An examination of secondary mathematics teachers' technological pedagogical content knowledge

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This paper aims to examine secondary mathematics teachers' technological pedagogical content knowledge (TPACK) and diversities in it due to teachers' gender, age and years of experience. The participants of the study were 138 secondary mathematics teachers in Istanbul, Turkey. An adapted TPACK-M scale with three constructs (TCK, TPK and TPACK) was used to collect data. Results showed that TPACK level of teachers was moderate. According to demographic results, there was no significant difference in TPACK perception of male and female mathematics teachers. Also, small negative correlation was found between age and teachers' TPACK. Furthermore, there was no significant difference in TPACK perception and teaching experience of teachers.

Keywords: Technological pedagogical content knowledge, secondary mathematics teacher, integrating technology in mathematics education.

INTRODUCTION

In accordance with scientific and technologic developments in the world, technological opportunities of schools have increased in Turkey recently. Ministry of National Education (MoNE) has some attempts to integrate technology in schools. The FATIH project (Increasing Opportunities and Improvement of Technology Movement) is among the most significant educational investment of Turkey. 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, putting latest technologies into classroom without well trained teachers is not really technology integration (Dockstader, 1999). 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. According to technology principle of National Council of Teachers Mathematics (NCTM, 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 ICT is strongly emphasized in Turkish mathematics education curriculum (MoNE, 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. In order to effectively integrate technology in instruction, teachers should have an adequate technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006).

LITERATURE REVIEW

The knowledge needed for teachers to use technology strategically in mathematics instruction is a topic that has recently gained much attention (Neiss, Lee, Sadri, & Suharwoto, 2006; Mishra & Koehler, 2006). TPACK, 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) 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. TPACK for teaching with technology means that teachers should know how particular mathematics concept might be taught with technology so that students understand the concept (Niess, 2005).

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 & 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 a complicated construct and comprises many components, measuring the effectiveness of TPACK depends on the relationships of these components with each other (Koehler, Mishra, Bouck, DeSchryver, Kereluik, Shin, & Wolf, 2011). As a result of the 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 measurement tool of TPACK. Two main problems occurring during the measurement process are understanding the effects of teachers' domain knowledge on their current teaching practices and reliability, validity concerns of TPACK measurement methods (Abbitt, 2011). So, researchers try different methods to measure TPACK because of its dynamic characteristic.

The definition of TPACK concept looks like settled but it continues to be studied. So, most of the studies focused on the definition of TPACK and developing instruments to measure it (Mishra & Koehler, 2006; Koh, Chai, & Tsai, 2010; Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009). Also, many TPACK studies are conducted with pre-service teachers. Similarly to a general trend in TPACK studies in international arena, in Turkey most of the studies focused on adapting surveys or developing new ones to measure TPACK (Öztürk & Horzum, 2011; Yurdakul, Odabasi, Kilicer, Coklar, Birinci, & Kurt, 2012).

Also, the adaptation studies in Turkey did not focus on any specific content. According to the results from a pilot study of the FATIH project, teachers do not feel themselves adequate and confident in their knowledge. Therefore, the purpose of this study were to examine technological pedagogical content knowledge of secondary mathematics teachers at FATIH project schools and their possible gender, age and years of experience diversities related to TPACK by adopting mathematics specific scale (TPACK-M). The specific research problems addressed in this study are the following:

- What are the levels of secondary mathematics teachers' TPACK as measured by TPACK-M scale?
- Is there a significant difference in perception of Turkish secondary mathematics teachers' TPACK in terms of gender?
- Is there a significant relationship between TPACK and age of secondary mathematics teachers?
- Is there a significant difference in perception of Turkish secondary mathematics teachers' TPACK in terms of years of experience?

METHODOLOGY

This study contains the combination of survey and correlational research methodology (Creswell, 2012). In this study, all secondary mathematics teachers at FATIH project schools in Istanbul were identified as the target population. The reason why FATIH project teachers were determined as participants in this study is that they have already been equipped with technological devices such as interactive board and tablets. However, it was not practical to visit all schools to meet the teachers. So, multistage cluster sampling was used in the study. 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 the ratio of students per teacher. Then, those districts separated into three groups (low, middle and high). The participants of the study were 138 secondary mathematics teachers working at FATIH project schools in Istanbul. Among the participants, 62 (44.9 %) of them were male and 76 (55.1 %) female, aged between 29 and 62 years (*M=41.1, SD=6.04)*. When teaching experience of teachers was considered, majority of the teachers had teaching experience between 11 and 15 years. As demographic information, it was also asked to 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 percentage of desktop ownership (42.8%).

Technological pedagogical content knowledge of secondary mathematics teachers (TPACK-M) scale was used in the study after an adaptation into Turkish. For the adaptation of the study, the scale was translated into Turkish using a standard protocol. Also, both versions of the test applied twenty five pre-service mathematics teachers who are native in English and fluent in Turkish. The TPACK-M questionnaire was designed by (Handal, Campbell, Cavanagh, Petocz, & Kell, 2013) to identify teachers' TPACK in terms of technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK). It focuses on secondary mathematics teachers and involves three parts. A 5-point (from 1-strongly disagree to 5- strongly agree) Likert type scale contains a total of 30 items. Each construct has 10 items. Technology knowledge (TK) was not included in the questionnaire because of the research emphasis on discipline related technology. 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 examples of the items are, "I am able to use dynamic geometry software (e.g., GeoGebra, Geometer's Sketchpad, Autograph, Cabri)" (for TCK), "I am able to teach a concept using an interactive whiteboard" (for TPK) and "I am able to use technology to demonstrate mathematical models or concepts through learning objects (e.g., animations, simulations, online applications)" (for TPACK). Data was gathered through self-report. Non parametric statistical techniques were used to analyze the data.

RESULTS

Table 1 indicates mean values and standard deviations of participants' TPACK level for three constructs TCK, TPK, TPACK and for whole instrument.

According to Table 1, the 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)*. Three dimensions as low, moderate

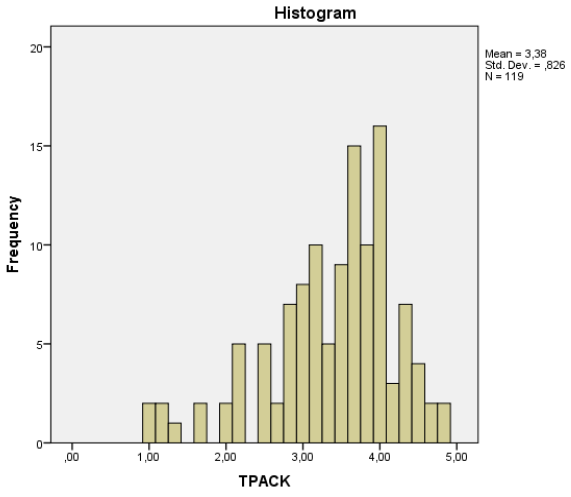

Figure 1: Distributions of TPACK Mean Score

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

Table 1: Mean TPACK scores

	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					

Table 2: Mann Whitney U test for gender 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

Table 3: Correlations between age and TPACK

	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				

Table 4: Kruskal- Wallis test for TPACK and teaching experience

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 et al., 2012). 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 TPACK) can be considered as moderate. The distributions of the mean TPACK score is illustrated in Figure 1.

In order to explore possible gender differences of secondary mathematics teachers' technological pedagogical content knowledge, non-parametric Mann-Whitney U test was used because of the violation of normality assumption. A Mann-Whitney U test results, shown in Table 2, revealed no significant difference in the TPACK levels of male and female mathematics teachers *(U=1557, z= -1.11, p=. 27)*.

Furthermore, the relationship between participants' age and TPACK perceptions was examined using Spearman rho correlation. As shown in Table 3, there were small negative correlation between age and technological pedagogical content knowledge of teachers (= −.16, p > .05)

In order to answer whether there is a difference in TPACK levels across five teaching experience levels, Kruskal-Wallis test was used. 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 4. So, there is not a significant difference in TPACK levels of mathematics teachers across five different teaching experience groups (*6.56, p= .16*).

DISCUSSION AND CONCLUSION

According to the results, the mean score of each construct and the whole instrument showed that secondary mathematics teachers generally rated themselves as moderate. The moderate mean score in TPACK (and

three constructs) may be explained by the familiarity with technology in daily life and in-service education 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 those 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, Mishra, & Koehler, 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 education related to technology use in education. This education is mainly focused 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 tablets, interactive whiteboards, teacher and student (ERI, 2014). 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 may still think pedagogical knowledge, content knowledge and technological knowledge separately. This does not mean technology integration.

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. 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 use of technology for pedagogical purposes 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, Banilower, McMahon, & Smith, 2001). This result may stem from teachers' lack of general knowledge about technology-related pedagogy.

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 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. 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 education which was constructed on similar content. This may be the reason why male and female teachers perceive themselves similar in terms of TPACK.

Furthermore, weak negative correlation was found between TPACK and age in this study consistent with previous studies (Koh et al., 2010; Öztürk, 2013). When teaching experience of participants was considered, there was no significant difference in TPACK levels of teachers across five teaching experience groups. 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 small numbers of teachers in some teaching experience categories. Previous study showed that age, gender and teaching experience all affect the teachers' 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.

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