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Examination of Classroom Teachers' Technological Pedagogical and Content Knowledge on the Basis of Their Demographic Profiles

Taner Altun
Department of Primary Teacher Education, Karadeniz Technical University

Abstract

This study aims to examine classroom teachers' Technological Pedagogical and Content Knowledge (TPACK) on the basis of different variables. A total of 322 classroom teachers in the city of Trabzon participated in the study. An adapted Turkish version of the TPACK scale was used as the data collection instrument. The obtained data was analyzed using SPSS 15.0 software. Independent t-test, ANOVA and Mann Whitney U-tests were used for statistical analysis. The results indicate that there are meaningful relationships and significant differences between variables of gender, having an Internet connection and the use of an ICT lab in the school, the use of educational software and the sub-factors of the TPACK scale. It is recommended that more practical CPD (Continuous Professional Development) opportunities for classroom teachers be provided in order to exploit the pedagogical benefits of ICT in primary schools.

Key words: *classroom teacher; demographic variables; TPACK.*

Introduction

In recent years, research on teacher education and ICT (Information and Communications Technology) has focused on the nature of teacher knowledge required for successful technology integration (Mishra and Koehler, 2006; Schmidt et al., 2009a). An extended theoretical framework called "Technological Pedagogical and Content Knowledge (TPACK)", based on Schulman's (1986) Pedagogical Content Knowledge (PCK) theory, has been developed by researchers in order to examine the nature of teachers' knowledge in the successful implementation of ICT into teaching and learning activities (Altun, 2007; Akkoc, 2010). TPACK is basically a combination of three sources of knowledge, which are technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) (Mishra and Koehler, 2006; Chai, Koh, and Tsai, 2010).

In its basic form, TPACK explores teachers' comprehension of how ICT can be used as a pedagogical tool in teaching and learning (Mishra and Koehler, 2006). As can be seen in Figure 1, TPACK is formulated on the basis of the interaction of three bodies of knowledge: (1) *pedagogical content knowledge* (Shulman, 1986), (2) *technological content knowledge* (knowing which kinds of technological tools are available for teaching different subjects), and (3) *technological pedagogical knowledge* (the ability to choose an ICT tool based on its facility to address a particular teaching/learning need) (Hu and Fyfe, 2010, p. 184).

In this sense, teachers should have the technical ability to use ICT resources and also be able to integrate them pedagogically into their teaching and learning processes to help students to learn a particular subjects content better (Koehler and Mishra, 2009).

Since the framework was developed, a vast amount of research has been carried out, particularly concentrating on the development of pre-service teachers' TPACK (Niess, 2005; Kocoglu, 2009; Schmidt et al., 2009b; Akkoc, 2010; Chai et al., 2010; Koh, Chai and Tsai, 2010; Karal and Bahcekapili, 2011; Kaya, Özdemir, Emre and Kaya, 2011). On the other hand, there have been studies which focused on practicing teachers' TPACK (Jones and Moreland, 2004; Hofer and Swan, 2007; Groth, Spickler, Bergner and Bardzell 2009; Shin et al., 2009). Broadly, studies with practicing teachers have shown that increased TPACK has resulted in enhanced teachers' knowledge and skills regarding combining technology with pedagogy in classroom settings. However, it is argued that the integration of technology is a very personal undertaking for teachers. It is believed that contextual factors and many variables affect the development of teachers' TPACK (Jones and Moreland, 2004; Hofer and Swan, 2007).

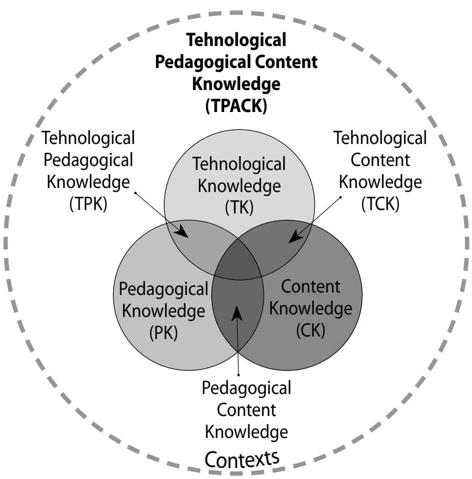

Figure 1. *Framework of TPACK (graphic from http://tpack.org/)*

The Context

As in other countries, classroom teachers in Turkey are also expected to improve their skills and knowledge in technology and pedagogy, and to utilize ICT in education effectively. It has been argued that classroom teachers are "generalists" who are expected to deliver a diverse range of subject matter in the primary curriculum, including using ICT as a tool in all subjects (Ardzejewska, McMaugh and Coutts 2010). In other words, classroom teachers tend to take on broader teaching responsibilities than the upper level teachers in primary education. Despite this fact, limited research has been undertaken on classroom teachers' knowledge and use of ICT in education (Tezci, 2010; Altun and Sancak, 2010). Previous studies generally focused on teachers' attitudes towards ICT (Tezci, 2010), self-efficacy levels in ICT and computers (Sahin, 2009; Kaya, et al. 2011) and views about opportunities in and barriers to ICT integration (Akkoyunlu, 2002). No studies in Turkey have been carried out with the focus on classroom teachers' perceptions of TPACK and its relationships with their demographic variables. In this sense, it is assumed that this study is important in terms of inspiring other studies which would focus on investigating primary teachers' TPACK.

On the other hand, international literature about TPACK generally focuses on the issues of pre-service teachers' TPACK (Schmidt et al., 2009b; Hu and Fyfe, 2010; Koh et al., 2010; Kaya et al., 2011) and is said to be mostly carried out in the USA (Koh et al., 2010, p. 565). Limited studies explored practicing teachers' TPACK through surveys (except Koehler and Mishra, 2005; Lee and Tsai, 2010). Groth et al. (2009) investigated teachers' TPACK development through qualitative methods, while Jones and Moreland (2004) attempted to enhance primary school teachers' pedagogical content knowledge in technology through case studies. In addition, a very limited number of TPACK survey studies which investigate TPACK with respect to the teachers' demographic profiles have been published. In fact, it has been suggested in the literature that the relationship between the TPACK constructs and the teacher demographic variables needs to be investigated further. There is a need to examine whether these variables have stronger influences on the TPACK perceptions of in-service teachers because this will provide information for the planning of teacher development programs (Lee and Tsai, 2010, p. 571).

Purpose of the Study

Given the lack of existent body of research regarding investigating teachers' TPACK, this study proposes to examine issues related to TPACK with a study of Turkish classroom teachers. In this sense, the main purpose of this study is to examine the TPACK of Turkish classroom teachers and its relationship with their demographic profiles (i.e. gender, teaching experience, teaching level, use of computers and the Internet, use of an IT lab and educational software). A general hypothesis of the research is that demographic profiles would affect teachers' TPACK. From that hypothesis, the following initial predictions were generated to be tested through a survey:

- There is a difference between the gender of teachers and their TPACK.
- Teachers' teaching grade levels affect teachers' perceptions of TPACK.
- Teachers' teaching experience affects their TPACK perceptions.
- There is a difference between having a computer with Internet connection at home and teachers' perceptions of TPACK.
- Teachers' use of IT labs in schools affects their perceptions of TPACK.
- There is a difference between the increased use of educational software during classes and teachers' perceptions of TPACK.

Method

In its nature, this study uses general deductive research methods (Hitchcock and Hughes, 1995). A hypothesis states the researcher's expectations concerning the relationship between the variables in the research problem and *deductive hypotheses*, said to be derived from theory, to contribute to the science of education by providing evidence that supports, expands or contradicts a given theory (Gay, 1987, pp. 53–55). The hypothesis of this study was formulated following the related literature as it is based on the implications of the previous research. In their study, for example, Koh et al. (2010) revealed that pre-service teachers' TPACK perceptions were fairly consistent with their demographic variables (i.e. age, gender and teaching level). It is predicted that demographic profiles of in-service teachers will influence their perceptions of TPACK.

A Turkish version of the TPACK survey (adapted by Bahcekapili, 2011) was used as a data collection instrument. In the spring semester of the 2010–2011 academic year 480 questionnaires were distributed to classroom teachers working in primary schools in Trabzon and a total of 322 teachers responded to the survey (return rate 67%). The area and the teachers were selected through random sampling. The data on the demographic profiles of teachers who responded to the survey are presented in Table 1 below:

Table 1. *Demographic information about teachers*

Variables	Categories	n	%
Gender	Female	150	46.6
	Male	172	53.4
Grade Level	1st Grade	64	19.9
	2nd Grade	67	20.8
	3rd Grade	65	20.1
	4th Grade	62	19.3
	5th Grade	64	19.9
Teaching Experience	0–15 years	72	22.4
	16+ years	250	77.6
I have a computer in my classroom	No	51	15.8
	Yes	271	84.2
I have Internet connection in the classroom	No	109	33.9
	Yes	213	66.1
I have a computer at home	No	17	5.3
	Yes	305	94.7
I have Internet connection at home	No	36	11.2
	Yes	286	88.8
I use an ICT lab in school	Always	84	26.1
	Sometimes	65	20.2
	Rarely	133	41.3
	Never	40	12.4
I use educational software (Vitamin etc.) during my instruction	**Always**	74	23.0
	Sometimes	37	11.5
	Rarely	143	44.4
	Never	68	21.1

It is believed that the provided variables represent teachers' demographic profiles. Gender, grade being taught and teaching experience are commonly used variables in this kind of research. In addition, preliminary studies (Becker and Ravitz, 1999; Alev, 2003; Tezci, 2010) showed that having a computer and Internet connection both in the classroom and at home are variables which determine teachers' level of technology use. It is for this reason that the investigated variables were assumed as descriptive background information about a teacher when his/her TPACK was investigated through a Likert-Type Scale.

As can be seen, 46.6% of the participants were female teachers and 53.4% were male teachers. The grade levels that the teachers taught were evenly distributed. Among the teachers participating in the study, 77.6% had over 16 years of teaching experience, which is an indicator of the government's policy to appoint experienced teachers in urban schools. As can be seen, the majority of teachers are provided with a computer (84.2%) and most of them (66.1%) have Internet connection in their classrooms. Similarly, the majority of teachers have a computer at home 94.7% and most of them

(88.8%) have the Internet connection. Despite the fact that all schools have installed ICT labs, the teachers' use of those labs seems to be low. This might be related to the teachers having computers and Internet connections in their own classrooms, which enables them to use them at any time. Finally, the use of educational software for teaching and learning purposes also seems to be low. There is a protocol between the Turkish Telecom and the Ministry of National Education regarding providing teachers with a free use of one of the most powerful educational software programs, TTNET VITAMIN in the classrooms. This educational software is interactive and Internet-based, developed for primary and secondary school use, approved by the Turkish Ministry of National Education (MONE) and is said to be compatible with the National Curriculum. It includes over 3,600 animations and experiments developed on the basis of child-centered education (http://www.ttnetvitamin.com.tr). As can be seen from Table 1, 23% of the teachers participating in the study responded that they always use this software in the classroom. Other teachers reported not using it very often but it is understood that they are all familiar with it.

The Instrument

The study "Survey of Pre-service Teachers' Knowledge of Teaching and Technology", developed by Schmidt et al. (2009a), was used as the main source of data collection. With permission, the survey was translated into Turkish and adapted by Bahcekapili (2011). On the basis of a series of statistical analyses such as Confirmatory Factor Analysis (CFA), validity and reliability checks and other suitability indices (CFI= .86, TLI= .85, RMSEA= .064, SRMR= .064) the instrument was deemed to be a working instrument and suitable for the Turkish context. Cronbach's Alpha reliability values of between .80 and .90 were found in the model by Bahcekapili (op. cit.). In this study, Cronbach's Alpha value for the whole instrument was .982. The survey comprises the total of 47 Likert-Type items. Those items are grouped under 10 sub-dimensions of TPACK. The sub-dimensions and number of items are as follows:

- TK (Technological Knowledge)–7 items
- CK (Content Knowledge)
    - CK–M (Content Knowledge–Mathematics) – 3 items
    - CK–S (Content Knowledge–Science) – 3 items
    - CK–SS (Content Knowledge–Social Studies) – 3 items
    - CK–L (Content Knowledge–Literacy) – 3 items
- PK (Pedagogical Knowledge) – 7 items
- PCK (Pedagogical Content Knowledge) – 4 items
- TCK (Technological Content Knowledge) – 4 items
- TPK (Technological Pedagogical Knowledge) – 5 items
- TPACK (Technological Pedagogical and Content Knowledge) – 8 items

Some examples of items in TPACK scale are as follows:

I know how to solve my own technical problems. (TK)

I can use a mathematical way of thinking. (CK–M)

I have sufficient knowledge of science. (CK-S)

I can use a wide range of teaching approaches in the classroom setting. (PK)

I can select effective teaching approaches to guide students' thinking and learning in social studies. (PCK)

I know about technologies that I can use for understanding and practicing science. (TCK)

I can choose technologies that enhance the content for a lesson. (TPK)

I can teach lessons that appropriately combine science, technologies and teaching approaches. (TPCK)

It is assumed that, as the TPACK instrument consists of four curriculum subjects (Math, Science, Social Studies and Literacy) under the Content Knowledge (CK) dimension, the survey would be suitable for classroom teachers to understand and for them to provide opinions comfortably as they are generalist teachers teaching those subjects. Furthermore, it was assumed that investigating the way in which generalist teachers combine four components of TPACK would provide clearer insights into the state of ICT integration in primary education in Turkey.

In addition to the TPACK survey, a preliminary questionnaire concerning the demographic profiles of the participants was developed by the author and attached to the TPACK survey. In order to investigate the relationships between these variables and teachers' TPACK, this preliminary questionnaire included as the pre-determined independent variables questions on gender, teaching experience, access to a computer and the Internet in the classroom and at home, availability of an ICT lab in the school, and usage of educational software in the classroom.

While this study yielded valuable insights by using the developed preliminary demographic information questionnaire and the TPACK survey, it is imperative to note that its limitations make it questionable. For instance, it is difficult to come to a deeper understanding of the process and the contextual differences through questionnaires which are standardized and, by their nature, limited in length and depth of responses (Muijs, 2004, p. 44). In addition, the ecological validity of the study can be questioned, as it needs to show that the research has included and addressed as many characteristics and factors of a given situation as possible in order to avoid reproducing the rhetoric of "policies" in education (Cohen, Manion and Morrison 2011, p. 195).

Results

The data obtained through the scale were analyzed with the help of SPSS 15.0 software. In the analysis, parametric and non-parametric tests were employed.

Gender and Teachers' TPACK

Table 2 below summarizes the findings about the difference between the gender variable and teachers' TPACK.

Table 2. *Independent t-test results about gender and teachers' TPACK.*

Dimensions of TPACK	Gender	N	Mean	Sd.	t	p
TK (Technological Knowledge)	Female Male	150 172	23.9197 23.5523	5.73182 5.82921	.554	**.580**
CK–M (Content Knowledge–Mathematics)	Female Male	150 172	12.5352 12.1975	2.15888 2.44304	1.270	**.205**
CK–SS (Content Knowledge–Social Studies)	Female Male	150 172	12.0147 12.0468	2.38249 2.40324	-.117	**.907**
CK–S (Content Knowledge–Science)	Female Male	150 172	12.3500 11.7490	2.03502 2.37946	2.350	**.019***
CK–L (Content Knowledge–Literacy)	Female Male	150 172	12.7400 12.1986	2.31701 2.42147	1.990	**.047***
PK (Pedagogical Knowledge)	Female Male	150 172	29.9052 28.5468	4.47028 5.78194	2.263	**.024***
PCK (Pedagogical Content Knowledge)	Female Male	150 172	17.4197 16.2674	5.22015 3.11470	2.407	**.017***
TCK (Technological Content Knowledge)	Female Male	150 172	16.8346 16.1231	2.84073 3.19891	2.040	**.042***
TPK (Technological Pedagogical Knowledge)	Female Male	150 172	20.0418 19.9527	3.61550 3.85226	.208	**.836**
TPCK (Technological Pedagogical Content Knowledge)	**Female** **Male**	**150** **172**	**36.3860** **35.7090**	**6.64797** **6.69356**	**.886**	**.376**

*p<0.05

The results of the independent t-test analysis illustrate that there is a significant relationship between the gender variable and some of the sub-dimensions (CK–S, CK–L, PK and TCK) of teachers' TPACK perceptions ($t_{CK\text{-}S}$=2.350; $t_{CK\text{-}L}$=1.990; t_{PK}=2.263; t_{PCK}=2.407 and t_{TCK}=2.040, $p<0.05$). According to these results, it can be seen that on these dimensions female teachers had higher scores than their male colleagues. If the mean scores are examined, it can also be seen that female teachers' scores are relatively higher than those of the male teachers, despite closer scores, meaning that the level of meaningfulness is low. In other dimensions of TPACK no significant difference was found on the basis of the gender variable.

Level of Teaching Grade and Teachers' TPACK

On the basis of one-way variance analysis (ANOVA) no significant difference between the teaching grade variable and teachers' TPACK was found. It can be said that the grade level teaching has no correlation with teachers' technological pedagogical and content knowledge.

Teaching Experience and TPACK

In order to investigate the difference between the teaching experience of the participant teachers and their TPACK, an independent t-test analysis was employed. The results are shown in Table 3 below:

Table 3. *Results regarding the difference between teaching experience and teachers' TPACK*

Dimensions of TPACK	Experience	N	Mean	Sd.	t	p
TK (Technological Knowledge)	0-15 16+	105 217	24.0762 23.5392	5.54821 6.02077	.769	**.442**
CK–M (Content Knowledge–Mathematics)	0-15 16+	105 217	12.0412 12.4607	2.16157 2.40491	-1.515	**.131**
CK–SS (Content Knowledge–Social Studies)	0-15 16+	105 217	11.5334 12.2399	2.39820 2.36243	-2.503	**.013***
CK–S (Content Knowledge–Science)	0-15 16+	105 217	11.7615 12.0499	2.32674 2.24069	-1.069	**.286**
CK–L (Content Knowledge–Literacy)	0-15 16+	105 217	12.1656 12.4892	2.36617 2.44525	-1.125	**.261**
PK (Pedagogical Knowledge)	0-15 16+	105 217	28.3811 29.3228	4.86232 5.54167	-1.486	**.138**
PCK (Pedagogical Content Knowledge)	0-15 16+	105 217	16.1404 17.0402	2.76045 4.68546	-1.820	**.070**
TCK (Technological Content Knowledge)	0-15 16+	105 217	15.9730 16.5914	2.92598 3.22964	-1.660	**.098**
TPK (Technological Pedagogical Knowledge)	0-15 16+	105 217	19.5797 20.1370	3.97765 3.69931	-1.236	**.217**
TPCK (Technological Pedagogical Content Knowledge)	0-15 **16+**	105 **217**	35.3328 **36.2944**	6.56569 **6.72378**	-1.212	**.226**

*p<0.05

Independent t-test results indicate that, on the basis of teaching experience only, a significant difference was found in CK–SS (Content Knowledge–Social Studies) sub-dimension (t_{CK-SS}=-2.503; $p<0.05$). It was determined that the mean scores of teachers (X=12.2399) who had 16+ years of teaching experience were higher than the mean scores of those teachers who had teaching experience of between 0 and 15 years (X=11.5334).

Having a Computer in the Classroom and Teachers' TPACK

At this point the Mann Whitney U-test, which is one of the non-parametric tests, was employed since the sample of the study was not suitable for parametric analysis. Mann Whitney U-test results revealed that there was no difference between the availability of a computer in the classroom and teachers' TPACK.

Having Internet Connection in the Classroom and Teachers' TPACK

Independent t-test analysis results are presented in Table 4.

Table 4. *Differences between having Internet connection in the classroom and teachers' TPACK.*

Dimensions of TPACK	Internet Connection	N	Mean	Sd.	t	p
TK (Technological Knowledge)	No Yes	109 213	22.5321 24.3192	6.09275 5.66864	-2.610	**.009***
CK–M (Content Knowledge–Mathematics)	No Yes	109 213	12.0243 12.4772	2.54250 2.20922	-1.653	**.099**
CK–SS (Content Knowledge–Social Studies)	No Yes	109 213	11.6700 12.1832	2.44216 2.35509	-1.827	**.069**
CK–S (Content Knowledge–Science)	No Yes	109 213	11.4763 12.2013	2.56599 2.06541	-2.740	**.006***
CK–L (Content Knowledge–Literacy)	No Yes	109 213	12.0254 12.5670	2.70155 2.24850	-1.907	**.057**
PK (Pedagogical Knowledge)	No Yes	109 213	27.9911 29.5401	6.21308 4.76469	-2.483	**.014***
PCK (Pedagogical Content Knowledge)	No Yes	109 213	16.3600 16.9448	2.98227 4.66144	-1.191	**.235**
TCK (Technological Content Knowledge)	No Yes	109 213	15.9848 16.5970	3.20429 3.09788	-1.659	**.098**
TPK (Technological Pedagogical Knowledge)	No Yes	109 213	19.2911 20.2951	3.98636 3.65651	-2.261	**.024***
TPCK (Technological Pedagogical Content Knowledge)	No **Yes**	109 **213**	34.9164 **36.5256**	6.83131 **6.54706**	-2.056	**.041***

*p<0.05

The results of the analysis revealed a significant difference between having the Internet connection in the classroom and some of the sub-dimensions of TPACK ($t_{TK=}$-2.610; $t_{CK\text{-}S}$=-2.740; t_{PK}=-2.483; t_{TPK}=-2.261; t_{TPCK}=-2.056, $p<0.05$).

In dimensions such as TK (Technological Knowledge), CK–S (Content Knowledge–Science), PK (Pedagogical Knowledge), TPK (Technological Pedagogical Knowledge) and TPCK (Technological Pedagogical Content Knowledge), the mean scores of the teachers who reported having the Internet access in their classrooms were higher than those of teachers who claimed they had no Internet connection.

Having a Computer at Home and Teachers' TPACK

At this point, once again, the Mann Whitney U-test was employed and the results revealed that there was no relationship between having a computer at home and teachers' technological, pedagogical and content knowledge, with the exception of the CK–SS (Content Knowledge–Social Studies) dimension of TPACK ($t_{CK\text{-}SS}$=.026, $p<0.05$).

Having Internet Connection at Home and Teachers' TPACK

On this variable the Mann Whitney U-test was employed and the results are presented in Table 5 below:

Table 5. *Differences between having Internet connection at home and teachers' TPACK.*

Dimensions	Internet at Home	N	Mean	Mean Total	U	p
TK (Technological Knowledge)	No Yes	36 286	125.53 166.03	4519.00 47484.00	3853.000	**.014***
CK–M (Content Knowledge–Mathematics)	No Yes	36 286	156.07 162.18	5618.50 46384.50	4952.500	**.703**
CK–SS (Content Knowledge–Social Studies)	No Yes	36 286	164.36 161.14	5917.00 46086.00	5045.000	**.842**
CK–S (Content Knowledge–Science)	No Yes	36 286	133.65 165.01	4811.50 47191.50	4145.500	**.051**
CK–L (Content Knowledge–Literacy)	No Yes	36 286	184.32 158.63	6635.50 45367.50	4326.500	**.108**
PK (Pedagogical Knowledge)	No Yes	36 286	158.54 161.87	5707.50 46295.50	5041.500	**.839**
PCK (Pedagogical Content Knowledge)	No Yes	36 286	143.81 163.73	5177.00 46826.00	4511.000	**.214**
TCK (Technological Content Knowledge)	No Yes	36 286	139.25 164.30	5013.00 46990.00	4347.000	**.121**
TPK (Technological Pedagogical Knowledge)	No Yes	36 286	146.86 163.34	5287.00 46716.00	4621.000	**.312**
TPCK (Technological Pedagogical Content Knowledge)	No Yes	36 286	126.36 165.92	4549.00 47454.00	3883.000	**.016***

*p<0.05

The results revealed that there is a significant difference between having Internet connection at home and certain dimensions of teachers' TPACK. According to the results, there is a meaningful difference between having Internet connection at home and the Technology Knowledge (TK) and TPCK (Technological Pedagogical Content Knowledge) dimensions of TPACK (P_{TK}=014; and P_{TPCK}=.016, $p<0.05$).

It is surprising that having a computer which is not connected to the Internet, either in the classroom or at home, does not make any difference in terms of its relationship with teachers' TPACK. On the other hand, it was revealed that having Internet connection makes a positive impact on teachers' TPACK. On the basis of this finding, it can be said that a computer without the Internet access has limited benefits for teachers' knowledge of technology and pedagogy in contemporary time.

Use of IT Lab in School and Teachers' TPACK

As mentioned earlier, an IT lab (consisting of minimum 20 PCs with Internet connection, printers and a projector) is available in every primary school in Turkey.

Teachers use IT labs when necessary, on a rotation system. The results of the differences between the use of IT labs and teachers' TPACK are presented in Table 6 below:

Table 6. *Differences between the use of IT Lab and TPACK.*

Dimensions	Factor	Sum of Squares	Sd.	MS	F	*p*
TK (Technological Knowledge)	Within groups Between groups Total	524.122 10527.592 11051.714	3 318 321	174.707 33.106	5.277	**.001***
CK–M (Content Knowledge–Mathematics)	Within groups Between groups Total	5.287 1742.352 1747.638	3 318 321	1.762 5.479	.322	**.810**
CK–SS (Content Knowledge–Social Studies)	Within groups Between groups Total	25.865 1813.107 1838.972	3 318 321	8.622 5702	1.512	**.211**
CK–S (Content Knowledge–Science)	Within groups Between groups Total	11.044 1642.337 1653.382	3 318 321	3.681 5.165	.713	**.545**
CK–L (Content Knowledge–Literacy)	Within groups Between groups Total	27.414 1853.781 1881.195	3 318 321	9.138 5.830	1.568	**.197**
PK (Pedagogical Knowledge)	Within groups Between groups Total	66.966 9087.955 9154.921	3 318 321	22.322 28.578	.781	**.505**
PCK (Pedagogical Content Knowledge)	Within groups Between groups Total	47.681 5544.066 5591.747	3 318 321	15.894 17.434	.912	**.436**
TCK (Technological Content Knowledge)	Within groups Between groups Total	67.254 3103.193 3170.447	3 318 321	22.418 9.758	2.297	**.078**
TPK (Technological Pedagogical Knowledge)	Within groups Between groups Total	148.532 4474.841 4623.374	3 318 321	49.511 14.072	3.518	**.015***
TPCK (Technological Pedagogical Content Knowledge)	Within groups Between groups **Total**	472.129 13841.756 **14313.885**	3 318 **321**	157.376 43.528	3.616	**.014***

*p<0.05

One-Way variance analysis (ANOVA) illustrates a significant difference between teachers' use of an IT lab and their TPACK in TK, TPK and TPCK dimensions (F_{TK}=5.277; F_{TPK}=3.518; F_{TPCK}=3.616, $p<0.05$).

In order to ascertain the source of difference in the dimensions (TK, TPK and TPCK), Least Significant Difference (LSD) Post Hoc analysis was carried out. For the TK dimension it was found that the mean scores of teachers who responded "always" to the item *"I use ICT lab in the school" (X*=3.90826) were higher than the mean scores of teachers who responded "sometimes" (X=1.48314); "rarely" (X=2.42511) and "never" (X=1.32892) to the same item.

Similarly, for the TPK dimension it was found that the mean scores of teachers who responded "sometimes" to the item *"I use ICT lab in the school"* (*X*=2.12251) were higher than the mean scores of teachers who responded "never" (X=.67276) to the item.

Finally, LSD Post Hoc analysis for the TPCK dimension illustrates that the mean scores of teachers who responded "sometimes" to the item *"I use ICT lab in the school"* (*X*=3.50948) were higher than the mean scores of teachers who responded "never" (X=1.28933) to the item.

Use of Educational Software and Teachers' TPACK

The final variable, teachers' use of educational software within their teaching process, was examined through the scale in order to check its relationship with teachers' TPACK. One-way ANOVA analysis results for this variable are presented in Table 7 below:

Table 7. *Differences between the use of educational software and teachers' TPACK*

Dimensions	Factor	Sum of Squares	Sd.	MS	F	*p*
TK (Technological Knowledge)	Within groups Between groups Total	1213.443 9838.272 11051.714	3 318 321	404.481 30.938	13.074	**.000***
CK–M (Content Knowledge–Mathematics)	Within groups Between groups Total	20.176 1727.462 1747.638	3 318 321	6.725 5432	1.238	**.296**
CK–SS (Content Knowledge–Social Studies)	Within groups Between groups Total	5.209 1833.762 1838.972	3 318 321	1.736 5.767	.301	**.825**
CK–S (Content Knowledge–Science)	Within groups Between groups Total	19.515 1633.867 1653.382	3 318 321	6.505 5.138	1.266	**.286**
CK–L (Content Knowledge–Literacy)	Within groups Between groups Total	11.528 1869.667 1881.195	3 318 321	3.843 5.879	.654	**.581**
PK (Pedagogical Knowledge)	Within groups Between groups Total	112.511 9042.411 9154.921	3 318 321	37.504 28.435	1.319	**.268**
PCK (Pedagogical Content Knowledge)	Within groups Between groups Total	63.067 5528.680 5591.747	3 318 321	21.022 17.386	1.209	**.306**
TCK (Technological Content Knowledge)	Within groups Between groups Total	95.013 3075.434 3170.447	3 318 321	31.671 9.671	3.275	**.021***
TPK (Technological Pedagogical Knowledge)	Within groups Between groups Total	148.520 4474.854 4623.374	3 318 321	49.507 14.072	3.518	**.015***
TPCK (Technological Pedagogical Content Knowledge)	Within groups Between groups Total	563.192 13750.693 14313.885	3 318 321	187.731 43.241	4.341	**.005***

*p<0.05

The results show that there are significant differences between teachers' use of educational software during classes and four sub-factors of the TPACK scale (F_{TK}=13.074; F_{TCK}=3.275; F_{TPK}=3.518; F_{TPCK}=4.341, $p<0.05$). In other words, there is a relationship between the use of educational software during teaching and learning activities and teachers' technological, pedagogical and content knowledge.

In order to ascertain the source of the difference in the identified dimensions of the TPACK scale, once again LSD Post Hoc analysis was carried out. The results indicate that for the dimension TK, the mean scores of teachers who responded that they "always" (X=5.76828) use educational software during classes are higher than the mean scores of teachers who responded "rarely" (X=3.99801) and "never" (X=2.94868).

For the TCK dimension, the mean scores of teachers who responded that they "always" (X=1.64676) use educational software during classes are higher than those of teachers who responded "never" (X=.70914).

For the TPK dimension, the mean scores of teachers who responded that they "always" (X=2.05887) use educational software during classes are higher than those of teachers who responded "sometimes" (X=1.65286); "rarely" (X=1.45669) and "never" (X=.60218).

Finally, for the TPCK dimension, the mean scores of teachers who responded that they "always" (X=4.40242) use educational software during classes are higher than those for teachers who responded "never" (X=1.86425).

Discussion

To begin with, the findings of the study seem to suggest that there are some critical variables that affect classroom teachers' TPACK in certain dimensions. Gender is one of the most checked variables in teachers' engagement with ICT and in other pedagogical studies (Teo, 2008; Tezci, 2010). In this study, the results illustrated that female teachers attained higher scores than their male counterparts in certain dimensions of the TPACK scale. This finding was not consistent with the previous research findings on pre-service teachers in which male participants rated their TK higher than females did (Koh et al., 2010). It is quite revealing that for the Content Knowledge (Science and Literacy), Pedagogical Knowledge, Pedagogical Content Knowledge and Technological Content Knowledge dimensions of TPACK, female teachers had higher scores than male respondents. This might be related to the teachers' attitudes towards teaching, where positive attitudes of female teachers towards pedagogy and technology may result in higher scores. It can be seen that female teachers' opinions were more related to the pedagogy (PK, PCK) and content (CK–S, CK–L, PCK) elements of teacher knowledge competencies rather than technology (except TCK). In other words, it can be argued that female teachers are more interested in, or perhaps knowledgeable about, the "pedagogy" and "content" dimensions of TPACK and are less interested in the technology component.

The study offered no evidence of any significant difference regarding the relationship between the teachers' level of teaching grade and their TPACK. In their study, Koh et al.

(2010) concluded that TPACK perceptions did not differ in relation to teaching level (though they compared primary and secondary level pre-service teachers' perceptions of TPACK). The results of this study are not surprising as all participating teachers were generalists with teaching experience in all grades of lower primary school level. As mentioned earlier, due to the rotation system in Turkey, classroom teachers teach the same group of students for five years (starting from first grade to fifth grade). Consequently, they are capable of teaching all grades so, as found in this study, the level of teaching grade does not affect classroom teachers' TPACK.

In the study almost no relationship between the teaching experience of participant teachers and their TPACK (except for the CK–SS dimension) was determined. This finding was not consistent with the findings of Lee and Tsai (2010) who determined a significant difference between the older and the younger teachers' attitudes towards TPACK and TPACK-W self-efficacy. As can be seen from Table 1, the majority of participating teachers (77.6%) had more than 15 years of teaching experience, which is a result of the teacher appointment system in Turkey, where younger teachers work in towns and villages in their early years and then they move to urban schools based on their assessment scores in school inspections. Therefore, it can be said that, due to the similar age group in the research sample (which was unintentional), no relationship was found between the age variable and the teachers' TPACK.

One of the main findings of the study was that having a computer in the classroom and at home does not have any effect on the teachers' TPACK. On the other hand, having Internet connection makes a meaningful difference in the teachers' knowledge. It is clear that a computer without Internet connection does not offer as many educational opportunities. The Internet enriches the computer in terms of accessing, retrieving and storing information. Despite the fact that the majority of participant teachers have at least one computer in their classrooms (84.2%) and their homes (94.7%), it is apparent that this has no effect on their TPACK. For teachers who have access to the Internet, the results revealed a meaningful relationship with teachers' TPACK in dimensions such as TK, CK–S, PK, TPK and TPCK. This finding supports Levin and Wadmany's (2005) findings that teachers' knowledge is affected in rich, technology-based environments. Furthermore, this result seems to be parallel to Eachus and Cassidy (2006) who concluded that the number of hours per week and the length of time as a regular user of the Internet were positively correlated indicating that the more experienced Internet users have a stronger sense of self-efficacy (p. 5).

As sketched out in this study, the teachers' TPACK scores were higher for those teachers using the IT lab more frequently in their schools than for the teachers using it less frequently. It has been reported that the computer and Internet use is more consistently related to certain types of changes in practice and teacher perception than others. It has also been revealed that the relationship between technology use and pedagogical change is truly casual (Becker and Ravitz, 1999, p. 381). The findings of this study, parallel to Becker and Ravitz's study, also demonstrate the relationship between teachers' engagement with the Internet and their knowledge of technology, pedagogy and content.

Finally, it was shown that there is a meaningful relationship between the teachers' frequency of use of educational software and their TPACK. It is known that computers and related technologies can be integrated into educational practice through the use of educational software. In other words, computers achieve their potential for students through educational software and it has been reported that effective computer based pedagogy is related to teachers' use of educational software with their students (Niederhauser and Stoddart, 2001). This study offered findings that teachers' TPACK perceptions were affected if teachers were more frequent users of provided educational software such as TTNET VITAMIN in their teaching activities. Mumcu, Haslaman and Usluel (2008) proposed that one of the indicators of effective technology integration into teaching is the easy access to hardware and educational software by teachers and their guided use for educational purposes. The findings of this study were also consistent with other research findings that teachers' engagement with an online educational program (GeoThentic software) resulted in an increase in teachers' technology (TK), technological content knowledge (TCK) and TPACK domains (Doering, Veletsianos, Scharber and Miller, 2009). The findings of the present study support the arguments that when teachers utilize educational software effectively, their knowledge levels as well as their skills are affected and are said to be changed in a positive direction.

Conclusion

This study aimed to examine the relationships, if any, between various independent variables and classroom teachers' technological, pedagogical and content knowledge (TPACK) on the basis of quantitative results. The findings of the study suggest that various variables such as gender, utilization of IT resources, the Internet and educational software affect the development of teachers' TPACK in terms of certain dimensions.

Despite the fact that the survey research techniques deal with numerical counting, percentages, and statistical coefficients, we are still at an early stage in understanding how the dimensions of TPACK are integrated and interact throughout a classroom teacher's pedagogical formation. It seems fair to say that teachers should be supported with pedagogically sound technology and in this way we can learn more about how teachers make technology pedagogically sound (Ferdig, 2006) from their practices.

The findings of the study offer co-relational evidence between classroom teachers' engagement with ICT and their perceptions of TPACK. However, it is unclear whether the teachers' TPACK is transferable in the classroom context. It could be suggested that more observation-based studies within the qualitative research approach, such as that of Groth et al. (2009), should be carried out in order to obtain clearer insights into how classroom teachers' engagement with ICT in classroom settings affect their

TPACK. As Harris, Mishra and Koehler (2009) suggested, teachers should be offered an awareness of creating learning activity types within a specific content area and applying them in pedagogical processes, knowing which technology is appropriate to develop TPACK and how to use it.

The findings of this study seem to suggest that there is a relationship between teachers' utilization of IT resources in the lab and the Internet and dimensions of TPACK. Hence, as suggested by Ferdig (2006), there is a need for further research explaining and examining, for example, how the World Wide Web (www) or educational software like Vitamin might be used by classroom teachers to help primary school students to learn Science or Mathematics. At the present time we have no data about participating teachers' professional development processes in which they describe how, when and where they developed their TPACK and the level they are at. One of the limitations of this study is the lack of data about the participating teachers' attendance of any in-service teacher education activities or about opportunities they had during their pre-service education in terms of TPACK development. In addition, more in-depth interviews with some of the selected teachers would provide us with the qualitative data which might help us to understand the meanings of the coefficients and the relationships between the pre-determined variables and the classroom teachers' TPACK more clearly.

It is clear from the study results that the development of teachers' TPACK is affected by the frequent use of ICT resources, such as the Internet, the IT lab and educational software. Since classroom teachers are required to deliver more than one subject of the curriculum, it is fair to suggest that they should be offered more access to ICT resources and should be supported in terms of professional development in all curriculum areas, as well as being given opportunities to teach in more technologically enriched classrooms. As emphasized by Yelland (2002), without appropriate professional development opportunities teachers will not be able to accommodate ICT in their programs effectively (p. 87).

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Taner Altun
Department of Primary Teacher Education,
Fatih Faculty of Education,
Karadeniz Technical University
61335 Akçaabat
Trabzon, Turkey
taltun@ktu.edu.tr

Istraživanje pedagoškoga i predmetnoga tehnološkog znanja učitelja na osnovu njihovih demografskih profila

Sažetak

Ovo istraživanje ima za cilj ispitati pedagoško i predmetno tehnološko znanje (eng. TPACK – Technological Pedagogical and Content Knowledge) učitelja na osnovu različitih varijabli. U istraživanju je sudjelovalo ukupno 322 učitelja u gradu Trabzonu. Kao instrument prikupljanja podataka korištena je verzija TPACK skale prilagođena turskome jeziku. Dobiveni podatci analizirani su SPPS 15 računalnim programom. Tijekom statističke analize koristili su se nezavisni t-test, ANOVA i Mann-Whitneyjev U-test. Rezultati upućuju na to da postoje značajne veze i bitne razlike između varijabli spola, postojanja internetske veze i korištenja kompjuterskih laboratorija u školi, korištenja edukativnih računalnih programa i podčimbenika TPACK skale. Preporučuje se organiziranje što više praktičnih trajnih stručnih usavršavanja za učitelje da bi se bolje iskoristile pedagoške prednosti informacijsko-komunikacijske tehnologije u osnovnim školama.

Ključne riječi: *demografske varijable; TPACK (eng.) – pedagoško i predmetno tehnološko znanje; učitelj*

Uvod

U posljednjih nekoliko godina, istraživanja o izobrazbi nastavnika u informacijsko-komunikacijskoj tehnologiji bila su usmjerena prema vrsti znanja koje nastavnici trebaju posjedovati da bi uspješno integrirali tehnologiju u nastavni proces (Mishra i Koehler, 2006; Schmidt i sur., 2009a). Istraživači su izradili prošireni teorijski okvir poznat kao *pedagoško i predmetno tehnološko znanje* (eng. TPACK) koji se temelji na Schulmanovoj (1986) teoriji o pedagoškom i predmetnom znanju, da bi se ispitala vrsta nastavničkoga znanja o uspješnom uvođenju informacijsko-komunikacijske tehnologije u nastavni proces i nastavne aktivnosti (Altun, 2007; Akkoc, 2010).

Pedagoško i predmetno tehnološko znanje u osnovi je kombinacija triju izvora znanja, a to su: tehnološko znanje, pedagoško znanje i predmetno znanje (Mishra i Koehler, 2006; Chai, Koh i Tsai, 2010).

U svojemu osnovnome obliku, pedagoško i predmetno tehnološko znanje istražuje shvaćanje nastavnika o tomu kako se informacijsko-komunikacijska tehnologija može koristiti kao pedagoški alat u poučavanju i učenju (Mishra i Koehler, 2006) Kao što se može vidjeti na slici 1, pedagoško i predmetno tehnološko znanje temelje se na interakciji triju područja znanja: (1) *pedagoškoga predmetnog znanja* (Schulman, 1986), (2) *tehnološkoga predmetnog znanja* (znanje o tome koje su vrste tehnoloških alata na raspolaganju za poučavanje različitih školskih predmeta) i (3) *tehnološkoga pedagoškog znanja* (sposobnost odabiranja informacijsko-komunikacijskih alata prema njihovoj prikladnosti određenim potrebama učenja i poučavanja) (Hu i Fyfe, 2010: 184).

U tom smislu, nastavnici bi trebali biti tehnički osposobljeni za korištenje izvora informacijsko-komunikacijske tehnologije i trebali bi ih moći pedagoški integrirati u proces poučavanja, ali i u učenički proces učenja, da bi im pomogli bolje usvojiti sadržaj određenoga predmeta (Koehler i Mishra, 2009).

Otkako je taj teorijski okvir izrađen, provela su se mnogobrojna istraživanja koja su se posebice usredotočila na razvoj pedagoškoga i predmetnoga tehnološkog znanja učitelja pripravnika (Niess, 2005; Kocoglu, 2009; Schmidt i sur., 2009b; Akkoc, 2010; Karal i Bahcekapili, 2011; Chai i sur., 2010; Koh, Chai i Tsai, 2010; Kaya, Özdemir, Emre i Kaya, 2011). Međutim, provedena su i istraživanja koja su bila usmjerena na pedagoško i predmetno tehnološko znanje nastavnika koji već rade u struci (Jones i Moreland, 2004; Hofer i Swan, 2007; Groth, Spickler, Bergner i Bardzell 2009; Shin i sur., 2009). Općenito gledajući, istraživanja provedena među nastavnicima pripravnicima pokazala su da je veće pedagoško i predmetno tehnološko znanje rezultiralo većim znanjem i boljim vještinama nastavnika u kombiniranju tehnologije i pedagogije u praktičnoj nastavi. Međutim, neki tvrde da je integracija tehnologije u nastavu vrlo osoban pothvat za nastavnike. Vjeruje se da kontekstualni čimbenici i mnoge varijable utječu na razvoj nastavnikova, pedagoškoga i predmetnoga tehnološkog znanja (Jones i Moreland, 2004; Hofer i Swan, 2007).

Slika 1.

Kontekst

Kao i u drugim zemljama, i od učitelja u Turskoj očekuje se da razvijaju i poboljšavaju svoje vještine i znanje o tehnologiji i pedagogiji, te da uspješno koriste informacijsko-komunikacijsku tehnologiju u obrazovanju. Neki tvrde da su učitelji u stvari nastavnici generalisti od kojih se očekuje da poučavaju širok raspon nastavnih sadržaja u osnovnoškolskome kurikulumu, uključujući i korištenje informacijsko-komunikacijske tehnologije kao alata u svim nastavnim predmetima (Ardzejewska, McMaugh i Coutts 2010). Drugim riječima, učitelji imaju veće odgovornosti pri poučavanju nego nastavnici koji predaju u višim razredima osnovne škole. Usprkos toj činjenici, proveden je mali broj istraživanja o njihovu poznavanju i korištenju informacijsko-komunikacijske tehnologije u nastavnome procesu (Tezci, 2010; Altun i Sancak, 2010). Prijašnja istraživanja općenito su se bavila stavovima nastavnika o informacijsko-komunikacijskoj tehnologiji (Tezci, 2010), o njihovoj razini poznavanja informacijsko-komunikacijske tehnologije i računala (Sahin, 2009; Kaya i sur. 2011) te o njihovim pogledima na mogućnosti i prepreke u integriranju informacijsko-komunikacijske tehnologije u nastavni proces (Akkoyunlu, 2002). U Turskoj nisu provedena istraživanja koja bi se bavila time kako nastavnici shvaćaju tehnološko, pedagoško i predmetno znanje i njegove veze s ostalim demografskim varijablama. U tome smislu smatra se da je ovo istraživanje bitno kao poticaj drugim istraživanjima koja bi se bavila analizom tehnološkoga, pedagoškog i predmetnog znanja nastavnika u osnovnim školama.

S druge strane, međunarodna literatura u kojoj se raspravlja o pedagoškom i predmetnom tehnološkom znanju općenito se bavi problemima istoga kod pripravnika (Schmidt i sur., 2009b; Hu i Fyfe, 2010; Koh i sur., 2010; Kaya i sur., 2011). Takva istraživanja najviše se provode u SAD-u (Koh i sur., 2010: 565). U malom se broju istraživanja putem upitnika analiziralo pedagoško i predmetno tehnološko znanje učitelja koji već rade u struci (osim kod Koehlera i Mishre, 2005; Leeja i Tsaija, 2010). Grot i sur. (2009) proučavali su razvoj tehnološkoga, pedagoškog i predmetnog znanja nastavnika primjenom kvalitativnih metoda, dok su Jones i Moreland (2004) analizom slučaja pokušali povećati pedagoško i predmetno znanje tehnologije kod nastavnika koji rade na osnovnim školama. K tomu, objavljen je oskudan broj rezultata istraživanja o pedagoškom i predmetnom tehnološkom znanju s obzirom na demografske profile nastavnika. U stvari, literatura predlaže da se daljnje i dublje istraži veza između odrednica pedagoškoga i predmetnoga tehnološkog znanja i demografskih varijabli. Postoji potreba da se ispita imaju li ove varijable jak utjecaj na to kako učitelji shvaćaju pedagoško i predmetno tehnološko znanje. To bi pružilo smjernice za planiranje programa stručnog usavršavanja nastavnika (Lee i Tsai, 2010: 571).

Cilj istraživanja

Zbog nedostatka postojećih istraživanja o tehnološkome pedagoškom i predmetnom znanju nastavnika, ovo istraživanje predlaže analizu problema povezanih s tim znanjem na primjeru studije provedene među turskim učiteljima. Stoga je glavni cilj ovoga istraživanja ispitati pedagoško i predmetno tehnološko znanje turskih učitelja i njegovu vezu s njihovim demografskim profilima (npr. spol, radno iskustvo, razredi u kojima poučavaju, uporaba računala i interneta, uporaba računalnih laboratorija i obrazovnih računalnih programa). Opća je hipoteza istraživanja da demografski profili utječu na pedagoško i predmetno tehnološko znanje nastavnika. Iz te hipoteze proizlaze sljedeće pretpostavke koje će se testirati tijekom provođenja istraživanja:

Postoji razlika između spola učitelja i njihova, pedagoškoga i predmetnog tehnološkog znanja.

Razredi u kojima učitelji poučavaju utječu na način na koji shvaćaju svoje tehnološko, pedagoško i predmetno znanje.

Radno iskustvo učitelja utječe na njihovo poimanje tehnološkoga, pedagoškog i predmetnog znanja.

Postoji razlika između posjedovanja računala i internetske veze kod kuće i u školi i poimanja nastavnika o njihovu pedagoškom i predmetnom tehnološkom znanju.

Mjera u kojoj nastavnici koriste računalne laboratorije u školama utječe na njihovo poimanje tehnološkoga, pedagoškog i predmetnog znanja.

Postoji razlika između povećane uporabe edukativnih računalnih programa tijekom nastave i poimanja nastavnika o pedagoškom i predmetnom tehnološkom znanju.

Metode

Po svojoj prirodi, ovo se istraživanje koristi metodama općega deduktivnog istraživanja (Hitchcock i Hughes, 1995). Hipoteza navodi očekivanja voditelja istraživanja s obzirom na veze između varijabli u problemu istraživanja i deduktivnih hipoteza koje se izvode iz teorije. Cilj je istraživanja da doprinose obrazovnoj znanosti tako što će predočiti dokaze koji podupiru i proširuju navedenu teoriju ili joj proturječe (Gay, 1987: 53–55). Hipoteza istraživanja formulirana je i izvedena iz srodne literature jer se temelji na implikacijama prethodnih istraživanja. U svojemu su istraživanju, Koh i sur. (2010) otkrili da su poimanja pripravnika o pedagoškom i predmetnom tehnološkom znanju uglavnom u skladu s njihovim demografskim varijablama (npr. dob, spol, razredi u kojima poučavaju). Predviđa se da će demografski profili nastavnika koji rade u školama utjecati na njihovo poimanje pedagoškoga i predmetnoga tehnološkog znanja.

Turska verzija upitnika o pedagoškom i predmetnom tehnološkom znanju koju je prilagodio Bahcekapili (2011) koristila se kao instrument prikupljanja podataka. U proljetnom semestru 2010./2011. akademske godine, učiteljima koji rade u osnovnim školama Trabzona podijeljeno je 480 upitnika. Ispunilo je upitnik 322 učitelja (67%). Područje i nastavnici bili su izabrani metodom slučajnog odabira. Rezultati o demografskom profilu nastavnika koji su ispunili upitnik prikazani su u tablici 1.

Tablica 1.

Smatra se da navedene varijable predstavljaju demografski profil nastavnika. Spol, razredi u kojima poučavaju i radno iskustvo često su korištene varijable u istraživanjima ovoga tipa. K tomu, preliminarne studije pokazuju da su posjedovanje računala i internetske veze i u učionici i kod kuće varijable koje određuju nastavnikov stupanj korištenja tehnologije. Upravo su zbog toga ispitivane varijable uzete kao deskriptivne informacije o nastavniku kada se njegovo/njezino tehnološko, pedagoško i predmetno znanje analiziralo Likertovom skalom.

Kao što se može vidjeti 46,6% ispitanika bile su učiteljice, a 53,4% učitelji. Razredi u kojima su poučavali bili su ravnomjerno raspodijeljeni. Od učitelja koji su sudjelovali u istraživanju 77,6% ima više od 16 godina radnoga staža u prosvjeti, što je pokazatelj vladine politike da se u gradskim školama zapošljavaju iskusni nastavnici. Također se može vidjeti da većina nastavnika ima na raspolaganju računalo (84,2%) i većina (66,1%) ih je u svojim učionicama spojena na internet. Nadalje, većina nastavnika ima računalo kod kuće (94,7%), a većina (88,8%) ima i internetsku vezu. Usprkos činjenici da su sve škole opremljene računalnim laboratorijem, čini se da ih nastavnici rijetko koriste. Ovo može biti povezano s činjenicom da nastavnici imaju računalo i internetsku vezu u svojim učionicama, pa ih mogu koristiti u bilo koje vrijeme. Na kraju, uporaba edukativnih računalnih programa u poučavanju i učenju prilično je mala. Dogovorom koji su sklopili Turkish Telecom i Ministarstvo nacionalnog obrazovanja nastavnicima je omogućeno besplatno korištenje jednog od najboljih edukativnih računalnih programa, TTNET VITAMIN u učionicama. Taj edukativni interaktivni računalni program koristiti se internetom, a namijenjen je učenicima osnovne i srednje škole. Odobrilo ga je tursko Ministarstvo nacionalnog obrazovanja i u skladu je s Nacionalnim kurikulumom. Sastoji se od više od 3600 animacija i eksperimenata koji su izrađeni na modelu obrazovanja kojemu je dijete u središtu (http://www.ttnetvitamin.com.tr). Iz tablice 1 vidljivo je da je 23% nastavnika koji su sudjelovali u istraživanju odgovorilo da ga uvijek koriste u razredu. Ostali nastavnici ga ne koriste često, ali se može zaključiti da su upoznati s njime.

Instrument

Istraživanje *Pregled znanja koje pripravnici imaju o poučavanju i tehnologiji*, a kojega su proveli Schmidt i sur. (2009a), koristilo se kao glavni izvor prikupljanja podataka. Taj je rad, uz dopuštenje, na turski preveo i prilagodio Bahcekapili (2011). Na temelju niza statističkih analiza kao što su potvrdna faktorska analiza (eng. CFA), provjera valjanosti i pouzdanosti i drugi indeksi prikladnosti (CFI= 0,86, TLI= 0,85, RMSEA= 0,064, SRMR= 0.064), procijenilo se da je instrument prikladan kao radni instrument i da je prikladan za turske uvjete. U tome je modelu Bahcekapili (gore citirano) pronašao Cronbachove alfa vrijednost pouzdanosti između 0,80 i 0,90, dok je Cronbachova alfa vrijednost za cijeli instrument izračunata kao 0,982. Istraživanje se sastojalo od 47 stavova Likertove skale. Ti su stavovi grupirani u 10 poddimenzija pedagoškoga i predmetnoga tehnološkog znanja. Poddimenzije i broj stavova su sljedeći:

- TK (tehnološko znanje) – 7 stavova
- CK (predmetno znanje)
    - CK–M (predmetno znanje – matematika) – 3 stava
    - CK–S (predmetno znanje – prirodne znanosti) – 3 stava
    - CK–SS (predmetno znanje – društvene znanosti) – 3 stava
    - CK–L (predmetno znanje – pismenost) – 3 stava
- PK (pedagoško znanje) – 7 stavova
- PCK (pedagoško predmetno znanje) – 4 stava
- TCK (tehnološko predmetno znanje) – 4 stava
- TPK (tehnološko pedagoško znanje) – 5 stavova
- TPACK (pedagoško i predmetno tehnološko znanje) – 8 stavova

Slijede neki primjeri stavova u skali pedagoškoga i predmetnoga tehnološkog znanja:

Znam kako riješiti svoje tehničke problem (TK)

Mogu se koristiti matematičkim načinom razmišljanja (CK-M)

Imam dostatno znanje prirodnih znanosti (CK-S)

Mogu se koristiti čitavim nizom pristupa poučavaju u razredu (PK)

Mogu odabrati učinkovite pristupe poučavanju da bih vodio/vodila učenike k promišljanju i učenju u području društvenih znanosti (PCK)

Znam dovoljno o tehnologijama kojima se mogu koristiti da bi učenici razumjeli i uvježbali znanje o prirodnim znanostima (TCK)

Mogu odabrati tehnologije koje prate sadržaj koji predajem na nastavnom satu (TPK)

Mogu predavati sadržaje koji kombiniraju prirodne znanosti, tehnologije i pristupe poučavanju (TPCK).

Kako se TPACK instrument sastoji od četiriju nastavnih predmeta iz kurikuluma (matematike, prirodnih znanosti, društvenih znanosti i pismenosti) unutar kategorije Predmetno znanje (CK), pretpostavlja se da bi istraživanje bilo prikladno za učitelje i pružilo bi im priliku da slobodno daju svoje mišljenje budući da su upravo oni učitelji koji predaju sve te predmete. Nadalje, pretpostavilo se da bi analiza načina na koji učitelji kombiniraju četiri komponente pedagoškoga i predmetnoga tehnološkog znanja pružila jasniji uvid u stupanj integracije informacijsko-komunikacijskih tehnologija u osnovnoškolsko obrazovanje u Turskoj.

Uz TPACK istraživanje, autor je pripremio i dodao istraživanju i uvodni upitnik o demografskim profilima ispitanika. Da bi ispitao veze između tih varijabli i pedagoškoga i predmetnoga tehnološkog znanja učitelja, uvodni je upitnik sadržavao kao unaprijed određene nezavisne varijable pitanja o spolu, radnom iskustvu u prosvjeti, pristupu računalu i internetu u učionici i kod kuće, dostupnost računalnog laboratorija u školi i uporabu edukativnih računalnih programa u učionici.

Iako je istraživanje pružilo vrijedan uvid korištenjem uvodnoga upitnika o demografskim podatcima i TPACK istraživanju, neophodno je istaknuti da ga njegova ograničenja čine upitnim. Na primjer, teško je dublje razumjeti proces i kontekstualne razlike kroz upitnike koji su standardizirani i po svojoj prirodi ograničene duljine i dubine odgovora (Muijs, 2004: 44). Nadalje, ekološka vrijednost istraživanja može također biti dovedena u pitanje jer bi ona trebala pokazati da je istraživanje uključilo i obradilo što više karakteristika i čimbenika određene situacije da bi se izbjeglo ponavljanje retorike u obrazovnoj politici (Cohen, Manion i Morrison 2011: 195).

Rezultati

Podatci dobiveni skalom analizirani su uz pomoć SPSS 15 računalnoga programa. U analizi su se koristili parametrijski i neparametrijski testovi.

Spol i pedagoško i predmetno tehnološko znanje učitelja

Tablica 2 jest sažetak rezultata dobivenih o razlici između varijable spola i pedagoškoga i predmetnoga tehnološkog znanja učitelja.

Tablica 2.

Rezultati analize nezavisnog t-testa pokazuju da postoji značajna veza između varijable spola i nekih poddimenzija (CK–S, CK–L, PK i TCK) poimanja učitelja o pedagoškom i predmetnom tehnološkom znanju ($t_{CK\text{-}S}$=2,350; $t_{CK\text{-}L}$=1,990; t_{PK}=2,263; t_{PCK}=2,407 and t_{TCK}=2,040, $p<0,05$). Na temelju tih rezultata može se vidjeti da su u tim dimenzijama učiteljice imale veći rezultat nego njihovi kolege učitelji. Ako se analiziraju srednje vrijednosti rezultata, može se također vidjeti da su one prilično veće kod učiteljica nego kod učitelja, usprkos tome što su naizgled izjednačene (što bi značilo da je njihov značaj mali). U drugim dimenzijama pedagoškoga i predmetnoga tehnološkog znanja nije uočena značajna razlika što se tiče varijable spola.

Razred i pedagoško i predmetno tehnološko znanje učitelja

Na temelju jednosmjerne analize varijance (ANOVA) nije uočena značajna razlika između razreda u kojemu učitelj poučava i njegovoga/njezinoga pedagoškog i predmetnoga tehnološkog znanja. Može se zaključiti da razred u kojemu predaje nema veze s pedagoškim i predmetnim tehnološkim znanjem učitelja.

Radno iskustvo u prosvjeti i pedagoško i predmetno tehnološko znanje

Da bi se ispitala razlika između radnog iskustva učitelja ispitanika i njihova pedagoškoga i predmetnoga tehnološkog znanja, korištena je analiza nezavisnog t-testa. Rezultati su prikazani u tablici 3.

Tablica 3.

Rezultati nezavisnog t-testa pokazuju da je samo na temelju radnoga iskustva uočena značajna razlika u podkategoriji CK-SS (predmetno znanje – društvene znanosti) ($t_{CK\text{-}SS}$=-2,503; $p<0,05$). Utvrđeno je da su srednje vrijednosti učitelja (X=12,2399) koji imaju 16 i više godina radnoga iskustva u prosvjeti veće od srednjih vrijednosti učitelja čije je radno iskustvo između 0 i 15 godina (X=11,5334).

Dostupnost računala u učionici i pedagoško i predmetno tehnološko znanje učitelja

Budući da uzorak istraživanja nije bio pogodan za parametrijsku analizu, ovdje se koristio Mann- Whitneyjev U-test koji je jedan od neparametrijskih testova. Rezultati Mann-Whitneyjeva U-testa pokazali su da nema razlike između dostupnosti računala u učionici i pedagoškoga te predmetnoga tehnološkog znanja učitelja.

Dostupnost internetske veze u učionici i pedagoško i predmetno tehnološko znanje učitelja

Rezultati analize nezavisnog t-testa prikazani su u tablici 4, a pokazali su da postoji značajna razlika između dostupnosti internetske veze u učionici i neke od poddimenzija pedagoškoga i predmetnoga tehnološkog znanja ($t_{TK=}$-2,610; t_{CK-S}=-2,740; t_{PK}=-2,483; t_{TPK}=-2,261; t_{TPCK}=-2,056, p<0,05).

Tablica 4.

U dimenzijama poput TK (tehnološko znanje), CK-S (predmetno znanje – prirodne znanosti), PK (pedagoško znanje), TPK (tehnološko pedagoško znanje) i TPCK (pedagoško i predmetno tehnološko znanje) srednja vrijednost učitelja koji su odgovorili da imaju pristup internetu u svojoj učionici veća je od srednje vrijednosti učitelja koji su odgovorili da u učionici nemaju internetsku vezu.

Posjedovanje računala kod kuće i pedagoško i predmetno tehnološko znanje učitelja

I u ovome dijelu primijenjen je Man- Whitneyjev U-test, a rezultati su pokazali da ne postoji veza između posjedovanja računala kod kuće i pedagoškoga i predmetnoga tehnološkog znanja učitelja, osim u CK-SS dimenziji (predmetno znanje – društvene znanosti) pedagoškoga i predmetnoga tehnološkog znanja (t_{CK-SS}=0,026, p<0,05).

Dostupnost kućne internetske veze i pedagoško i predmetno tehnološko znanje učitelja

U analizi ove varijable primijenjen je Mann-Whitneyjev U-test, a rezultati su prikazani u Tablici 5.

Tablica 5.

Ti su rezultati pokazali da postoji značajna razlika između dostupnosti internetske veze kod kuće i određenih dimenzija pedagoškoga i predmetnoga tehnološkog znanja učitelja. Prema tim rezultatima, postoji značajna razlika između dostupnosti internetske veze kod kuće i tehnološkog znanja u TK i TPCK dimenzijama (P_{TK}=0,014; and P_{TPCK}=0,016, p<0,05).

Iznenađuje činjenica da posjedovanje računala koje nema internetsku vezu ni kod kuće ni u učionici, ne čini nikakvu razliku s obzirom na pedagoško i predmetno tehnološko znanje učitelja. Međutim, pokazalo se da dostupnost internetske veze ima pozitivan utjecaj na pedagoško i predmetno tehnološko znanje učitelja. Na temelju tih rezultata može se reći da računalo bez internetske veze ima ograničenu dobrobit za učiteljevo poznavanje tehnologije i pedagogije u modernome vremenu.

Korištenje računalnog laboratorija u školi i pedagoško i predmetno tehnološko znanje učitelja

Kao što je već spomenuto, računalni laboratorij (koji se sastoji od barem 20 računala s internetskom vezom, printera i projektora) postoji u svakoj osnovnoj školi u Turskoj. Učitelji koriste računalne laboratorije kada je potrebno, sustavom rotacije. Rezultati razlika između uporabe računalnih laboratorija i pedagoškoga i predmetnoga tehnološkog znanja učitelja prikazani su u tablici 6.

Tablica 6.

Jednosmjerna analiza varijance (ANOVA) pokazuje značajnu razliku između korištenja računalnog laboratorija i nastavnikova pedagoškoga i predmetnoga tehnološkog znanja u TK, TPK i TPCK dimenzijama (F_{TK}=5,277; F_{TPK}=3,518; F_{TPCK}=3,616, $p<0,05$).

Da bi se utvrdio razlog razlike u navedenim dimenzijama, provedena je post hoc analiza najmanje značajne razlike. Što se tiče TK dimenzije utvrđeno je da je srednja vrijednost učitelja koji su odgovorili „uvijek" na stav „Koristim se računalnim laboratorijem u školi" (*X*=3,90826) bila veća od srednje vrijednosti učitelja koji su na tu tvrdnju odgovorili „ponekad" (X=1,48314), „rijetko" (X=2,42511) i „nikada" (X=1,32892).

Slično tomu, za dimenziju TPK se pokazalo da je srednja vrijednost učitelja koji su na tvrdnju „Koristim se računalnim laboratorijem u školi" odgovorili „ponekad" (*X*=2,12251) bila veća od srednje vrijednosti učitelja koji su na tu tvrdnju odgovorili „nikada" (X=1,28933).

Uporaba edukativnih računalnih programa i pedagoško i predmetno tehnološko znanje učitelja

Stupanj u kojem učitelji koriste edukativne računalne programe tijekom procesa poučavanja ispitivan je kroz cijelu skalu da bi se provjerila njegova veza s pedagoškim i predmetnim tehnološkim znanjem učitelja. Rezultati jednosmjerne analize varijance (ANOVA) za tu varijablu prikazani su u tablici 7, a pokazuju da postoje značajne razlike između stupnja u kojem se učitelji koriste edukativnim računalnim programima tijekom nastave i četiriju podfaktora TPACK skale (F_{TK}=13,074; F_{TCK}=3,275; F_{TPK}=3,518; F_{TPCK}=4,341, $p<0,05$). Drugim riječima, postoji veza između uporabe edukativnih računalnih programa tijekom procesa poučavanja i učenja i pedagoškog i predmetnog tehnološkog znanja učitelja.

Tablica 7.

Da bi se utvrdio razlog razlike u spomenutim dimenzijama TPACK skale, još jednom je provedena post hoc analiza najmanje značajne razlike. Rezultati su pokazali da je unutar TK dimenzije srednja vrijednost učitelja koji su odgovorili da se „uvijek" (X=5,76828) koriste edukativnim računalnim programima tijekom nastave bila veća od srednje vrijednosti učitelja čiji su odgovori bili „rijetko“ (X=3,99801) i „nikada“ (X=2,94868).

Što se tiče TCK dimenzije srednja vrijednost učitelja koji su odgovorili da se „uvijek“ (X=1,64676) koriste edukativnim računalnim programima u nastavi bila je veća od srednje vrijednosti učitelja koji su na tu tvrdnju odgovorili „nikada“ (X=,70914).

Što se TPK dimenzije tiče, srednja vrijednost učitelja koji su odgovorili da se „uvijek“ (X=2,05887) koriste edukativnim računalnim programima tijekom nastave bila je veća od srednje vrijednosti učitelja koji su odgovorili „ponekad“ (X=1,65286), „rijetko“ (X=1,45669) i „nikada“ (X=0,60218).

Na kraju, što se tiče TPCK dimenzije, srednja vrijednost učitelja koji su odgovorili da se „uvijek“ (X=4,40242) koriste edukativnim računalnim programima bila je veća od srednje vrijednosti učitelja koji su na tu tvrdnju odgovorili „nikada“ (X=1,86425).

Rasprava

Kao prvo, rezultati istraživanja upućuju na to da postoje neke ključne varijable koje utječu na pedagoško i predmetno tehnološko znanje učitelja u određenim dimenzijama. Spol je jedna od najčešće provjeravanih varijabli u istraživanjima opsega u kojemu učitelji koriste IKT, kao i u drugim pedagoškim istraživanjima (Teo, 2008; Tezci, 2010). U ovome su istraživanju rezultati pokazali da učiteljice postižu veće rezultate nego njihovi muški kolege u određenim dimenzijama skale pedagoškoga i predmetnoga tehnološkog znanja. Ovaj rezultat nije u skladu s rezultatima prijašnjih istraživanja o pripravnicima u kojima su muški ispitanici procijenili da je njihovo znanje informacijsko-komunikacijskih tehnologija veće od onoga njihovih kolegica (Koh i sur., 2010). Dosta je značajno da su u sljedećim dimenzijama pedagoškoga i predmetnoga tehnološkog znanja učiteljice ostvarile bolje rezultate nego muški ispitanici: u predmetnom znanju (prirodne znanosti i pismenost), pedagoškom znanju, pedagoškom predmetnom znanju i tehnološkom predmetnom znanju. To može biti povezano sa stavovima nastavnika o poučavanju, u kojima pozitivan stav učiteljica prema pedagogiji i tehnologiji može dovesti do boljih rezultata. Može se vidjeti da su mišljenja učiteljica više vezana uz elemente pedagogije (PK; PCK) i predmeta (CK-S, CK-L, PCK) u sklopu učiteljskih kompetencija, nego što su vezana uz tehnologiju (osim TCK). Drugim riječima, možemo tvrditi da učiteljice imaju više interesa ili možda znanja u pedagoškim i predmetnim dimenzijama pedagoškoga i predmetnoga tehnološkog znanja, a manje interesa pokazuju za tehnološku dimenziju.

Istraživanje nije pokazalo značajnu razliku s obzirom na vezu između razreda u kojima učitelji poučavaju i njihova pedagoškoga i predmetnoga tehnološkog znanja. Koh i sur. (2010) u svojemu su istraživanju zaključili da se shvaćanje pedagoškoga i predmetnoga tehnološkog znanja ne razlikuje s obzirom na razred u kojemu učitelji poučavaju (iako su uspoređivali shvaćanja pripravnika u osnovnoj i srednjoj školi). Rezultati toga istraživanja nisu iznenađujući jer su svi učitelji ispitanici predavali više predmeta i imali su radno iskustvo u svim nižim razredima osnovne škole. Kao što je već ranije spomenuto, zbog sustava rotacije u Turskoj učitelji poučavaju istu skupinu učenika pet godina (od prvog do petog razreda). Stoga imaju sposobnost poučavanja svih razreda, pa kao što je ovo istraživanja pokazalo razred u kojemu poučavaju nema utjecaja na pedagoško i predmetno tehnološko znanje učitelja.

U istraživanju nije pronađena gotovo nikakva veza između radnoga iskustva učitelja ipitanika i njihova pedagoškoga i predmetnoga tehnološkog znanja (osim u CK-SS dimenziji). Taj podatak nije u skladu s rezultatima do kojih su došli Lee i Tsai (2010) koji su uočili značajnu razliku između stavova mlađih i starijih učitelja o pedagoškom i predmetnom tehnološkom znanju i uspješnosti u TPACK-W dimenziji. Kao što tablica 1 prikazuje, većina učitelja sudionika (77,6%) imala je više od 15 godina radnoga iskustva u prosvjeti, što je rezultat politike zapošljavanja učitelja i nastavnika u Turskoj prema kojoj mlađi učitelji rade u manjim gradovima i selima na početku svoje karijere, a kasnije se premještaju u urbane škole ovisno o ocjeni njihova rada koju daje prosvjetna inspekcija. Stoga se može reći da zbog slične dobne skupine u uzorku istraživanja (koja je bila nenamjerna) nije uočena veza između varijable dobi i, pedagoškoga i predmetnoga tehnološkog znanja učitelja.

Jedan od najvažnijih rezultata istraživanja bila je činjenica da posjedovanje računala u učionici i kod kuće nema nikakva utjecaja na pedagoško i predmetno tehnološko znanje učitelja. Međutim, dostupnost internetske veze čini značajnu različku u znanju učitelja. Jasno je da računalo bez internetske veze ne pruža puno edukativnih mogućnosti. Internet obogaćuje računalo u smislu pristupa, skidanja i pohranjivanja informacija. Usprkos tomu što većina učitelja ispitanika ima barem jedno računalo u svojoj učionici (84,2%) i kod kuće (94,7%), očito je da to nema nikakva utjecaja na njihovo pedagoško i predmetno tehnološko znanje. Rezultati istraživanja pokazali su da je, kada učitelji imaju pristup Internetu, vidljiva značajna veza s pedagoškim i predmetnim tehnološkim znanjem učitelja u dimenzijama kao što su TK, CK-S, PK, TPK i TPCK. Taj je rezultat u skladu s onima Levina i Wadmanyja (2005) koji su utvrdili da bogata tehnološka okolina ima utjecaj na znanje učitelja. Nadalje, ovaj rezultat je sličan i onomu Eachusa i Cassidyja (2006) koji su zaključili da su broj sati i dužina vremena koje redovni korisnici interneta provedu na internetu u pozitivnoj korelaciji, što pokazuje da iskusniji korisnici interneta imaju veći osjećaj samoučinkovitosti (Eachus i Cassidy, 2006: 5).

Kao što je već navedeno u ovome istraživanju, srednje vrijednosti učitelja u pedagoškome i predmetnome tehnološkom znanju bile su veće kod učitelja koji se češće koriste računalnim laboratorijem u svojoj školi nego kod učitelja koji se njime rjeđe koriste. Primijećeno je da je uporaba računala i interneta češće u vezi s nekim promjenama u nastavnom procesu i shvaćanjima nastavnika. Također se pokazalo da je veza između uporabe tehnologije i pedagoških promjena uistinu povremena (Becker i Ravitz, 1999: 381). I ovo istraživanje je, kao i ono Beckera i Ravitzyja, pokazalo vezu između korištenja internetom od strane učitelja i njihova znanja o tehnologiji u pedagogiji i predmetima.

Na kraju, pokazalo se da postoji značajna veza između učestalosti kojom se učitelji koriste edukativnim računalnim programima i njihova pedagoškoga i predmetnoga tehnološkog znanja. Poznato je da se računala i računalne tehnologije mogu uključiti u obrazovanje putem edukativnih računalnih programa. Drugim riječima, za učenike računala ostvaruju svoj puni potencijal kroz edukativne računalne programe, a pokazalo se i da je učinkovita pedagogija koja se temelji na uporabi računala povezana s time koliko se učitelji koriste edukativnim računalnim programima u svome radu s učenicima (Niederhauser i Stoddart, 2001). Također se pokazalo da na shvaćanja nastavnika o pedagoškom i predmetnom tehnološkom znanju utječe češće korištenje dostupnih edukativnih računalnih programa kao što su TTNET i VITAMIN u nastavnome radu. Mumcu, Haslaman i Usluel (2008) smatraju da je jedan od pokazatelja učinkovite integracije tehnologije u nastavni proces i mogućnost lakog pristupa učitelja hardveru i edukativnim računalnim programima i njihova uporaba u edukativne svrhe. Rezultati ovoga istraživanja u skladu su i s onima koji pokazuju da je korištenje mrežnoga edukativnog računalnog programa (GeoThentic software) rezultiralo većim tehnološkim znanjem (TK), tehnološkim predmetnim znanjem (TCK) i pedagoškim i predmetnim tehnološkim znanjem (Doering, Veletsianos, Scharber i Miller, 2009). Rezultati potvrđuju i tvrdnju da se razine znanja i vještine učitelja mijenjaju na bolje kada se učitelji učinkovito koriste edukativnim računalnim programima.

Zaključak

Ovo istraživanje imalo je za cilj ispitati veze, ukoliko postoje, između različitih nezavisnih varijabli i pedagoškoga i predmetnoga tehnološkog znanja učitelja na osnovu kvantitativnih rezultata. Rezultati istraživanja pokazuju da varijable kao što su spol, korištenje internetskih izvora znanja, internet i edukativni računalni programi utječu na razvoj nekih dimenzija pedagoškoga i predmetnoga tehnološkog znanja učitelja.

Usprkos činjenici da se tehnike provođenja istraživanja bave računanjem, postotcima i statističkim koeficijentima još uvijek smo na početnom stupnju razumijevanja toga kako su dimenzije pedagoškoga i predmetnoga tehnološkog znanja integrirane i u kakvom su odnosu tijekom učiteljeva pedagoškog razvoja. Čini se poštenim reći da bi učitelji trebali dobiti pedagoški primjerenu tehnologiju pa bismo mogli dobiti uvid u to kako učitelji čine tehnologiju pedagoški primjerenom na temelju njihova rada (Ferdig, 2006).

Rezultati istraživanja pružaju dokaze o korelaciji između učestalosti kojom se učitelji koriste informacijsko-komunikacijskim tehnologijama i njihova shvaćanja pedagoškoga i predmetnoga tehnološkog znanja. Međutim, nije jasno može li se pedagoško i predmetno tehnološko znanje učitelja prenijeti u učionicu, tj. u kontekst poučavanja. Možemo predložiti da bi trebalo provesti više istraživanja temeljenih na promatranju i kvalitativnom pristupu, kao što je ono Grotha i sur. (2009), da bi se dobio bolji uvid u to koliko učiteljevo korištenje informacijsko-komunikacijskim tehnologijama u nastavi utječe na pedagoško i predmetno tehnološko znanje učitelja. Kao što su Harris, Mishra i Koehler (2009) predložili, učitelji bi trebali razviti svijest o izradi raznih vrsta nastavnih aktivnosti unutar područja nekoga predmeta i njihovoj primjeni u pedagoškim procesima. Također bi trebali znati koja je tehnologija prikladna za razvoj pedagoškoga i predmetnoga tehnološkog znanja i kako bi se njome trebali koristiti.

Rezultati ovoga istraživanja upućuju i na to da postoji veza između korištenja informacijsko-tehnoloških izvora u laboratoriju i na internetu i dimenzija pedagoškoga i predmetnoga tehnološkog znanja. Stoga kako je pokazao Ferdig (2006), postoji potreba za daljnjim istraživanjima koja bi mogla ispitati i objasniti, na primjer kako učitelji mogu koristiti Word Wide Web (www) ili edukativne računalne programe poput VITAMIN-a kako bi pomogli osnovnoškolcima pri učenju prirodnih znanosti i matematike. U ovome trenutku nemamo podatke o stručnom usavršavanju učitelja sudionika u ovome istraživanju u kojima bi oni opisali kako, kada i gdje su stekli svoje pedagoško i predmetno tehnološko znanje i na kojem su stupnju ovladanosti njime. Jedno od ograničenja ovoga istraživanja jest nedostatak podataka o sudjelovanju učitelja ispitanika u stručnom usavršavanju ili o mogućnostima stjecanja, pedagoškoga i predmetnoga tehnološkog znanja koje su imali tijekom svojega pripravničkog staža. K tomu, više ozbiljnijih intervjua s odabranim učiteljima pribavilo bi nam kvalitativne podatke koji bi nam pomogli bolje razumjeti značenje koeficijenata i veze između unaprijed određenih varijabli i pedagoškoga i predmetnoga tehnološkog znanja učitelja.

Jasno je vidljivo iz rezultata istraživanja da na stjecanje pedagoškoga i predmetnoga tehnološkog znanja učitelja utječe učestala upotreba izvora informacijsko-komunikacijskih tehnologija, kao što su internet, računalni laboratorij i edukativni računalni programi. Budući da učitelji predaju više od jednog predmeta, korektno je reći da bi im trebalo omogućiti više pristupa informacijsko-komunikacijskim izvorima i da bi im trebalo pružiti stručno usavršavanje u svim područjima kurikuluma, kao i mogućnost da poučavaju u tehnološki bolje opremljenim učionicama. Kao što je naglasio Yelland (2002), bez mogućnosti prikladnoga stručnog usavršavanja učitelji neće moći učinkovito uključiti informacijsko-komunikacijske tehnologije u svoju nastavu (Yelland, 2002: 87).