of a Teacher: Teacher Knowledge & Teacher Education*, New York: Teachers College Press.

Gunter, G. and D., Baumbach, 2004, Curriculum Integration in A. Kovalchick and K.Dawson (eds.), *Education and Technology: An Encyclopedia*, pp. 193-194, Santa Barbara, CA: ABC-CLIO.

Güven, İ., 2012, "The 4+4+4 School Reform Bill and the Fatih Project: Is it a Reform?", *Elementary Education Online*, Vol. 11, No. 3, pp. 556-577.

Hackett, G., 1985, "Role of Mathematics Self-Efficacy in the Choice of Math-Related Majors of College Women and Men: A Path Analysis*", Journal of Counseling Psychology*, Vol. 32, No. 1, pp. 47–56.

Hackett, G., and N. E. Betz, 1989, "An Exploration of the Mathematics Self-Efficacy/Mathematics Performance Correspondence", *Journal for Research in Mathematics Education*, 20, pp. 261–273.

Handal, B., C., Campbell, M., Cavanagh, P., Petocz, and N., Kelly, 2012, "Integrating Technology, Pedagogy and Content in Mathematics Education", *Journal of Computers in Mathematics and Science Teaching*, Vol. 31, No. 4, pp. 387-413.

Handal, B., C., Campbell, M., Cavanagh, P., Petocz, and N. Kelly, 2013, "Technological Pedagogical Content Knowledge (TPACK) of Secondary Mathematics Teachers", *Contemporary Issues in Technology and Teacher Education*, Vol. 13, No. 1.

Hardy, G., 2012, “Interdisciplinary Inquiry: Bridging the Conceptual Worlds of Science and Mathematics”, In *American Education Research Association Conference*. Vancouver, Canada.

Harris, J.B., P., Mishra, and M.J. Koehler, 2007, “Teachers’ Technological Pedagogical Content Knowledge: Curriculum-Based Technology Integration Reframed”, *2007 Conference of the American Educational Research Association.*

Harris, J., P., Mishra, and M. Koehler, 2009, “Teachers' Technological Pedagogical Content Knowledge and Learning Activity Types: Curriculum-based Technology Integration Reframed”, *Journal of Research on Technology in Education,* Vol. 41, No. 4, pp. 393-416.

Harrison, A. W., R. K., Rainer, Jr., W. A., Hochwarter, and K. R. Thompson, 1997, “Testing the Self-Efficacy-Performance Linkage of Social-Cognitive Theory”, *Journal of Social Psychology,* Vol. 137, No. 1, pp. 79-87.

Henson, R., 2002, “From Adolescent Angst to Adulthood: Substantive Implications and Measurement Dilemmas in the Development of Teacher Efficacy Research”, *Educational Psychologist,* Vol. 37, No. 3, pp. 137-150.

Hill, H. C., D. L., Ball, and S. G. Schilling, 2008, “Unpacking Pedagogical Content Knowledge: Conceptualizing and Measuring Teachers' Topic-Specific Knowledge of Students”, *Journal for Research in Mathematics Education,* Vol. 39, No. 4, pp. 372-400.

Hill, T., N. D., Smith, and M. F. Mann, 1987, “Role of Efficacy Expectations in Predicting the Decision to Use Advanced Technologies: The Case of Computer”, *Journal of Applied Psychology,* Vol. 72, No. 2, pp. 307-313.

Hohlfeld, T. N., A. D., Ritzhaupt, A. E., Barron, and K. Kemker, 2008, “Examining the Digital Divide in K-12 Public Schools: Four-Year Trends for Supporting ICT Literacy in Florida”, *Computers & Education,* Vol. 51, No. 4, pp. 1648-1663.

Hughes, J.E., 2003, "Toward a Model of Teachers' Technology-Learning", *Action in teacher education,* Vol. 24, No. 4, pp. 10-17.

İşman, A., 2002, "Sakarya Öğretmenlerin Eğitim Teknolojileri Yönünden Yeterlilikleri", *The Turkish Online Journal of Educational Technology,* Vol. 1, No. 1, pp. 72-91.

Jiang, N., 2007, "Selective Integration of Linguistic Knowledge in Adult Second Language Learning", *Language Learning,* 57, pp. 1–33.

Jimoyiannisa, A., and V. Komisb, 2007, "Examining Teachers' Beliefs about ICT in Education: Implications of a Teacher Preparation Programme", *Teacher Development,* Vol.11, No.2, pp. 149-173, http://www.scribd.com/doc/15081673/Examining-Teachers-Beliefs-About-ICT-in-Education.

Karadeniz, Ş., and S. Vatanartıran, 2013, "Adaptation of a TPACK Survey to Turkish for Secondary School Teachers", *International Journal of Human Sciences,* Vol. 10, No. 2, pp. 34-47, http://www.j-humansciences.com/ojs/index.php/IJHS/article/view/2636.

Karatas, F.I., 2014, "A Model for the Relationship of Elementary Teachers' Technological Self-efficacy and Student Achievement.", *Proceedings of Society for Information Technology & Teacher Education International Conference 2014.*

Kayaduman H, M., Sırakaya , S., Seferoğlu, 2011, "Eğitimde FATIH Projesinin Öğretmenlerin Yeterlik Durumları Açısından Incelenmesi", *Akademik Bilişim Konferansı,* Malatya: İnönü Üniversitesi, http:// www.ab.org.tr/ab11/bildiri/136.doc.

Kellenberger, D. and S., Hendricks, 2003, *Predicting Teachers' Computer Use for Own Needs, Teaching, and Student Learning.*

Koehler, M.J. and P., Mishra, 2005, "What Happens When Teachers Design Educational Technology? The Development of Technological Pedagogical Content Knowledge", *Journal of Educational Computing Research,* Vol. 32, No. 2, pp. 131-152.

Koehler, M.J. and P., Mishra, 2005a, "Teachers Learning Technology by Design", *Journal of Computing in Teacher Education,* Vol. 21, No. 3, pp. 94-102.

Koehler, M.J. and P. Mishra, 2005b, "What Happens When Teachers Design Educational Technology? The Development of Technological Pedagogical Content Knowledge", *Educational Computing Research,* Vol. 32, No. 2, pp. 131-152.

Koehler, M. J., and P., Mishra, 2008, "Introducing TPACK", In AACTE Committee on Innovation and Technology, *Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators*, pp. 3-29, New York: Routledge for the American Association of Colleges for Teacher Education.

Koehler, M. J., and P. Mishra, 2009, "What is Technological Pedagogical Content Knowledge?", *Contemporary Issues in Technology and Teacher Education,* Vol. 9, No. 1, pp. 60-70.

Koehler, M.J., P., Mishra, K., Hershey, and L. Peruski, 2004, "With a Little Help from Your Students: A New Model for Faculty Development and Online Course Design", *Journal of Technology and Teacher Education,* Vol. 12, No. 1, pp. 25-55.

Koehler, M.J., P. Mishra, and K. Yahya, 2007, "Tracing the Development of Teacher Knowledge in a Design Seminar: Integrating Content, Pedagogy and Technology", *Computers & Education 49*, pp. 740-762.

Koh, J., C., Chai, and C. Tsai, 2010, "Examining the Technological Pedagogical Content Knowledge of Singapore Pre-service Teachers with a Large-Scale".

Korobili, S., A., Togiaa, and A., Malliari, 2010, "Computer Anxiety and Attitudes among Undergraduate Students in Greece", *Computers in Human Behavior,* Vol. 26, No. 3, pp. 399-405.

König, J., S., Blömeke, L., Paine, W. H., Schmidt, and F.-J. Hsieh, 2011, "General Pedagogical Knowledge of Future Middle School Teachers: On the Complex Ecology of Teacher Education in the United States, Germany, and Taiwan", *Journal of Teacher Education,* Vol. 62, No. 2, pp. 188-201.

Kukafka, R., S.B., Johnson, A. Linfante, and J.P. Allegrante, 2003, "Grounding a New

Information Technology Implementation Framework in Behavioral Science: A Systematic Analysis of the Literature on IT Use", *Journal of Biomedical Informatics,* Vol. 36, No. 3, pp. 218-227.

Kutluca, T., and G., Ekici, 2010, "Öğretmen Adaylarının Bilgisayar Destekli Eğitime İlişkin Tutum ve Öz-Yeterlik Algılarının İncelenmesi", *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 38, pp. 170-188.

Lee, C. and C., Chai, 2008, "Your Students Metacognition Through Cognitive Simulations", *Engaging and Managing Learners: Practitioners' Perspectives*, Pearson 9810680384.

Lee, E., 2005, *Conceptualizing Pedagogical Content Knowledge from the Perspective of Experienced Secondary Science Teacher*, PhD Thesis, University of Texas.

Lee, H., and K., Hollebrands, 2008, "Preparing to Teach Mathematics with Technology: An Integrated Approach to Developing Technological Pedagogical Content Knowledge", *Contemporary Issues in Technology and Teacher Education,* Vol. 8, No. 4, pp. 326-341.

Lee, M.H. and C.C. Tsai, 2010, "Exploring Teachers' Perceived Self Efficacy and Technological Pedagogical Content Knowledge with Respect to Educational Use of the World Wide Web" *Instructional Science: An International Journal of the Learning Sciences,* Vol. 38, No. 1, pp. 1-21.

Lee, C. B., C. S., Chai, T., Teo, and D. Chen, 2008, "Preparing Pre-service Teachers' for the Integration of ICT Based Student Centered Learning (SCL) Curriculum", *Journal of Education, 13,* pp. 15-28.

Lei, J., 2009, "Digital Natives as Pre-service Teachers: "What Technology Preparation Is Needed?" *Journal of Computing in Teacher Education*, Vol. 25, No. 3, pp. 87−97.

Littrell, A., M., Zagumny, and L. Zagumny, 2005, "Contextual and Psychological Predictors of Instructional Technology Use in Rural Classrooms", *Educational Research Quarterly,* Vol. 29, No. 2, pp. 37-47.

Lumpe, A. T. and E. Chambers, 2001, "Assessing Teachers' Context Beliefs about Technology Use", *Journal of Research on Technology in Education,* Vol. 34, No. 1, pp. 93-107.

Marcinkiewicz, H. R., 1994, "Computers and Teachers: Factors Influencing Computer Use in the Classroom", *Journal of Research on Computing in Education,* Vol. 26, No. 2, pp. 220- 237.

Margerum-Leys, J., and R. W. Marx, 2003, "Teacher Knowledge of Educational Technology: A Case Study of Student/Mentor Teacher Pairs", In Y. Zhao (Ed.), What Should Teachers Know About Technology? Perspectives and Practices, pp. 123–159, Greenwich, CO: Information Age Publishing.

Margerum-Leys, J., and R. W. Marx, 2004, "The Nature and Sharing of Teacher Knowledge of Technology in A Student Teacher/Mentor Teacher Pair", *Journal of Teacher Education*, Vol. 55, No. 5, pp. 421–437.

McCaughtry, N., 2005, "Elaborating Pedagogical Content Knowledge; What It Means to Know Students and Think About Teaching", *Teachers and Teaching: Theory into Practice,* Vol. 11, No. 4, pp. 379-395.

McGrail, E., 2005, "Teachers, Technology, and Change: English Teachers' Perspectives", *Journal of Technology Education,* Vol. 13, No. 1, pp. 5-24.

Menzi, N., E., Çalişkan, and O., Çetin, 2012, "Öğretmen Adaylarının Teknoloji Yeterliliklerinin Çeşitli Değişkenler Açısından İncelenmesi", *Anadolu Journal of Educational Sciences International (AJESI),* Vol. 2, No. 1, pp. 1-18.

Ministry of National Education [MoNE], 2010, *Eğitimde FATİH Projesi*, http://fatihprojesi.meb.gov.tr/tr/index.php, [Accessed March 2013].

MoNE, 2008, *Öğretmen Yeterlilikleri Öğretmenlik Mesleği Genel ve Özel Alan Yeterlilikleri*, Ankara: the Ministry of National Education.

Milli Eğitim Bakanlığı Talim ve Terbiye Kurulu Başkanlığı, 2009, "Lise Matematik Dersi 9-12. Sınıflar Öğretim Programı ve Kılavuzu", Ankara.

Milli Eğitim Bakanlığı Talim ve Terbiye Kurulu Başkanlığı, 2013, "Ortaöğretim Matematik Dersi (9-12. sınıflar) Öğretim Programı", Ankara.

Mishne, J., 2012, *An Investigation of the Relationships between Technology Use and Teachers' Self-Efficacy, Knowledge and Experience*, PhD Thesis, Pepperdine University.

Mishra, P., and M.J., Koehler, 2005, "Educational Technology by Design: Results from A Survey Assessing Its Effectiveness", In C. Crawford, et al (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2005*, Chesapeake, VA: AACE.

Mishra, P., and M.J., Koehler, 2006, "Technological Pedagogical Content Knowledge: A Framework for Integrating Technology in Teacher Knowledge", *Teachers College Record*, Vol. 108, No. 6, pp. 1017-1054.

Mishra, P., and M.J., Koehler, 2007, "Technological Pedagogical Content Knowledge (TPCK): Confronting the Wicked Problems of Teaching with Technology", In C. Crawford, et al (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2007*. Chesapeake, VA: AACE.

Mishra, P., M.J., Koehler, and Y., Zhao, 2007, "Communities of Designers: A Brief History and Introduction", In P. Mishra, M.J. Koehler, & Y. Zhao (Eds.), *Faculty development by design: Integrating technology in higher education*, Charlotte, NC: Information Age Publishing.

Morine-Dershimer, G., and T., Kent, 1999, "The Complex Nature and Sources of Teachers' Pedagogical Knowledge", In J. Gess-Newsome, and N. G. Lederman, *Examining pedagogical content knowledge: the construct and its implications for science education,* pp. 21-50, Dordrecht ; Boston: Kluwer Academic Publisher.

Nathan, E. J., 2009, *An Examination of the Relationship between Pre-service Teachers' Level of Technology Integration Self Efficacy (TISE) and Technological Pedagogical Content Knowledge (TPACK),* PhD Thesis, University of Houston.

North, A. S., and J. M., Noyes, 2002, "Gender Influences on Children's Computer Attitudes and Cognitions", *Computers in Human Behaviour, 18,* pp. 135-150.

National Council of Teachers of Mathematics, 2008, *The Role of Technology in the Teaching and Learning of Mathematics*, http://www.nctm.org/about/content.aspx?id=14233, accessed at December 2013.

National Council of Teachers of Mathematics (NCTM), 2000, *The Technology Principle*, http://standards.nctm.org/document/chapter2/techn.htm, [Accessed June 2014].

Niess, M.L., 2005, "Preparing Teachers to Teach Science and Mathematics with Technology: Developing a Technology Pedagogical Content Knowledge", *Teaching and Teacher Education, 21,* pp. 509-523.

Niess, M. L., K., Lee, P., Sadri, and G., Suharwoto, 2006, "Guiding In-service Mathematics Teachers in Developing a Technology Pedagogical Knowledge (TPCK)", *In Society for Information Technology Teacher Education International Conference Proceedings of SITE 2006,* Orlando, Florida.

Niess, M.L., 2006, "Gues Editorial: Preparing teachers to teach mathematics with technology", *Contemporary Issues in Technology and Teacher Education,* Vol. 6, No. 2, pp. 195-203.

Pajares, M. F., 1992,"Teachers' Beliefs and Educational Research: Cleaning up a Messy Construct", *Review of Educational Research*, Vol. 62, No. 3, pp. 307–333.

Perkmen S. and E. Tezci, 2011, *Eğitimde Teknoloji Entegrasyonu: Materyal Geliştirme ve Çoklu Ortam Tasarımı,* Ankara: Pegem Akademi Yayınları.

Royer, R., 2002, "Supporting Technology Integration through Action Research", *The Clearing House*, Vol. 75, No. 5, pp. 233-237.

Sanders, J., 2006, "Gender and Technology: What the Research Tells Us?", In C. Skelton, L. Smulyan, and B. Francis, *The SAGE Handbook of Gender and Education,* pp. 307-322, London: SAGE.

Schoepp, K.W., 2004, *Technology Integration Barriers in a Technology- Rich Environment: A CBAM Perspective*, PhD Thesis, University of Calgary.

Seferoğlu, S.S., and C., Akbıyık, 2005, "İlköğretim Öğretmenlerinin Bilgisayara Yönelik Öz-Yeterlilik Algıları Üzerine Bir Çalışma", *Eğitim Araştırmaları Dergisi*, 19, pp. 89-101.

Semiz, K.and M.L., Ince, 2012, "Pre-service Physical Education Teachers' Technological Pedagogical Content Knowledge, Technology Integration Self-Efficacy and Instructional Technology Outcome Expectations", *Australasian Journal of Educational Technology*, Vol. 28, No. 6, pp. 1248-1265.

Shaughnessy, M., 2004, "An Interview with Anita Woolfolk: The Educational Psychology of Teacher Efficacy", *Educational Psychology Review*, Vol. 16, No. 2, pp. 153-176.

Smith, H., S., Higgins, K., Wall, and J. Miller, 2005, "Interactive Whiteboards: Boon or Bandwagon? A Critical Review of the Literature*", Journal of Computer Assisted Learning*, 21, pp. 91-101.

Stoilescu, D. and D., McDougall, 2009, "A Technological Pedagogical Content Knowledge Framework for Mathematics Teachers", In T. Bastiaens et al. (Eds.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2009*, pp. 722-727, Chesapeake, VA: AACE.

Şahin, I., 2011, "Development of Survey of Technological Pedagogical and Content Knowledge (TPACK)", *The Turkish Online Journal of Educational Technology (TOJET)*, Vol. 10, No. 1, pp. 97-105.

Ottenbreit-Leftwich, A.T. ,2012, "The Importance of Using Subject-Specific Technology Uses to Teach TPACK: A Case Study", In D. Polly, C. Mims, K. Perschitte (Eds.), Creating Technology-Rich Teacher Education Programs: Key Issues, pp. 152-169.

Öztürk, E, 2013, "Sınıf Öğretmeni Adayların Bazı Değişkenler Tarafından İncelenmesi", *Uşak Üniversitesi Sosyal Bilimler Dergisi*, pp. 223-238.

Öztürk, E. and M.B., Horzum, 2011, "Teknolojik Pedagojik İçerik Bilgisi Ölçeği'nin Türkçeye Uyarlaması.",*Ahi Evran Üniversitesi Eğitim Fakültesi Dergisi,* Vol. 12, No. 3, pp. 255-278.

Pajares, F., and J., Kranzler, 1995, "Self-Efficacy Beliefs and General Mental Ability in Mathematical Problem-Solving", *Contemporary Educational Psychology*, *20*, pp. 426-443.

Pajares, F., and D.M., Miller, 1994, "Role of Self-Efficacy and Self-Concept Beliefs in Mathematics Problem Solving: A Path Analysis", *Journal of Educational Psychology*, Vol. 86, No. 2, pp. 193-203.

Pajares, F., and D.M., Miller, 1995, "Mathematics Self-Efficacy and Mathematics Performances: The Need for Specificity of Assessment", *Journal of Counseling Psychology*, Vol. 42, No. 2, pp. 190-198.

Pajares, F., 1996, "Self-Efficacy Beliefs in Academic Settings", *Review of Educational Research, 66,* pp. 533-578.

Pallant, J. ,2007, *SPSS Survival Manual A Step by Step Guide to Data Analysis using SPSS for Windows third edition,* Berkshire , England: Open University Press.

Penuel, W. R., 2005, *Research: What It Says About 1 to 1 Learning?,* Cupertino, CA: Apple.

Perkmen, S., 2008, *Factors That Influence Pre-service Teachers' Technology Integration Performance,* PhD Thesis, Iowa State University.

Pierson, M. E., 2001, "Technology Integration Practice as a Function of Pedagogical Expertise", *Journal of Research on Computing in Education*, Vol. 33, No. 4, pp. 413–430.

Preiner, J., 2008, *Introducing Dynamic Mathematics Software to Mathematics Teachers: The Case of GeoGebra* , PhD Thesis , University of Salzburg.

Riggs, I. M., and L. G., Enochs, 1993, "A Microcomputer Beliefs Inventory for Middle School Students: Scale Development and Validation", *School Science and Mathematics,* Vol. 2, No. 3, pp. 383-391.

Risser, H.S., 2011, "What Are We Afraid Of? Arguments against Teaching Mathematics with Technology in the Professional Publications of Organizations for US Mathematicians", *International Journal for Technology in Mathematics Education*, Vol. 18, No. 2, pp. 97-101.

Schmidt, D. A., E., Baran, A.D., Thompson, P., Mishra, M.J., Koehler, and T.S., Shin, 2009, "Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Pre-service Teachers", *Journal of Research on Technology in Education,* Vol. 42, No. 2, pp. 123-149.

Schmidt, D. A., E., Baran, A. D., Thompson, P., Mishra, M. J., Koehler, and T. S. Shin, 2009a, "Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Pre-service Teachers", *Journal of Research on Technology in Education,* Vol. 42, No. 2, pp. 123-149.

Schmidt, D. A., E., Baran, A. D., Thompson, P., Mishra, M. J., Koehler, and T. S. Shin, 2009b, "Examining Pre-service Teachers' Development of Technological Pedagogical Content Knowledge in an Introductory Instructional Technology Course", In I. Gibson, R. Weber, K. McFerrin, and R. Carlsen (Ed.), *Proceedings of the Society for Information Technology & Teacher Education International Conference 2009*, pp. 4145-4151, Chesapeake, VA: AACE.

Shulman, L. S., 1986, "Those Who Understand: Knowledge Growth in Teaching", *Educational Researcher*, Vol. 15, No. 2, pp. 4-14.

Shulman, L. S., 1987, "Knowledge and Teaching: Foundations of the New Reform", *Harvard Educational Review*, Vol. 57, No. 1, pp. 1-22.

Tabachnick, B. G., and L. S., Fidell, 2007, *Using Multivariate Statistics.* Boston: Allyn & Bacon.

Tamir, P., 1988, "Subject Matter and Related Pedagogical Knowledge in Teacher Education", *Teaching and Teacher Education*, Vol. 4, No. 2, pp. 99-110.

Tella, A. and C. O., Ayeni, 2006, "The Impact of Self-Efficacy and Prior Computer Experience on the Creativity of New Librarians in Selected Universities Libraries in Southwest Nigeria", *Library Philosophy and Practice*, Vol. 8, No. 2, pp. 1-12.

Teo, T., 2009, "Examining the Relationship between Student Teachers' Self-Efficacy Beliefs and Their Intended Uses of Technology for Teaching: A Structural Equation Modeling Approach", *The Turkish Online Journal of Technology*, Vol. 8, No. 4, pp. 7-16.

Thompson, A. D., 2008, "Breaking News: TPCK Becomes TPACK!", *Journal of Computing in Teacher Education*, Vol. 24, No. 2, pp. 2007–2008.

Timur, B. and M.F., Taşar, 2011, "The Development of Pre-Service Science Teachers' Technological Pedagogical Content Knowledge in Force and Motion Subjects", *the European Conference on Educational Research (ECER),* Berlin, Germany.

Toker, A.,2007, "Öğretmen Yetiştirme Programının Gelecekteki Teknoloji Kullanımına Yönelik Teknoloji Eğitimi Bakımından Değerlendirilmesi", *I.Burdur Sempozyumu*, pp.1053-1057.

Uğurlu, R., 2009, *Teknolojik Pedagojik Alan Bilgisi Çerçevesinde Önerilen Eğitim Programı Sürecinde Öğretmen Adaylarının Şekillendirici Ölçme ve Değerlendirme Bilgi ve Becerilerinin Gelişiminin İncelenmesi,* M.S. Thesis, Marmara University.

Vallerand, R. J., 1989, "Toward a methodology for the Transcultural Validation of Psychological Questionnaires - Implications for Studies in the French Language", *Canadian Psychology-Psychologie Canadienne,* Vol. 30, No. 4, pp. 662-680.

Van Braak, J., 2001, "Individual Characteristics Influencing Teachers' Class Use of Computers", *Journal of Educational Computing Research*, Vol. 25, No. 2, pp. 141-157.

Van Braak, J., J., Tondeur, and M. Valcke, 2004, "Explaining Different Types of Computer Use among Primary School Teachers", *European Journal of Psychology of Education*, Vol. 19, No. 4, pp. 407-422.

Vannatta, R. A., and N., Fordham, 2004,"Teacher Dispositions as Predictors of Classroom Technology Use", *Journal of Research on Technology in Education*, Vol.36, No.3, pp. 253-271.

Wallace, R. M., 2004, "A Framework for Understanding Teaching with the Internet", *American Educational Research Journal*, Vol. 41, No. 2, pp. 447–488.

Wang, L., P. A., Ertmer, and T. J., Newby, 2004," Increasing Pre-service Teachers' Self-Efficacy Beliefs for Technology Integration", *Journal of Research on Technology in Education*, Vol. 36, No. 3, p. 231.

Weiss, I. R., E. R., Banilower, K. C., McMahon, and P.S. ,Smith, 2001, *Report of the 2000 National Survey of Science and Mathematics Education*. Chapel Hill, NC: Horizon Research, Inc.

Windschitl, M, and K., Sahl, 2002, "Tracing Teachers' Use of Technology in a Laptop Computer School: The Interplay of Teacher Beliefs, Social Dynamics, and Institutional Culture", *American Educational Research Journal,* Vol. 39, No. 1, pp. 165-205.

Wozney, L., V., Venkatesh, and P., Abrami, 2006, "Implementing Computer Technologies: Teachers' Perceptions and Practices", *Journal of Technology and Teacher Education*, Vol. 14, No. 1, pp. 173-207.

Yaghi, H. M., 2001,"Subject Matter as a Factor in Educational Computing by Teachers in International Settings", *Journal of Educational Computing Research*, 24, pp. 139–154.

Yurdakul, I.K., H.F., Odabasi, K., Kilicer, A.N., Coklar, G., Birinci, and A.A. Kurt., 2012, "The Development, Validity and Reliability of TPACK-Deep: A Technological Pedagogical Content Knowledge Scale", *Computers & Education, 58*, pp. 964-977.

Yüksel, İ., and M., Alemdar, 2012, "Teachers' ICT Integration States on the Eve of FATIH Project". *Problems of Education in the 21st Century*, 44, pp. 29-42.

Zhao, Y., K., Pugh, S., Sheldon, and J., Byers, 2002, "Conditions for Classroom Technology Innovations", *Teachers College Record*, Vol. 104, No.3, pp. 482-515.