Analysis of Technological Pedagogical Content Knowledge Studies in Turkey: A Meta-Synthesis Study

Gül Kaleli Yılmaz [1]

Abstract

The purpose of this research is to analyze the Technological Pedagogical Content Knowledge (TPACK) studies in Turkey by using meta-synthesis method and to present the type of tendency in this field. In the research, a total of 59 studies made up of 37 papers, 15 dissertations, and 7 assertions which were published between the years of 2008-2014 and chosen through purposeful sampling method were analyzed. Google Academics search engine, TÜBİTAK ULAKBİM DergiPark, YÖK National Dissertation Center, EBSCOhost-ERIC ve SPRINGER databases took advantages of selecting the studies. Each study were examined within the context of the study's purpose, subject area, method, sample, data collection tools, teaching applications and results by being subjected to content analysis. Obtained data were interpreted depending on the frequency and partly illustrated through tables and graphs. In the research, the results showed that a significant portion of the studies were conducted with the aims of scale validation/adaptation, examination of TPACK competences and developments; that a few number of studies focused on a special subject area; that survey study and data collection tolls such as scale/survey were used mostly; that studies conducted with prospective teachers were majority; that although it had been revealed that the participants usually have high levels of TPACK competence/perception in quantitative studies, the situation was contrary in qualitative weighted studies; that different teaching applications such as TPACK workshops, mixed vocational development program, blended learning increases TPACK. In light of the obtained results, it was seen that studies targeting TPACK development in which implementations are carried in a long process through using a quite number of data collection tools are needed in Turkey. Besides, it was recognized that the courses in education faculties should be re-updated according to TPACK and teachers or prospective teachers should be trained with the help of courses or in/pre-service training programs. Lastly, recommendations were made for researchers, program makers and appliers who will do studies in this field.

[1] Bayburt University, Faculty of Education, Department of Primary Education, Turkey, gyilmaz@bayburt.edu.tr

Introduction

A teacher must have different qualifications apart from content knowledge order to conduct his/her lessons. These qualifications are described in the framework of Pedagogical Content Knowledge by Shulman (1986, 1987). According to the theoretical framework which put forward by Shulman, a teacher must firstly have a deep content knowledge and pedagogical knowledge in order to teach content knowledge effectively. However the result of the technological changing and development have propounded in recent years that it is not enough to have only a teacher's pedagogical content knowledge and usage of technology knowledge should be handle among the teachers' qualifications (Anderson, 2008). As it is known technology includes all machines, methods, processes, management and control mechanisms which serves as a bridge between practice and science that utilized in the process of implementation of science to the problems of production, transportation, education and etc. areas (Alkan, 1998). As a result of developments in the field of technology, technologies that used in education have shown changes towards advanced technology (computers, etc.) from standard technology (blackboard, chalk etc.). However, there are still more important issues in the use of technology in educational process. Previously, the use of technology in education was considered to create a reform. Despite this, technology has been studied only for mounting to traditional learning and that has prevented the realization of the expected changes. There are several factors underlying why this change has not taken place. These factors are discussed under two groups as internal (belief, attitude, self-confidence etc.) and external (equipment, time, technical support etc.) by various researchers (Ertmer, 2005; Mazman and Koçak-Usluel, 2011). Ertmer (2005) states that when the technology is intended to be integrated into te courses, external factors can be easily resolved, however it is more difficult and significant process to change the internal factors that are directly related to the teachers. As it is known, the main element that makes education meaningful and effective is teacher (Çelik and Bindak, 2005). The quality of education-training is in a direct relationship with qualifications of teachers and no matter how functional the training program has been prepared, if teachers who are the main element of the education are not competent in this field, it is obvious that the expected change will not take place (Demirel and Kaya, 2003). Moreover, it is known that any reform movement will not be succesfull unless it is well understood, internalized, and applied in an effective manner by teachers (Baki, 2002). Therefore, how the technology should be used in courses has to be taught to teachers firstly. TPACK steps in at this point.

TPACK is based on Shulman's (1987) pedagogical content knowledge idea; in order to define teachers understand the technological and pedagogical content knowledge that is in interaction with technology to effective education . TPACK has three basic components. These are; content, pedagogy and technology.
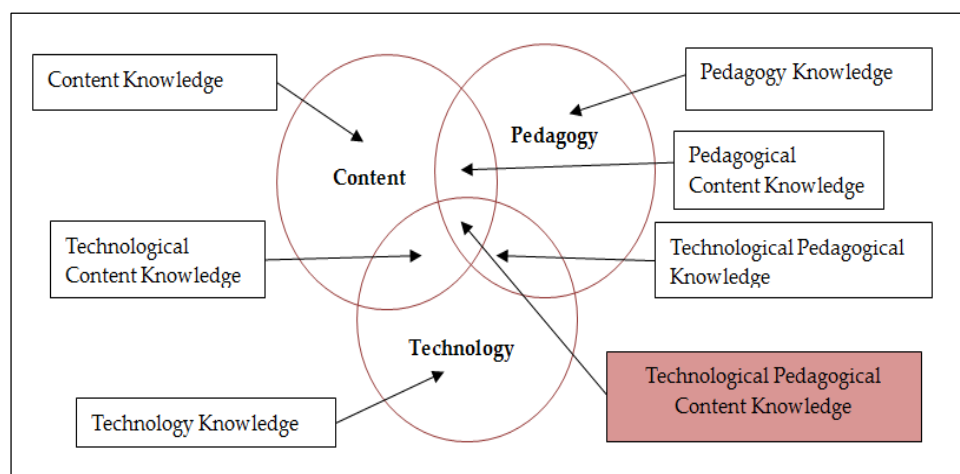
Figure 1. TPACK framework and knowledge components (Koehler and Mishra, 2008)

Each component within TPACK is explained briefly below (Koehler and Mishra, 2008):

Content Knowledge: It is the knowledge about the subject that needs to be learned or taught.

Pedagogy Knowledge: It includes knowledge about methods, techniques and strategies used in the classroom and it does not deal with what is being taught, it deals with how it is being taught.

Technology Knowledge: It is the knowledge that teachers have concerning the use of all technological tools-instrument ranging from standard technologies (black board, chalk etc.) to advanced technologies (computer etc.).

Technological Content Knowledge: It is the knowledge about which technology is suitable for the subject to be taught and to which opportunities and limitations technology may bring in the teaching of the subject.

Pedagogical Content Knowledge: It is the knowledge about how a subject area should be taught.

Technological Pedagogical Knowledge: It includes knowledge about how various technological instruments can be used in education and how the education process would change through the use of technology.

Technological Pedagogical Content Knowledge (TPACK): It is the knowledge about how technology could be used to understand the illustrations of concepts, to teach the content with different constructivist ways, to develop new knowledge theories and strengthen existing knowledge theories and how technology could help conceptual complexities.

The explanations above suggest that a teacher should integrate technology into his/her courses; he/she requires having TPACK first. It is seen that a large number of studies on TPACK have been carried in the recent years because of this requirement. Especially in the studies conducted abroad, it is observed that an important portion of studies are carried as face to face lecture/course activities, researchers directly involved in the process, TPACK components are examined separately and applications undertaken usually increase the TPACK development of the participants either partially or entirely (Guzey and Roehrig, 2009; Jang and Chen, 2010; Chai, Koh, Tsai and Tan, 2011; Morsink, Hagerman, Heintz, Boyer, Harris and Kereluik, 2011; Niess, Van-Zee and Gillow-Wiles, 2011). Furthermore, two researches seeking to reveal what kind of tendencies towards TPACK exists abroad were encountered during reviews. One of them was conducted by Voogt, Fisser, Pareja-Roblin, Tondeur and Braak (2013). Voogt et.al., (2013) at the research in which he reviewed 56 studies published between the years of 2005-2011 with systematic literature review, obtained the results that TPACK is a complex concept, the major strategies for increasing students' and teachers' TPACK development are lessons and course designs supported with technology in which the teacher and students actively are involved in the process; even though teachers have experience with technology, they are unable to show it. Another study is the literature review carried by Chai, Koh and Tsai (2013). 74 papers that examine technology integration within TPACK framework and were published between 2003 and 2011 were reviewed in the study. The papers to be included in the study were chosen among Web of Science and Scopus databases. Results such as the studies are mostly conducted in 2010, a considerable part of the studies were carried in North America, only four studies from Turkey were included in the relevant research, qualitative, quantitative and mixed research approaches were adopted, the studies are mostly carried on the subject area of education technologies and usually constructivist philosophy is accepted were obtained. When the literature is reviewed, no studies putting forward what kind of tendency exists in Turkey on TPACK were encountered. In this regard, within the scope of this study, it is aimed to examine dissertations, papers and assertions about TPACK which were carried by Turkish researchers in Turkey and to set forth what kind of tendency exists in this field in our country by using meta synthesis method. The answers to the questions below were sought: In the TPACK studies carried in Turkey;

1. Which aims were targeted?
2. Which subject areas were examined?
3. Which methods were used and how was the process run?
4. Which sample groups were chosen?
5. Which data collection tools were used for what purposes?
6. What kind of similarities and differences exist among the teaching applications being used?
7. What results were obtained?

Significance of the Research

Since TPACK studies carried in Turkey are being undertaken on which subjects with what purposes, which methods are being used and which processes are being followed, what consequent to this study, what kind of similarities and differences exist among the applications, which results are obtained and what kind of studies are needed will be explained in details consequent to this study, it will shed light to those who will conduct research in this field. Researchers will be able to see what kind of a TPACK tendency exist in Turkey in general by reading this paper instead of reading 59 studies one by one and they would direct their own studies in a better way. Furthermore, thanks to this paper, hence researches will be able to know which subjects had been studied before; undertaking same kinds of studies would be avoided.

Limitations of the Research

This research covers the studies produced by Turkish researchers in Turkey between the years of 2008-2014 and is limited to 59 studies listed in the references. In the examined studies it has been seen on the studies which have been observed, that, apart from the TBAP, the attitude towards the lectures, perception on the use of smart board and variables like way of instructions were also studied. But since the TBAP dimension has been dealt with, data which does not concern TBAP directly has not been included in to the study. For example a surveillance carried out, may prove that TBAP levels of the prospective teacher or their attitudes for mathematics could be high. Yet their high level of attitude for mathematics is not a direct result regarding to TBAP. Therefore such data was excluded from the scope of the study. However it is a significant result that those who have high attitude towards the mathematics also have high TBAP, so these data been included in the study as directly relevant to TBAP.

Method

Design of the Research

This research is a meta-synthesis study within content analysis studies. Meta-synthesis is the interpretation and synthesizing the studies carried on the same subject through forming themes or main templates with a critical point of view. In meta synthesis researches, it is aimed to examine the studies carried on a specific subject with a qualitative insight and set forth their similarities and differences comparatively and constitute a rich source of reference for researchers, teachers and other relevant individuals who does not have opportunity to access all studies (Çalık and Sözbilir, 2014). The meta-synthesis study was used in this research too, since it is aimed to analyze the studies on TPACK prepared by Turkish researchers and what is carried out in Turkey with qualitative methods and to determine what kind of a tendency exists.

Data Collection and the Criteria for Their Inclusion to the Research

It was seen that the Technological Pedagogical Content Knowledge which has been abbreviated as TPACK or TPCK in literature in English were being used with different abbreviations such as "TPAB", "TPİB", "TÖMAB". Therefore, "TPAB", "TPİB", "TÖMAB", , "TPACK", "TPCK", "technological pedagogical", "technological pedagogical content knowledge" keywords were used during the research. The studies to be included in the research were reached through Google Academic search engine, TÜBİTAK ULAKBİM DergiPark, National Dissertation Center of Board of Higher Education, EBSCOhost-ERIC and SPRINGER databases. While identifying the resources to be included in the study, conditions were having the sample that is subject of the study within borders of Turkey and being a paper, dissertation or assertion what is carried out by Turkish researchers. After this elimination process, research was conducted over 59 studies 37 of which were papers, 15 of which were dissertations, the rest 7 were assertions.

Coding Process

Initially, related parts of each study included in the research were read in details and the obtained data were noted to paper. Later, data were re-checked and unnecessary parts were removed and pivot data of each study were recorded to computer environment. The studies were examined one by one according to their research problems and codes were appointed for each theme. Furthermore, in order to avoid having plentiful data, each examined study was coded as A1, A2,…, A59 and these codes were used in the research.

Validity and Reliability of the Research

In order for preventing any mistakes during the coding process, studies were examined in a long period and all the pivot data obtained were written. For ensuring the reliability of the coding, after about one month the researcher conducted the analyses again, it was seen that the coding matches in itself consistent in %98. Furthermore, the study was evaluated by two expert academicians one of whom was an expert on TPACK field and the other was an expert on meta-synthesis and its validity and reliability was checked.

Analysis of Data

In this research, initially, data obtained from qualitative and quantitative studies were presented for each theme as tables or graphs in connection with the aim of the team. The purpose of presenting data as such was that both it is visual and it provides the opportunity to have an idea about the studies carried at first sight. Only frequencies were included in tables and graphs statistically. After a general explanation is made under each table or graph, what the similarities and differences recognized are analyzed according to their degree of importance in details through using content analysis method.

Results

Findings obtained as a result of data analysis were included in this part.

Aims of Reviewed Studies

The table and explanations about the aims of studies reviewed within the scope of the research are included below:

Table 1. Data concerning the aims of the reviewed studies

Aims	Studies	f
Identification of TPACK competencies	A4, A6, A10, A12, A13, A15, A17, A21, A24, A28, A43, A52	12
The research of the relation between TPAB and different variables	A5, A25, A31, A36, A38, A40, A49, A51, A58	9
Examination of TPACK development	A3, A11, A26, A32, A34, A53, A57, A59	8
Adapted TPACK scale/survey into Turkish and testing its validity and reliability	A14, A20, A23, A27, A29, A41, A54	7
Examination of the effect of the program prepared with an aim to gain TPACK on developments in different components	A1, A2, A16, A39, A56	5
Determination of the relation among TPACK and learning strategies/teaching styles/thinking styles	A9, A18, A19, A35	4
Development of scale/survey for TPACK	A8, A22, A50	3
Examination TPACK and technology integration	A30, A33, A42	3
Examination of the relationship between the prepared teaching materials and TPACK	A46, A47, A48	3
Identification of TPACK self-confidences	A45, A55	2
Identification of TPACK images	A7	1
The explanation of required PAB and TPAB for instruction.	A37	1
Examination of the relation among TPACK components	A44	1

As it is seen in Table 1, a considerable part of the studies were conducted with the purpose of identifying TPACK competencies, the research of the relation between TPAB and different variables, adapted TPACK scale into Turkish and testing its validity and reliability and examining the TPACK development. It stands out that there are fewer studies carried for other purposes.

Subject Areas Dealt by the Reviewed Studies
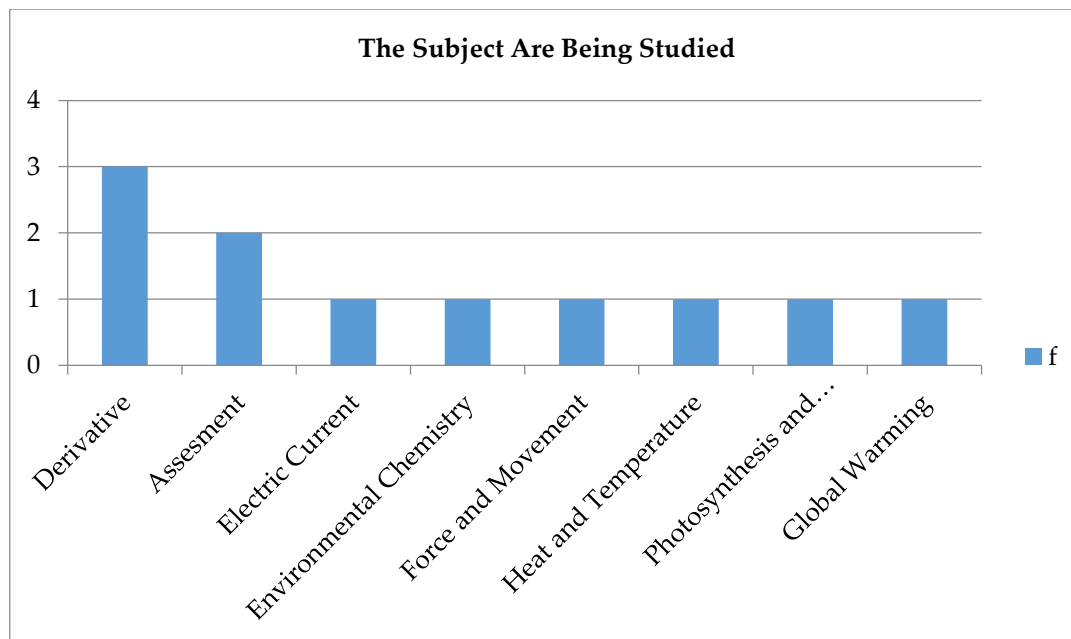
Figure 2. Studied Subject Areas

It was recognized that a specific subject area was focused in only 11 of the reviewed studies, view/perception/competence etc. were sought to be identified in others. When Figure 2 is examined, it stands out that the subjects dealt with these studies were on science and mathematics fields. Among these studies, related to the field of mathematics and those in which assessment and evaluation and derivative subjects were examined are parts of TÜBİTAK project numbered 107K531 (A1, A2, A16, A39, A56). The paper (A11) covers the environmental chemistry among field of science and the other studies are postgraduate and PhD dissertations (A6, A25, A26, A31 and A53). However, having only 11 studies among 59 reviewed studies that focus on a specific subject area reveals the deficiency in this field. Thus, when the fact that TPACK necessitates to have knowledge about technological tools-instruments that are needed to be used in teaching a specific subject is taken into consideration, actually it is obvious that carrying every study on a specific subject area would put forward more effective results.

Methods Used in Reviewed Studies

The table and explanations about the methods of studies reviewed within the scope of the research are included below:

Table 2. Data concerning the Methods of the Reviewed Studies

Research Method		Studies	f
Quantitative	Survey	A4, A5, A8, A9, A12, A14, A15, A17, A18, A19, A20, A21, A22, A23, A25, A27, A28, A29, A31, A34, A35, A36, A38, A40, A41, A44, A45, A49, A50, A51, A52, A54, A55	33
	Experimental method	A3, A10, A11, A26, A47, A48	6
	Relational research method	A43	1
Qualitative	Case Study	A1, A2, A7, A16, A39, A56, A57	7
	Phenomenology research	A13	1
	Grounded theory	A42	1
Mixed Method		A6, A24, A32, A53, A58	5
Literature Review		A30, A33, A37, A59	4
Action Research		A46	1

In a considerable part of the reviewed studies, the survey study that is among quantitative research methods was chosen. In almost all of the studies in which survey study was applied, it was recognized that the data was collected with a few number of measuring tools and the current situations was sought to be revealed through conducting short term researches. Two of the experimental studies are PhD dissertations (A26 and A47); four were papers (A3, A10, A11 and A48). These studies were carried in a long process within the scope of courses such as Special Teaching Methods (STM), School Experience (SE), School teaching Performance (SP), Teaching Design (TD) Computer Assisted Mathematics Teaching (CAMT) and applications were performed by prospective teachers occasionally. In the study in which the relational research method was used, the data of the study were collected in a short period of time by only using scale.

One of the studies in which case study method was applied is assertion (A7), two of the studies are paper (A2, A39), and the others are postgraduate dissertations (A1, A16, A56, A57). Three of these studies are postgraduate dissertations produced out of TÜBİTAK project numbered 107K531 (A1, A16, A56), and two of the studies are paper (A2, A39). All five of these studies were carried in a long process after TPACK workshops held under the project, both qualitative and quantitative data collection tools were used in the studies and applications were performed by prospective teachers. In the dissertation carried by A57, a long term study was conducted with postgraduate students. In the study, the module of learning by design with TPACK game activities was observed, quantitative and qualitative data collection tools were used. A7 carried a long term study by using qualitative data collection tools and micro teaching method within the scope of STM and SP courses. The phenomenology research method was used in only one study and study data were obtained through focus groups with a few numbers of individuals (A13). The study which covers the grounded theory method, the data has been collected in a long period, based on a distance education, making use of any tools to collect data (A42).

Two of the studies in which mixed method was used is PhD dissertation (A6, A53), two are postgraduate dissertations (A24, A32), on is paper (A58). Three dissertations were carried in a long process and initially participants were trained on TPACK. In the later process, teacher/ prospective teachers' teaching technology supported lessons were ensured, studies were carried through the use of qualitative and quantitative data collection tools (A6, A32, A53). Although quantitative and qualitative data collection tools were used in the other two studies, these studies took relatively short compared to others. When the Table 2 is examined, it is seen that four studies were carried in literature review type. In the first study, to define the common and different aspects of the models which aim to improve TPAB (A30), in the second, within the framework of TPAB in order to establish an effective technological integration, İndications have been developed on the dimensions like hardware, software and technical support (A33), in the third one, the pedagogical content knowledge and TPAB are explained for a teacher to be provided for instruction (A37) and in the last study, a systematical review of literature was carried out on the TPAB developments of the candidates of mathematics teachers between 2005-2013 (A59). Lastly, in only one study it was observed that the action research method was used. In this study, within the framework of TPAB, the lecture was designed; Instructional Technologies Material Design and in this concept making use of many different tools like surveys, observations, diaries, to collect data in a long process, the abilities of the candidate teachers were tried to be assessed on instruction material design (A46).

Sample Group of the Reviewed Studies

45 of the studies reviewed within the scope of the research were carried with prospective teachers, 8 were with teachers, 1 was with postgraduate students, and 1 was with instructors. Since the other 4 studies are literature reviews, any sort of sample group was not examined.
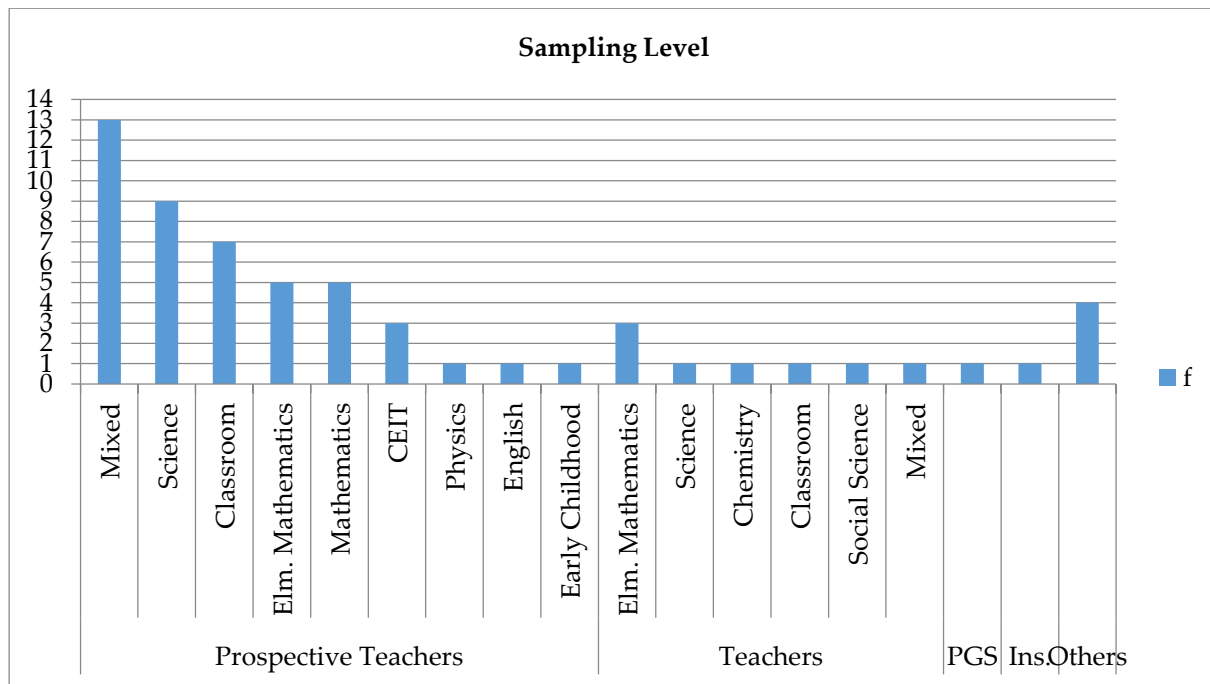
PGS: Postgraduate student, Ins: Instructor, Elm: Elementary,
CEIT: Computer Education and Instructional Technology

Figure 3. Sample Level

Data Collection Tools Used in the Reviewed Studies
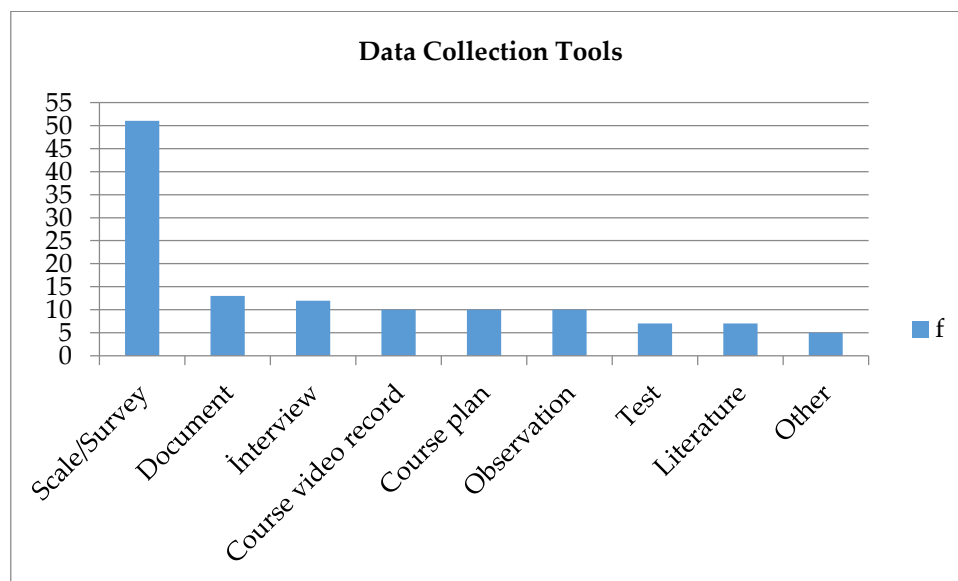

Figure 4. Data Collection Tools

Scale/survey was used in 51 studies reviewed within the scope of the research. The reason why scales and surveys were categorized under the same heading arises from using scale instead of survey and survey instead of scale in most of the reviewed studies. It was seen that a large number of various scales/surveys such as TPACK scale, self-confidence scale, competency scale, view survey were used in the reviewed studies. Even though it was recognized that scales/surveys were applied with the purpose of illustrating the general situation in a considerable number of studies, in some studies, they were with the aim of determining TPACK development of participants throughout the study (A3, A6 and A11).

As a result of the reviews, it was observed that in 14 studies, the documents (diaries, lecture notes, observation notes, Project reports, homework, seminar notes, blog comments and similar) were used. Among these, most commonly used lecture notes (A1, A16, A56), observation notes (A25, A26, A31) and diaries (A32, A46). It was recognized that interviews were used in 12 studies, Focus group discussions (A6, A13, A24) and interviews on course plan (A1, A16, A56) were used mostly in the reviewed studies. Course video records and course plans and observation were used in 10 studies. Observations or course video records were preferred in the studies taking classroom environment and other conditions into consideration. In some studies though, both observation and course video record was used simultaneously (A16, A25, A26, A31). Prospective teachers were asked to prepare course plans before performing technologically enriched micro teaching methods in the reviewed studies (A1, A6, A16, A25, A26, A56). Through examining the course plans, the TPACK developments of prospective teachers in different components were sought to be revealed. Furthermore, it was seen that test and literature were used in 7 reviewed studies. The usage of various tests such as conceptual test, achievement test computer knowledge test were observed (A6, A25, A31, A47). Only the literature was employed as the data collection tool since four of the studies in which literature was used were conducted for the purpose of literature review and three for scale development. The data collection tools called as other included concept map, drawing, learning and teaching material. It was seen that only a limited number of studies used concept map (A31), learning/teaching material (A42, A47, A48, A57) and drawing (A25) to determine the subject area information for TPAB.

Similarities and Differences among the Teaching Applications Used

Table 5. Teaching Application

Teaching Application	Studies	f
The courses customized according to TPACK	A6, A7, A10, A11, A25, A31, A42, A46, A47, A48, A53	11
TPACK workshops	A1, A2, A16, A39, A56	5
Micro teaching applications with smart board usage	A3	1
Blended learning environment	A26	1
Mixed vocational development program	A32	1
Learning by design module	A57	1

Among the reviewed studies, the research process was built upon a teaching application only in 20 studies. The most frequently used one is to teach courses such as STM, CAMT and SP being customized according to TPACK and to make prospective teacher perform technologically supported applications. It was observed that in five studies, prospective teachers'' TPACKs in different components were measured after TPACK workshops being held. After necessary theoretical information had been explained to prospective teachers in these workshops, applications were performed by using a large number of data collection tools and various computer soft wares such as Graphic Analysis to enhance their TPACK (A1, A2, A16, A39, A56). Learning by design module includes TPACK game activities (A57). In this learning module, a 14 week course covering integration of technology to teacher's education was performed. After necessary theoretical information was provided in the course, postgraduate students were lead to play four different TPACK games by means of a website and TPACK information was tried to be measured through different questions towards TPACK components. In micro teaching applications with smart board usage, initially prospective teachers were trained on smart board usage and later lessons within the scope of STM course were regularly taught on the smart board and prospective teachers' TPACKs were improved through making them perform applications (A3). In the mixed vocational development program, classroom teachers were provided with in-service training for three months (A32). These trainings were conducted in face to face, online learning and Web 2.0 environments and the participants were supported throughout the process. Later, teachers were observed at their classrooms where they use the technology. Finally, in one study, it was observed that courses such as STM and SP were performed through designing them according to blended learning environment formed by integrating face to face and online learning environments (A26). A large number of online components were effectively mixed with face to face environment in this learning environment. The participants' TPACK improvement was tried to be identified by using a large number of data collection tools in all of the mentioned studies. Furthermore, in all of the studies, after the necessary trainings were provided, participants were performed applications at the final stage and how exactly their TPACK improvement was sought to be revealed.

Conclusions Obtained in the Reviewed Studies

The conclusions obtained in the reviewed studies were examined in details and the conclusions directly related to TPACK are summarized in this part.

Table 6. Conclusions Obtained in the Reviewed Studies

Conclusions	Studies	f
A significant increase in TPACKs occurred after the application	A3, A6, A10, A11, A26, A32, A53, A57	8
A meaningful relationship does not exist between gender and TPACK	A12, A17, A19, A24, A35, A36, A45, A52	8
The Turkish versions of the customized scales are valid and reliable scales and could be used in Turkey	A14, A20, A23, A27, A41, A54	6
During the TPAB workshop, it was revealed that prospective teachers developed themselves on components such as measurement - evaluation, multiple demonstrations and student challenges	A1, A2, A16, A39, A56	5
The participants whose perceptions, attitude, competency and level for technology are higher have higher levels of TPACK	A5, A21, A38, A40, A58	5
TPACK levels of prospective teachers were not high enough	A15, A24, A25, A31, A43	5
Teachers whose years of seniority were low and who has knowledge on technology considers themselves more competent in TPACK	A4, A24, A35, A36	4
A meaningful relationship exists between teaching styles/learning strategies/thinking strategies and TPACK components	A9, A18, A19, A35	4
The participants have high levels of TPACK competencies	A12, A21, A28, A52	4
Scales developed as a result of scale validation studies are applicable and reliable measuring tools	A8, A22, A50	3
PCK of prospective teachers affected TPACK	A42, A43, A48	3
Prospective teachers have high levels of TPACK self-confidence	A45, A53, A55	3
When TPACKs improve, the quality of the material they prepare also improves	A46, A47, A48	3
Experiences related to technology affects opinions about technology integration	A13, A45	2
Prospective teachers self-perception of TPACK were high	A17, A58	2
A meaningful relationship exists between TPACK components	A44, A51	2
The major strategy for TPACK improvement is technologically supported lessons and courses	A46, A59	2
A strong and important relationship exists between TPACK and self-competency beliefs.	A49, A51	2
TPACK images of prospective teachers were enhanced	A7	1
Prospective teachers are quiet inadequate to use technology in lessons	A25	1
Customized scale was not suitable for prospective teachers in Turkey	A29	1
For TPACK improvement theoretical knowledge and real in class teaching experiences should be bridged	A30	1
The participants whose TPACK improvement are high perform more student centric applications in the teaching processes	A32	1
Indicators for technology integration were developed	A33	1
Their insights about the technology reflects to their using level	A34	1
The meaning of TPAB and PAB was explained	A37	1
TPACK greatly contributed to integration of technology to the lessons	A46	1

In the studies carried for identification of the status, it was observed that prospective teachers have high levels of TPACK competencies (A12, A21, A28, A52) and its self-confidence (A45, A53, A55), their self-competency perception of TPACK was high (A17, A58), their insights about the technology reflects to their using levels (A34), teachers whose years of seniority were low and who have knowledge on technology considers themselves more competent in TPACK (A4, A24, A35, A36), teachers whose perceptions, attitude, level and competency for technology are higher have higher levels of TPACK (A5, A21, A38, A40, A58).

In a few number of studies, it was set forth that TPACK levels of prospective teachers were not high enough (A15, A24, A31, A43) and they are quiet inadequate to use technology in lessons (A25). Furthermore, it was stated in a considerable number of studies that a significant increase in TPACKs occurred after the application (A3, A6, A10, A11, A26, A32, A53, A57). Moreover, it was stressed that scales developed as a result of scale validation studies are applicable and reliable measuring tools (A8, A22, A50), in customized scale studies though, the customized scale was not suitable for prospective teachers in Turkey in only one study (A29), in other studies, the Turkish versions of the customized scales are valid and reliable scales and could be used in Turkey (A14, A20, A23, A27, A41, A54).

Again in the studies carried, it was put forward that when prospective teachers' TPACKs improve, the quality of the material they prepare also improves (A46, A47, A48), their TPACK images were enhanced (A7), a meaningful relationship exists between teaching styles/learning-thinking strategies and TPACK components (A9, A18, A19, A35), experiences related to technology affects opinions about technology integration (A13, A45). During the TPAB workshop, it was revealed that pre-service teachers developed themselves on components such as measurement-evaluation, multiple demonstrations and student challenges (A1, A2, A16, A39, A56), that PAB of pre-service teachers affected TPAB (A42, A43, A48), that there are meaningful relations among the TPAB components (A44, A51), that TPAB greatly contributed to integration of technology to the lessons (A46) and that there was a positive and strong relation between the TPAB and self-sufficiency beliefs (A49, A51).

In the literature review type of studies, it was stated that, common and different dimensions concerning the three models developed for TPACK improvement were explained and the theoretical knowledge taught in education faculties to improve TPACK and real in class teaching experiences should be bridged in all of the models (A30) and the major strategy for TPACK improvement is technologically supported lessons and courses (A46, A59). It was seen that the meaning of TPAB and PAB was explained (A37) and indicators for technology integration were developed (A33). In a considerable part of the studies other than these, it was revealed that a meaningful relationship does not exist between gender and TPACK (A12, A17, A19, A24, A35, A36, A45, A52) and participants whose TPACK improvement are high perform more student centric applications in the teaching processes (A32).

Discussion

In this part, the results obtained from the research were discussed in line with the research problems. When the findings were examined, it is seen that the studies were mostly conducted for the purposes of scale adaptation, scale development, determination of TBAP proficiency and examination of relation between TPAB and various components. When the studies are carefully analyzed, it is seen that similar purposes were handled in especially those of review types, and the studies were carried out using only quantitative data collection tools on different sampling groups. However, after carrying a few studies that reveal the current situation, repeating these studies on different sample groups does not contribute to education-training. Instead, there is a need for carrying such studies that aims to examine TPACK developments of individuals participating to the study in a long process by using a large number of data collection tools simultaneously, ant to reveal how their TPACKs were increased and what has been took place in this process. Although there are studies conducted for this purpose, among the studies made in Turkey, such studies represent a rather low percentage compared to the general literature. As it is known, teachers in Turkey still do not use the technology in the lessons with a constructivist conception and they lack in integrating the technology to the lessons (Kaleli-Yılmaz, 2012). Also it comes to integrating the technology to the lessons, external factors such as hardware and software can easily be controlled, but internal factors directly concerning the teacher constitute a major barrier against integration of technology (Ertmer, 2005). TPAB, which the teacher has, is one of the internal factors having the most important role in the technology integration. Then, TPABs of teachers or pre-service teachers should be increased. In addition, alternative methods should be sought in order to enable teachers and pre-service teachers to make an association between technology and teaching and to integrate the technology to the lessons (Çalık, 2013). Therefore, it is important that future studies should be conducted for the purpose of increasing the TPAB and researching on alternative ways increasing the TPAB.

In a small portion of the reviewed studies, it was observed that a specific subject area as derivative, heat and temperature was focused. However, when the definition of TPACK is examined, it is understood that the technological knowledge should be adapted with pedagogical approaches special for a certain subject area. Thus, in studies aiming to examine TPACK, a certain subject area should be focused initially and after controlling the field knowledge of the participants, their TPACKs should try to be increased with proper technological and pedagogical approaches. No matter how strong the technology knowledge of a teacher/prospective teacher whose field knowledge is insufficient is, it is obvious that s/he would not integrate technology into the related subject, that is s/he could not have sufficient TPACK. Therefore, it is important to begin TPACK studies after conceptual misunderstandings and learning difficulties related to this field, if any, are resolved. In addition to the above, the necessary TPAB for each field of subject is different. For this reason, it is important that future studies should focus on different fields of subject and which methods or approaches in which fields of subject contribute to the development TPAB should be revealed.

When examined, it is seen that the studies conducted are mostly quantitative studies and mainly on review works using data collection tools such as scale/questionnaire. The number of studies using methods such as experimental methods, case studies and action research, which aim at finding out the change in the process, is rather low. Though especially in studies in which data were collected with qualitative ways by using scale/survey, results were generally obtained showing TPACKs of the participants are high, in studies in which data were collected by qualitative means like observation was put forward that teachers have insufficient technological knowledge and TPACK. In this context, it would be argued that collecting the data through quantitative ways solely is not proper; the obtained findings should be supported with qualitative data. Kaya and Kaya (2013) too, put forward that the data to be obtained with TPACK scales do not reveal the TPACKs that teachers/prospective teachers have, but does reveal the knowledge that they think they have or perceive within the scope of their TPACKs, or their self-confidence, the researchers who want to reveal the actually possessed TPACKs should use multiple data collection tools as interview and course plan together. Moreover, in

one of studies in which the scale was tried to be translated into Turkish in scale validation studies, it was revealed that the scale was not suitable for prospective teachers in Turkey (A29), in the other one though, it was suitable for the group with which the study was carried (A41). When the related studies are reviewed, it stands out that the scale was applied to prospective teachers in one of them (A29), and to teachers in the other (A41). This point shows that the scale is suitable for teachers, and unsuitable for pre-service teachers. Then, the studies should specify the applicable sampling groups for the scales developed.

It is seen that 45 of 59 studies examined were carried out with prospective teachers, and the number of studies conducted with teachers, graduate students and faculty members is less than the other group. The reason behind the fact that the studies are mostly done on the pre-service teachers is that pre-service teachers easily accessible and available since a significant number of teachers in Turkey do not want to be a part of the studies on this subject thinking that participation in such types of studies will bring extra burden of time and workload, that such studies will not at all be beneficial for them, and will reveal their insufficient aspects, or they reluctantly fill in the questionnaires or scales and pretend that they are more knowledgeable and competent than they actually are. Because willingness is the basis for these types of studies, the researcher should convince the teachers and exert efforts to reflect their real feelings and opinions. In fact, data yielded from the studies conducted on teachers who are active in teaching reveal more comprehensive information and provide more useful results about what the current situation is and what should be done. Naturally, the studies conducted with the prospective teachers are also important since it is obvious that a pre-service teacher having sufficient TPAB while in college will be more successful in technology integration to the classes when they actually starting teaching. However, considering the fact that a significant amount of the studies done in Turkey are those done with the prospective teachers, it is important that future studies should be conducted with teachers in terms of results to be obtained.

When the studies conducted are examined, it is seen that the research process in 20 studies were based on a teaching application. Among these, the most preferred teaching application is the design of lessons oriented at TPAB. These types of studies examine the change on long term and in the process and produce useful data. Increase in such type of studies is important because they will reveal detailed results to be undertaken necessary to improve TPABs of teachers and pre-service teachers in Turkey, methods to be preferred and design of the lessons. If any method or application used in many studies has a positive impact on TPACK is set forth, this would be a crucial step to be taken towards improving TPACKs of prospective teachers. At least, which methods would lead to success or which are not effective is revealed and other researchers would lean to these issues in their own researches.

Suggestions

It is recommended for the researchers who will carry studies in this field to carry their studies by building upon the teaching applications either recommended in the studies in the literature or they consider would be effective, instead of scale validation/customization or identifying the current situation. Carrying long term studies in which, after being told TPACK theoretical framework, the participants were presented how the technology would be integrated to special subject area with necessary equipment and a large number of application examples, the participants were regularly supported in this process, a lot of data collection tools as observation, interview were used is essential. Besides, a large number of pre/in-service training activities should be organized to enhance TPACK, teachers/prospective teachers should be supported for long period after these activities and what kind of processes they were been through should be recorded. A model for development of a TPACK exclusive to Turkish culture should try to be constituted by building upon the obtained results.

Environments which would reveal the thinking styles, learning-teaching strategies of prospective teachers should be designed in education faculties and prospective teachers should be provided with support to complement their insufficient sides strengthen positive aspects they have through recognizing the features they possess. More equipped teachers would be educated by this way. Besides, courses which teach prospective teachers how they would integrate technology to all subjects in their branches and how they would enhance their TPACKs should be introduced in education faculties. These courses should be instructed by instructors who are experts in TPACK field exclusive to related branch. At the same time, the contents, duration and performances of courses in education faculties such as Special Teaching Methods, Computerized Teaching, Teaching Technologies and Material Design should be reviewed and necessary updates should be done by taking into account the general technologies exclusive to teaching of each field.

It might be effective that teachers who are in performer positions examine the methods used in studies in which TPACK developments increased in details and try to adapt them to their lessons. Besides, for them to spread efforts to participate to all courses organized on TPACK, be enthusiastic for enhancing their TPACKs and make an effort are necessary. Finally, it was set forth in the studies that as long as teachers' TPACK levels rise, they perform more student centric applications. Thus, in order for designing student centric learning environments as constructivist approach necessitates, much emphasis should be put to the issue of developing teachers' TPACKs.

In conclusion, it may be useful to cover the teachers as sampling in the future studies and use of different teaching methods in the long term. Moreover, it would be enlightening for the other researchers in this field if the studies indicate in detail which teaching methods are applied under what type of a process and what kind of a contribution is given to the TPAB development.

References

Alkan, C. (1998). *Eğitim teknolojisi* (6. Baskı). Ankara: Anı Yayıncılık.

Anderson, T. (2008). Towards a theory of online learning. In T. Anderson (Ed.), *Theory and practice of online learning* (pp. 45-74): AU Press.

Baki, A. (2002). *Bilgisayar destekli matematik*. İstanbul: Ceren Yayın Dağıtım.

Chai, S. C., Koh, J. H. L., Tsai, C. C., & Tan, L. L. W. (2011). Modeling primary school preservice teachers' technological pedagogical content knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education*, *57*(1), 1184-1193.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Educational Technology & Society*, *16*(2), 31-51.

Çalık, M. (2013). "Effect of technology-embedded scientific inquiry on senior science student teachers' self-efficacy". *Eurasia Journal of Mathematics, Science & Technology Education*, *9*(3), 223-232. doi: 10.12973/eurasia.2013.931a

Çalık, M., & Sözbilir, M. (2014). İçerik analizinin parametreleri. *Eğitim ve Bilim*, *39*(174), 33-38.

Çelik, H. C., & Bindak, R. (2005). İlköğretim okullarında görev yapan öğretmenlerin bilgisayara yönelik tutumlarının çeşitli değişkenlere göre incelenmesi. *İnönü Üniversitesi Eğitim Fakültesi Dergisi*, *6*(10), 27-38.

Demirel, Ö., & Kaya, Z. (2003). *Öğretmenlik mesleğine giriş*. Ankara: Pegem Yayıncılık.

Ertmer, P. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration. *Educational Technology Research and Development*, *53*, 25-39.

Guzey, S. S., & Roehrig, G. H. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 25-45.

Jang, S. J., & Chen, K. C. (2010). From PCK to TPCK: Developing a transformative model of pre-service science teachers. *Journal of Science Education and Technology*, *19*(6), 553-564.

Kaleli Yılmaz, G. (2012). *Matematik öğretiminde bilgisayar teknolojisinin kullanımına yönelik tasarlanan HİE kursunun etkililiğinin incelenmesi: Bayburt ili örneği.* Doktora tezi, Karadeniz Teknik Üniversitesi, Eğitim Bilimleri Enstitüsü, Trabzon.

Kaya, Z., & Kaya. O. N. (2013). Öğretmen eğitiminde Vignette tekniği ve uygulamaları. *Education and Science*, *38*(168), 129-142.

Koehler, M. J., & Mishra, P. (2008). *Introducing TPCK in AACTE committee on innovation and technology*: *The handbook of technological pedagogical content knowledge (TPCK) for educators.* New York: American Association of Colleges of Teacher Education and Routledge.

Mazman, S. G., & Koçak U. Y. (2011). Bilgi ve iletişim teknolojilerinin öğrenme-öğretme süreçlerine entegrasyonu: Modeller ve göstergeler. *Eğitim Teknolojisi Kuram ve Uygulama*, *1*(1), 62-79.

Morsink, P. M., Hagerman, M. S., Heintz, A., Boyer, M., Harris, R., Kereluik, K., & Hartman, D. K. (2011). Professional development to support TPACK technology integration: The initial learning trajectories of thirteen fifth and sixth-grade educators. *Journal of Education*, *191*(2), 3-18

Niess, M. L., Van-Zee, E. H., & Gillow-Wiles, H., (2011). Knowledge growth in teaching mathematics/science with spreadsheets: Moving PCK to TPACK through online professional development. *Journal of Digital Learning in Teacher Education*, *27*(2), 42-52.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1-22.

Voogt, J., Fisser, P., Pareja-Roblin, N., Tondeur, J., & Braak, J. (2013). Technological pedagogical content knowledge: A review of the literature. *Journal of Computer Assisted Learning, 29*, 109-121.

Supplement 1. The Studies That Examined in the Research

A1. Akkaya, E. (2009). *Matematik öğretmen adaylarının türev kavramına ilişkin teknolojik pedagojik alan bilgilerinin öğrenci zorlukları bağlamında incelenmesi*. Yüksek lisans tezi, Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

A2. Akkoç, H. (2012). Bilgisayar destekli ölçme-değerlendirme araçlarının matematik öğretimine entegrasyonuna yönelik hizmet öncesi eğitim uygulamaları ve matematik öğretmen adaylarının gelişimi. *Turkish Journal of Computer and Mathematics Education*, *3*(2), 99-114.

A3. Akyüz, H. İ., Pektaş, M., Kurnaz, M. A., & Kabataş-Memiş, E. (2014). Akıllı tahta kullanımlı mikro öğretim uygulamalarının fen bilgisi öğretmen adaylarının TPAB' larına ve akıllı tahta kullanımına yönelik algılarına etkisi. *Cumhuriyet International Journal of Education*, *3*(1), 1-14.

A4. Bal, M. S., & Karademir, N. (2013). Sosyal bilgiler öğretmenlerinin teknolojik pedagojik alan bilgisi konusunda öz değerlendirme seviyelerinin belirlenmesi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 34*(2), 15-32.

A5. Bilgin, İ., Tatar, E., & Ay, Y. (2012). Sınıf öğretmeni adaylarının teknolojiye karşı tutumlarının teknolojik pedagojik alan bilgisine katkısının incelenmesi. *X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi*, Niğde Üniversitesi, Niğde.

A6. Canbazoğlu-Bilici, S. (2012). *Fen bilgisi öğretmen adaylarının teknolojik pedagojik alan bilgisi ve öz yeterlikleri*. Doktora tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

A7. Canbazoğlu-Bilici, S., Yamak, H., & Kavak, N. (2012). Fen bilgisi öğretmen adaylarının teknolojik pedagojik alan bilgisi imajları. *X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi*, Niğde Üniversitesi, Niğde.

A8. Canbazoğlu-Bilici, S., Yamak, H., Kavak, N., & Guzey, S.S. (2013). Technological pedagogical content knowledge self-efficacy scale (TPACK-SeS) for pre-service science teachers: Construction, validation and reliability. *Eurasian Journal of Educational Research, 52*, 37-60.

A9. Canbolat, N. (2011). *Matematik öğretmen adaylarının teknolojik pedagojik alan bilgileri ile düşünme stilleri arasındaki ilişkinin incelenmesi*. Yüksek lisans tezi, Selçuk Üniversitesi Eğitim Bilimleri Enstitüsü, Konya.

A10. Ceylan, B., Türk, M., Yaman, F., & Kabakçı-Yurdakul, I. (2014). Determining the changes of information and communication technology guidance teacher candidates' technological pedagogical content knowledge competency information and communication technology usage stages and levels. *Eğitimde Kuram ve Uygulama*, *10*(1), 171-201.

A11. Çalık, M., Özsevgeç, T., Ebenezer, J., Artun, H., & Küçük, Z. (2014). Effects of 'Environmental Chemistry' Elective Course Via Technology-Embedded Scientific Inquiry Model on Some Variables. *Journal of Science Education and Technology*, *23*, 412-430.

A12. Çuhadar, C., Bülbül, T., & Ilgaz, G. (2013). Exploring of the relationship between individual innovativeness and techno-pedagogical education competencies of pre-service teachers. *Elementary Education Online*, *12*(3), 797-807.

A13. Demir, S., & Bozkurt, A. (2011). Primary mathematics teachers' views about their competencies concerning the integration of technology. *Elementary Education Online*, *10*(3), 850-860.

A14. Dikkartın-Övez, F. T., & Akyüz, G. (2013). İlköğretim matematik öğretmeni adaylarının teknolojik pedagojik alan bilgisi yapılarının modellenmesi. *Education and Science, 38*(170), 321-334.

A15. Doğan, M. (2012). Prospective Turkish primary teachers' views about the use of computers in mathematics education. *Journal of Mathematics Teacher Education*, *15*(4), 329-341.

A16. Ergene, B. (2011). *Matematik öğretmen adaylarının türev kavramına ilişkin teknolojik pedagojik alan bilgilerinin çoklu temsiller bileşeninde incelenmesi*. Yüksek lisans tezi, Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

A17. Gömleksiz, M. N., & Fidan, E. K. (2013). Self-efficacy perception levels of prospective classroom teachers toward technological pedagogical content knowledge. *Inonu University Journal of the Faculty of Education*, *14*(1), 87-113.

A18. Gündoğmuş, N. (2013). *Öğretmen adaylarının teknolojik pedagojik alan bilgileri ile öğrenme stratejileri arasındaki ilişkinin incelenmesi*. Yüksek lisans tezi, Necmettin Erbakan Üniversitesi Eğitim Bilimleri Enstitüsü, Konya.

A19. Gündoğmuş, N., & Gündüz, Ş. (2012). A study on the technological and pedagogical content knowledge of prospective teachers and their learning strategies. *6th International Computer and Instructional Symposium*, 4-6 Ekim (s. 20-24), Gaziantep.

A20. Hacıömeroğlu, G., Şahin, Ç., & Arcagök, S. (2014). Turkish adaptation of preservice teachers' technological pedagogical content knowledge assesment scale. *Eğitimde Kuram ve Uygulama*, *10*(2), 297-315.

A21. Kabakçı-Yurdakul, I. (2011). Öğretmen adaylarının teknopedagojik eğitim yeterliklerinin bilgi ve iletişim teknolojilerini kullanımları açısından incelenmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *40*, 397-408.

A22. Kabakçı-Yurdakul, I., Odabaşı, H. F., Kılıçer, K., Çoklar, A. N., Birinci, G., & Kurt, A. A. (2012). The development validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale. *Computers & Education*, *58*(3), 964-977.

A23. Karadeniz, Ş., & Vatanartıran, S. (2013). Adaptation of a TPACK survey to Turkish for secondary school teachers. *International Journal of Human Sciences*, *10*(2), 34-47.

A24. Karakaya, Ç. (2013). *Fatih projesi kapsamında pilot okul olarak belirlenen ortaöğretim kurumlarında çalışan kimya öğretmenlerinin teknolojik pedagojik alan bilgisi yeterlilikleri*. Yüksek lisans tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

A25. Kaya, Z. (2010). *Fen ve teknoloji öğretmen adaylarının fotosentez ve hücresel solunum konusundaki teknolojik pedagojik alan bilgisinin (TPAB) araştırılması*. Yüksek lisans tezi, Fırat Üniversitesi Fen Bilimleri Enstitüsü, Elazığ.

A26. Kaya, Z. (2014). *Harmanlanmış öğrenmenin fen bilgisi öğretmen adaylarının küresel ısınma konusundaki teknolojik pedagojik alan bilgisi ve sınıf içi öğretim becerilerinin geliştirilmesi üzerine etkisi*, Doktora tezi, Fırat Üniversitesi, Eğitim Bilimleri Enstitüsü, Elazığ.

A27. Kaya, S., & Dağ, F. (2013). Turkish adaptation of technological pedagogical content knowledge survey for elementary teachers. *Educational Sciences: Theory & Practice*, *13*(1), 291-306.

A28. Kaya, Z., Özdemir, T. Y., Emre, İ., & Kaya, O. N. (2011). Bilişim teknolojileri öğretmen adaylarının teknolojik pedagojik alan bilgisi öz yeterlik seviyelerinin belirlenmesi. *5th International Computer&Instructional Technologies Symposium*, 22-24 September, Elazığ, Turkey.

A29. Kaya, Z., Kaya, O. N., & Emre, İ. (2013). Teknolojik pedagojik alan bilgisi (TPAB) ölçeğinin Türkçeye uyarlanması, *Kuram ve Uygulamada Eğitim Bilimleri*, *13*(4), 2355-2377.

A30. Kaya, Z., & Yılayaz, Ö. (2013). Öğretmen eğitimine teknoloji entegrasyonu modelleri ve teknolojik pedagojik alan bilgisi, *Batı Anadolu Eğitim Bilimleri Dergisi*, *4*(8), 57-83.

A31. Kılıç, A. (2011). *Fen ve teknoloji öğretmen adaylarının elektrik akımı konusundaki teknolojik pedagojik alan bilgilerinin ve sınıf içi uygulamalarının araştırılması*, Yüksek lisans tezi, Fırat Üniversitesi Fen Bilimleri Enstitüsü, Elazığ.

A32. Kokoç, M. (2012). *Karma mesleki gelişim programı sürecinde ilköğretim sınıf öğretmenlerinin teknolojik pedagojik alan bilgisi deneyimleri üzerine bir çalışma*. Yüksek lisans tezi, Karadeniz Teknik Üniversitesi Eğitim Bilimleri Enstitüsü, Trabzon.

A33 Kuşkaya-Mumcu, F., Haşlaman, T., & Koçak-Usluel, Y. (2008). Teknolojik Pedagojik İçerik bilgisi modeli çerçevesinde etkili teknoloji entegrasyonunun göstergeleri. *8th International Educational technology conference* (s. 296-299), Eskişehir.

A34. Mandacı-Şahin, S., Aydoğan-Yenmez, A., Özpınar, İ., & Koçce, D. (2013). Öğretmen adaylarının teknolojik pedagojik alan bilgisi modeline uygun bir hizmet öncesi eğitim programının bileşenlerine ilişkin görüşleri. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *Özel Sayı* (1), 271-286.

A35. Mutluoğlu, A. (2012). *İlköğretim matematik öğretmenlerinin öğretim stili tercihlerine göre teknolojik pedagojik alan bilgilerinin incelenmesi*. Yüksek lisans tezi, Necmettin Erbakan Üniversitesi Eğitim Bilimleri Enstitüsü, Konya.

A36. Mutluoğlu, A., & Erdoğan, A. (2012). İlköğretim matematik öğretmelerinin TPAB düzeylerinin farklı değişkenler açısından incelenmesi. *6th International Computer and Instructional Symposium*, 4-6 Ekim (s.331-336), Gaziantep.

A37. Öner, D. (2010). Öğretmenin bilgisi özel bir bilgi midir? Öğretmek için gereken bilgiye kuramsal bir bakış. *Boğaziçi Üniversitesi Eğitim Dergisi*, *27* (2), 23-32.

A38. Özgen, K., Narlı, S., & Alkan, H. (2013). Matematik öğretmen adaylarının teknolojik pedagojik alan bilgileri ve teknoloji kullanım sıklığı algılarının incelenmesi. *Elektronik Sosyal Bilimler Dergisi*, *12*(44), 31-51.

A39. Özmantar, M. F., Akkoç, H., Bingölbali, E., Demir, S., & Ergene, B. (2010). Pre-Service Mathematics Teachers' Use of Multiple Representations in Technology-Rich Environments. *Eurasia Journal of Mathematics, Science & Technology Education*, *6*(1), 19-36.

A40. Öztürk, E. (2013). Sınıf öğretmeni adaylarının teknolojik pedagojik alan bilgilerinin bazı değişkenler açısından değerlendirilmesi. *Uşak Üniversitesi Sosyal Bilimler Dergisi*, *13*, 223-228.

A41. Öztürk, E., & Horzum, M.B. (2011). Teknolojik pedagojik içerik bilgisi ölçeğinin Türkçeye uyarlanması. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, *12*(3), 255-278.

A42. Pamuk, S. (2012). Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning*, *28*(5), 425-439.

A43. Pamuk, S., Ülken, A., & Dilek, N. Ş. (2012). Öğretmen adaylarının öğretimde teknoloji kullanım yeterliliklerinin teknolojik pedagojik içerik bilgisi kuramsal perspektifinden incelenmesi. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *9*(17), 415-438.

A44. Pamuk, S., Ergün, M., Çakır, R. Yılmaz, H. B., & Ayas, C. (2013). Exploring relationships among TPACK components and development of the TPACK instrument. *Education and Information Technologies.* Advance online publication. doi: 10.1007/s10639-013-9278-410.1007/s10639-013-9278-4

A45. Sancar-Tokmak, H., Yavuz-Konokman, G., & Yanpar-Yelken, T. (2013). Mersin üniversitesi okul öncesi öğretmen adaylarının teknolojik pedagojik alan bilgisi özgüven algılarının incelenmesi. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, *14*(1), 35-51.

A46. Sancar-Tokmak, H., Yanpar-Yelken, T., & Yavuz-Konokman, G. (2013). Pre-service Teachers' Perceptions on Development of Their IMD Competencies through TPACK-based Activities. *Educational Technology & Society*, *16*(2), 243-256.

A47. Selim, Y. (2009). *Matematik öğretmen adaylarının bilgisayar destekli olarak hazırladıkları öğretim materyalinin niteliği ile matematik ve öğretmenlik meslek bilgileri arasındaki ilişkilerin incelenmesi*. Doktora tezi, Atatürk Üniversitesi Fen Bilimleri Enstitüsü, Erzurum.

A48. Selim, Y., Tatar, E., & Öz, R. (2009). Matematik öğretmen adaylarının hazırladıkları öğretim materyallerinin TÖMAB modeli ile incelenmesi. *EÜFBED-Fen Bilimleri Enstitüsü Dergisi*, *2*(2), 239-251.

A49. Semiz, K., & İnce, M. L. (2012). Pre-service physical education teachers' technological pedagogical content knowledge, technology integration self-efficacy and instructional technology outcome expectations. *Australasian Journal of Educational Technology*, *28*(7), 1248-1265.

A50. Şahin, İ. (2011). Development of survey of technological pedagogical and content knowledge (TPACK). *TOJET: The Turkish Online Journal of Educational Technology*, *10*(1), 97-105.

A51. Şahin, İ., Çelik, İ., Aktürk, A. O., & Aydın, M. (2013). Analysis of Relationship between Technological Pedagogical Content Knowledge and Educational Internet Use. *Journal of Digital Learning in Teacher Education*, *29*(4), 110-117.

A52. Şimşek, Ö., Demir, S., Bağçeci, B., & Kinay, İ. (2013). Öğretim elemanlarının teknopedagojik eğitim yeterliliklerinin çeşitli değişkenler açısından incelenmesi. *Ege Eğitim Dergisi*, *14*(1), 1-23.

A53. Timur, B. (2011). *Fen bilgisi öğretmen adaylarının kuvvet ve hareket konusundaki teknolojik pedagojik alan bilgilerinin gelişimi*. Doktora tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

A54. Timur, B., & Taşar, M. F. (2011). Teknolojik pedagojik alan bilgisi öz güven ölçeğinin Türkçeye uyarlanması. *Gaziantep Üniversitesi Sosyal Bilimler Dergisi*, *10*(2), 839-856.

A55. Uçar, M. B., Demir, C., & Hiğde, E. (2013). Exploring the self-confidence of preservice science and physics teachers towards technological pedagogical content knowledge. 5th World Conference on Educational Sciences-WCES 2013, *Procedia Social and Behavioral Sciences*, *116*(2014), 3381-3384.

A56. Uğurlu, R. (2009). *Teknolojik pedagojik alan bilgisi çerçevesinde önerilen eğitim programı sürecinde öğretmen adaylarının şekillendirici ölçme ve değerlendirme bilgi ve becerilerinin gelişiminin incelenmesi*. Yüksek lisans tezi, Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

A57. Uygun, E. (2013). *Learning by design: An integrated approach for technological pedagogical content knowledge development*. Yüksek lisans tezi, Orta Doğu Teknik Üniversitesi Sosyal Bilimler Enstitüsü, Ankara.

A58. Yavuz-Konokman, G., Yanpar-Yelken, T., & Sancar-Tokmak, H. (2013). Sınıf öğretmeni adaylarının TPAB'lerine ilişkin algılarının çeşitli değişkenlere göre incelenmesi: Mersin üniversitesi örneği. *Kastamonu Eğitim Dergisi*, *21*(2), 665-684.

A59. Yigit, M. (2014). A review of the literature: How pre-service mathematics teachers develop their technological, pedagogical, and content knowledge. *International Journal of Education in Mathematics, Science and Technology*, *2*(1), 26-35.