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Educational Website Design Process: Changes in TPACK Competencies and Experiences

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Abstract

The number of technological pedagogical and content knowledge (TPACK) studies has been increasing day by day; however, limited number of studies has provided both quantitative and qualitative findings based on teachers' learning by design experiences. This study aimed to reveal the changes in pre-service teachers' TPACK competencies in the educational website design process and their experiences in the design process within the scope of a course based on TPACK framework and the learning by design approach. Designed as an embedded mixed design research, the study was conducted with 28 pre-service teachers. The data were collected through the TPACK-deep scale, a survey and e-mails sent to the instructors. The research concluded that the learning by design approach brings pre-service teachers' TPACK competencies in highly effective significant contributions. Moreover, it was revealed that the design process expands pre-service teachers' schemas regarding the properties which digital instructional materials should possess. The research also enlightened the motivating factors such as receiving support and the challenging factors such not being able to use software for the pre-service teachers in the design process. Finally, the findings were interpreted within the framework of TPACK and the learning by design approach and recommendations were made for future practices and studies.

Keywords: TPACK; Pre-Service Teachers; Website Design

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Introduction

Professional teaching courses that are taught at the faculties of education play an important role in pre-service teachers being able to integrate the education with information and communication technologies (ICT). One of the most important courses preparing pre-service teachers for the technological integration in Turkey is the Instructional Technology and Material Design (ITMD). The content of the course includes concepts about instructional technology, planning and implementing the proper technology, features of different instructional technologies and developing materials by using these technologies, and examining and evaluating the visual design principles and educational software (the Council of Higher Education, 2007). The vision set by the Ministry of National Education (2013) regarding the information technology in the Turkish educational system emphasizes the importance of this course on preparing prospective teachers for technology-integrated lessons.

Preparing pre-service teachers for the ICT integration is a complicated task due to the quick-changing nature of ICT and different information sources that need to be synthesized (Chai, Koh & Tsai, 2010). It is also difficult to create a knowledge base composed of different components for pre-service teachers (Pamuk, 2012). Technological integration models and approaches may lead the way in this respect. Yet, there are no guides on how to teach the ITMD course, which aims at bringing the ability to integrate learning-teaching processes with technology in pre-service teachers, on the basis of a certain theoretical infrastructure. At this point, technological pedagogical content knowledge (TPACK) framework, which focuses on what teachers need to know in integration of technology into education, and the learning by design approach, which shows the way of how to bring in TPACK, can be considered.

In this research, learning by design approach was adopted and the pre-service teachers designed an educational website for primary and secondary school students in the ITMD course. Hence, it was aimed that the pre-service teachers attain knowledge and skills necessary to create an interactive online environment that would contribute to students' non-class learning. The study investigated possible changes in the TPACK competencies of pre-service teachers who experienced a learning process by designing. It also aimed to reveal the factors that motivate and challenge the pre-service teachers in this process by focusing on their design experiences.

Theoretical background

The instructional planning should focus on the curricular requirements, learner needs, the affordances and limitations of existing technologies and the school and classroom environment so that educational technologies can be integrated with instruction effectively (Eryaman, 2006; Harris & Hofer, 2011). For such a planning, one needs to understand and support the mutual and complex relationship between technological, pedagogical and instructional contents in the TPACK framework through teacher training programs (Hoffer & Grandgenett, 2012).

The TPACK framework is composed of three main components: technology, pedagogy, and content. The components formed by the intersection of these three main components are the pedagogical content knowledge (PCK), the technological content knowledge (TCK), technological pedagogical knowledge (TPK) and the technological pedagogical content knowledge (TPCK) (Mishra & Koehler, 2006). The TPACK model is based on Shulman's (1987) idea of pedagogical content knowledge (PCK). PCK is about how a given subject or problem is organized and presented in accordance with different interests and skills of students (Shulman, 1987). TPACK, on the other hand, is a type of knowledge that a teacher possesses regarding the use of both pedagogical and technological knowledge together in teaching a given subject. The components of the TPACK model defines different types of knowledge which teachers need to have for an effective technological integration (Mouza, 2016). Criticizing the approaches that focus on attaining technological skills independently from pedagogy and content, the TPACK model argues that teachers' knowledge is complicated and versatile (Baran, Chuang & Thompson, 2011). The TPACK model can be utilized as

a theoretical framework for the professional developments of both pre-service and in-service teachers as well as for measuring the knowledge of teacher (Schmidt et al., 2009).

TPACK does not specify how to enhance the types of knowledge that teachers need to have even though it defines them (Koehler et al., 2011). Koehler and Mishra (2005a) regard the learning by design approach as a way of establishing relationships between technology, pedagogy, and content knowledge and securing the integration of pedagogy with educational technologies. In the learning by design approach, teachers design for a given area of subject and learning objectives by using the technological tools (Koehler & Mishra, 2005b). These designs are intended for solving an authentic problem. Learning by design is a form of contextualized knowledge construction (Chai, Koh, & Tsai, 2013) and teachers use technological, content and pedagogical knowledge together at every step of the design process (Koehler & Mishra, 2005b). Rosson and Carroll (2010) states that authenticity of the learning by design approach is developed through the brainstorming and the discussion of design ideas among peers in a team environment. More systematically, Baran and Uygun (2016) specified eight principles in accordance with the learning by design approach for improving participants' TPACK. These include These principles are "brainstorming of design ideas, design of technology-integrated artefacts, examination of design examples, engagement with theoretical knowledge, investigation of information and communication technology (ICT) tools, reflection on design experiences, applying design in authentic settings, and collaboration within design teams" (Baran & Uygun, 2016, p. 48). The ITMD course, which will guide pre-service teachers in designing materials for a given area of subject by using instructional technologies, can be organized as a course in which pre-service teachers' TPACK is developed by adopting the approach and principles of learning by design.

Implementing materials enriched with collaborative design activities and technology is an effective solution that improves teachers' TPACK (Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013). Different research studies conducted with pre-service teachers, in-service teachers, lecturers and faculty members reported the positive impact of learning by design activities on TPACK (Ansyari, 2015; Chai, Koh, & Tsai, 2010; Kafyulilo, Fisser, Pieters, & Voogt, 2015; Koehler & Mishra, 2005a; Koh & Chai, 2014; Sancar Tokmak, Yanpar Yelken, & Yavuz Konokman, 2013; Sancar Tokmak, 2015). There are few studies that integrate different strategies such as instructional design with educational technologies or content-based method courses (Mouza, 2016) and that investigate computer-based material design experiences of pre-service teachers (Baytak & Hirca, 2013). In addition, Baran and Canbazoğlu-Bilici (2015) stated that majority of TPACK research in Turkey is quantitative and based on scale results and requires design and application studies. It is considered important to design the research studies in consideration of the shortcomings in the literature.

The purpose of this research is to reveal the possible changes in the TPACK competencies of pre-service teachers in the process of designing an educational website within the scope of a course based on the TPACK model and the learning by design approach. This study also aims at reveal pre-service teachers' experiences in the design process. The guiding research questions are as follows:

1. Is there any significant difference between the TPACK competency pretest and posttest scores of pre-service teachers who design an educational website?
2. How does the pre-service teachers' perception of the necessary features of digital instructional materials change after designing educational website?
3. What are the contributions of educational website design to the pre-service teachers?
4. What are the circumstances that motivate the pre-service teachers in the process of educational website design?
5. What are the challenges the pre-service teachers confront in the process of educational website design?
6. What are the pre-service teachers' solutions to cope with the challenges confronted in the process of educational website design?

Method

Research design

The design of the research is the embedded mixed design which is one of the mixed research methods. In the embedded mixed design, researchers integrate a qualitative or quantitative research with the collection and analysis of both quantitative and qualitative data. Collection and analysis of the second data set can be before, during and/or after collecting and analysis of the data for the main research design (Creswell & Plano Clark, 2011). In this research, the qualitative data were embedded in the one-group pretest-posttest experimental research. Before, during and after the implementation, the qualitative data were collected and answers were sought for the last five questions abovementioned. The steps followed during the data collection process of the research which extended to 14 weeks are shown in Figure 1.

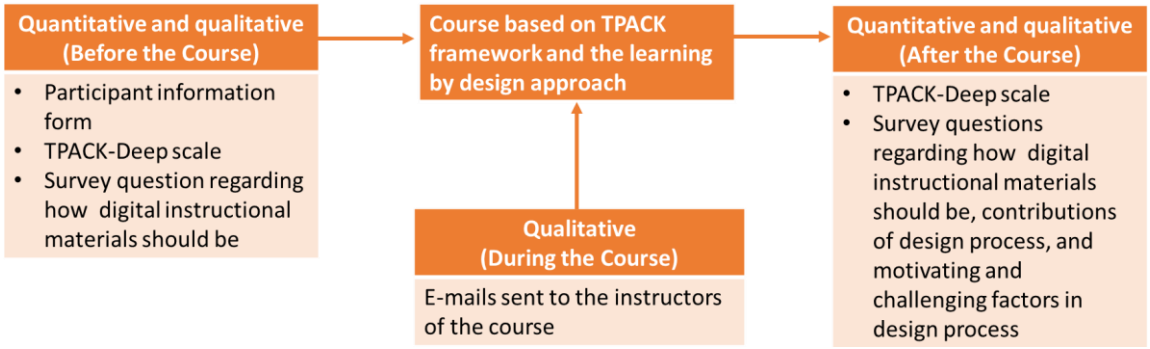

Figure 1. Data collection procedure of the study

Participants

The research was conducted with 28 pre-service teachers who were selected with the convenience sampling method and who registered in the Instructional Technology and Material Design (ITMD) course at the Department of Computer Education and Instructional Technology (CEIT) in a Turkish state university.

The characteristics of the research group are as follows in accordance with the data obtained with the participant information form filled by the pre-service teachers before the ITMD course started (Table 1).

Table 1 Participant characteristics

Variables		Frequency
Gender	Female	10
	Male	18
Experience of using computer	1-3 years	3
	4-6 years	9
	7-9 years	10
	More than 10 years	6
Duration of daily Internet usage	Less than 1 hour	4
	1-3 hours	13
	4-6 hours	5
	7-9 hours	5
	More than 10 hours	1
	Logging in social networks	25
Purpose of Internet usage	Researching	22

	Playing games	16
	Online shopping	15
	Chatting	14
	Website publishing	9
	Video publishing	7
	Blogging	3
	Podcasting	2
	Writing Wiki articles	1
Experience of digital instructional material design	Available	7
	Not Available	21

Before the course started, pre-service teachers' levels of using different instructional technologies such as image, audio and video editing, animation and game creation and website design were determined through the participant information form. It was seen that the percentage of pre-service teachers who had not used any of the instructional technologies in the form or who had low levels of using those technologies varied between 67.9% and 100%. In addition, the participants took the Introduction to the Science of Education and Educational Psychology courses before taking this course and the Instructional Principles and Methods and Curriculum and Education courses during this research under the name of pedagogical courses.

Data collection

The participant information form, TPACK-deep scale, the survey regarding the digital instructional materials and design process, and the e-mails sent to the instructors are the data collection instruments of this study. The participant information form is composed of questions related to gender, experience of using computer, duration of daily Internet usage, purpose of Internet usage, experience of digital instruction material design, and levels of using different instructional technologies.

The TPACK-deep scale, developed by Kabakçı Yurdakul, Odabaşı, Kılıçer, Çoklar and Kurt (2012), was used to observe the change in pre-service teachers' techno-pedagogical competencies. The reason why the TPACK-deep Scale was chosen over other TPACK scales in the literature is that it focuses on different aspects that shape the basis of TPACK's theoretical framework instead of measuring the components of TPACK individually. The TPACK-deep scale is composed of 33 items and four factors. These factors are design, exertion, ethics and proficiency. The design factor involves items related to pre-service teachers' design of instruction within the framework of their TPACK competencies; the exertion factor is composed of items regarding their competency of using technology for conducting the instruction and assessing and evaluating the effectiveness of the instruction; the ethics factor includes the items regarding their competencies about ethical issues such as privacy, accuracy and accessibility; and the proficiency factor is composed of items regarding pre-service teachers' ability to lead the technological integration and to solve problems about pedagogy, content and technology. The scale items are 5-point Likert type: "Strongly disagree", "Disagree", "Neither Agree or Disagree", "Agree", and "Strongly Agree." Cronbach's Alpha internal consistency coefficient was found to be .95 for the whole scale (Kabakçı Yurdakul et al., 2012). The internal consistency coefficients were found to be .97 for the pretest and .96 for the post test in this research conducted with 28 pre-service teachers. It was confirmed through the confirmatory factor analysis that the scale constitutes a four-factor structure (Kabakçı Yurdakul et al., 2012).

The survey on the digital instructional materials and the design process included an open-ended question asking what properties the digital instructional materials should possess. This question was asked to the participant both before and after the course. At the end of the course, three open-ended questions more were asked about the motivating and challenging factors experienced by pre-service teachers in the design process, how they cope with the challenging factors and the contributions made by digital instructional material design. Finally, several e-mails were sent to the course instructors to receive feedbacks about the problems experienced by pre-service teachers in the design process and their progress plans of their designs. All these e-mails were replied by the researchers meticulously.

Procedure

Firstly, the researchers prepared the content of the ITMD course' theoretical and practical class hours for the 14-week research period. TPACK-deep scale's design, exertion, ethics and proficiency subdimensions and the principles of TPACK-learning by design approach were considered during design of the course. The activities to guide pre-service teachers when designing digital instructional materials were specified for both theoretical and practical class hours.

In the theoretical class hours, the researchers gave place to the subjects such as concepts about the instructional technology, technological integration in education, properties of different instructional technologies and developing materials by using these technologies, and examining and evaluating the visual design principles and the educational software. It was aimed in the theoretical class hours that the pre-service teachers acquired the information that could play a role in improving their design competencies.

During the practical class hours, different instructional technologies and software programs that can be used for image, audio and video editing, animation and game creation and website design were presented. In addition, activities for improving pre-service teachers' skills of using these technologies in instruction (e.g. material design aiming the instruction of geometric shapes through the drag-and-drop game method using the Adobe Flash software and infographic design that allows for a visual presentation about the course contents of the first year of the CEIT department using Adobe Photoshop) were performed. These pieces of homework were designed as activities in which the pre-service teachers could use all the components of the TPACK model before starting their material design projects.

As a course project, it was asked from the pre-service teachers to design an educational website for a certain target group and area of subject as a digital instructional material. It was expected that these educational websites would include different materials such as infographic, video, game, test and animation to attract students' attention in accordance with their target grade levels, enhance their motivation and participation and ensure the evaluation of their knowledge.

Working in collaboration in pairs, the pre-service teachers firstly examined the curricula of Science, Mathematics and Instructional Technologies and identified the instructional objectives. They shared the target group and general purpose of the materials they were planning to design in regard to those instructional objectives with their friends. Next, they analyzed the target group and content of those materials and wrote reports by using the digital and printed sources in the company of guiding questions provided by the researchers. They also determined in their reports what to be careful about in their material designs in consideration of the target group and the content.

In the next step, it was asked from the pre-service teachers to specify the instructional methods, media and materials they would use for each instructional objective in a table along with their justifications. In addition, it was expected from them to plan every step of how the instruction would take place in their educational websites and create the template images of the materials. Hence, it was aimed that the pre-service teachers would design their educational websites taking all three of their technological, pedagogical and content knowledge into consideration. Finally, the reports written by the pre-service teachers in the stage of designing their materials were reviewed by the instructors and feedbacks were provided to the pre-service teachers.

The pre-service teachers who designed the materials started to develop their materials by using different instructional technologies in accordance with the knowledge and skills they had acquired in the theoretical and practical classes. In this process, the pre-service teachers were required to pay attention to the ethical issues regarding the technology. They were asked to mention the sources of different types of contents they used in their materials and be sure about the validity and reliability of those sources.

Different strategies were applied in the scope of the proficiency factor of their TPACK competencies. Primarily sharing the new technologies during the course in which the research was being conducted and using those technologies in the courses, the researchers set examples for leading the use of new technologies in instruction. In addition, the researchers diminished the amount of help they were giving to the pre-service teachers and asked them to investigate and solve the problems they were facing in the design process. Finally, the pre-service teachers shared their digital instructional materials and design processes with their friends in the classroom environment and they received feedbacks about the designed materials from each other.

Data analysis

The SPSS 20.0 software was used in the analysis of the quantitative data obtained with the TPACK-deep scale. Firstly, the dependent groups' t-test was performed by controlling its assumptions to see if there was significant difference between pre-service teachers' pretest and posttest TPACK-deep scores. Score difference distributions being normal and the data being in the type of at least equal interval type are the two assumptions of the dependent t-Test (Field, 2009). The differences between pretest and posttest scores obtained in each subdimension of the scale were calculated and it was examined with Kolmogorov-Smirnov test whether the normal distribution was achieved. It was seen that the normality assumption was met in all the scores calculated ($p > .05$).

Table 2 Inter-rater reliability scores of data analysis

Categories	Experts	Number of Coding	Intercoder Reliability
What properties the digital instructional materials should possess (Before the course)	Coder 1	52	86.8%
	Coder 2	49	
What properties the digital instructional materials should possess (After the course)	Coder 1	101	89.4%
	Coder 2	113	
The contributions to the pre-service teachers at the end of the educational website design	Coder 1	34	84.6%
	Coder 2	38	
The circumstances that motivate pre-service teachers in the process of educational website design	Coder 1	32	82.9%
	Coder 2	37	
The challenges pre-service teachers confront in the process of educational website design	Coder 1	32	88.6%
	Coder 2	34	
Ways of coping with the challenges pre-service teachers confront in the process of educational website design	Coder 1	50	81.0%
	Coder 2	55	
			86.1%

The content analysis method was utilized in the analysis of the qualitative data collected in the research. The four phases developed by Yıldırım and Şimşek (2013) were applied in the content analysis process. These are coding the data, finding the themes, organizing the codes and themes, and defining and interpreting the findings. To enhance the reliability of the qualitative data analysis, the two author of the research worked independently and identified the codes and themes in the first place, and then they came together to compare and discuss the given codes and themes. In addition, the intercoder reliability was calculated using Miles and Huberman's (1994) formula, Percentage of Agreement = Consensus / (Consensus + Dissidence) x 100. According to Miles and Huberman (1994, p. 64), it is recommended that percentage of agreement between two coders is higher than 70%. The reliability percentage was calculated separately for each category. The average reliability percentage of all categories as well as the number of coding and the reliability percentages for each category are shown in Table 2.

It is seen in Table 2 that the average percentage of agreement for all the categories is higher than the critical value mentioned by Miles and Huberman (1994, p.64). It is therefore possible to say

that the intercoder reliability was achieved (Büyüköztürk et al., 2008). Upon the completion of all validity and reliability procedures in the research, the codes obtained under the categories of the qualitative research questions were gathered under the themes and presented under the titles of findings and interpretation individually.

Findings

Change in pre-service teachers' TPACK competencies

To be able to see the changes in pre-service teachers' TPACK competencies after having designed the educational website, the scores obtained from the subdimensions of and the whole TPACK-deep scale were compared with the dependent t-test, and the results are presented in Table 3.

Table 3 The results of t-test regarding the pretest-posttest scores obtained by the participants from TPACK-deep scale

TPACK-deep		*N*	*M*	*SD*	*t*	*p*	*r*
Design	Pretest	28	36.36	6.19	-3.04	.005	.50
	Posttest		40.36	5.79			
Exertion	Pretest	28	44.14	6.91	-4.76	.000	.66
	Posttest		49.93	5.72			
Ethics	Pretest	28	21.71	4.12	-3.92	.001	.60
	Posttest		24.64	3.18			
Proficiency	Pretest	28	17.00	2.99	-3.32	.003	.54
	Posttest		19.57	3.64			
Total score	Pretest	28	119.21	18.20	-4.38	.000	.64
	Posttest		134.50	16.33			

It is seen in Table 3 that the average posttest scores obtained by the CEIT students from the scale subdimensions and the whole scale are higher than the average pretest scores. The t-test results in the table shows that there are significant differences between the design pretest (M = 36.36, SD = 6.17) and posttest scores (M = 40.36, SD = 5.79) (t (27) = -3. 04, $p < .05$, r = .50), the exertion pretest (M = 44.14, SD = 6.91) and posttest scores (M = 49.93, SD = 5.72) (t (27) = -4.76, $p < .05$, r = .66), the ethics pretest (M = 21.71, SD = 4.12) and posttest scores (M = 24.64, SD = 3.18) (t (27) = -3.92, $p < .05$, r = .60), the proficiency pretest (M = 17.00, SD = 2.99) and posttest scores (M = 19.36, SD = 3.64) (t (27) = -3.32, $p < .05$, r = .54), and finally, the total TPACK competency pretest (M = 119.21, SD = 18.20) and posttest scores (M = 134.50, SD = 16.33) (t (27) = -4.38, $p < .05$, r = .64). In addition to the significant differences, it was found that designing an educational website has a high impact on pre-service teachers' TPACK competencies. Based on this finding, it can be said that a course adopting the learning by design approach makes contributions to pre-service TPACK competencies.

Changes in pre-service teachers' perceptions of the properties of digital instructional materials (DIM)

The pre-service teachers wrote their thoughts about what properties the digital instructional materials (DIM) should possess down in the survey before and after the course. The data obtained were coded and are presented in Table 4 and Table 5.

Table 4 Pre-service teachers' pre-course perceptions of the properties of digital instructional materials

Category	Theme	Code	Number of coding
Properties of DIM (Before the course)	Conformity to Goal	Lucidity	10
		Conformity to attainments	2
		Permanent learning	2
		Instructiveness	1
		Reflectiveness of subject integrity	1
		Usefulness	1
	Visual Design	Visuality	9
		Easy designability	5
		Simplicity	2
		Not straining eyes	2
	Providing Motivation	Not boring	4
		Attractive	4
		Fun	1
			46

Table 5 *Pre-service teachers' post-course perceptions of the properties of digital instructional materials*

Category	Theme	Code	Number of coding
Properties of DIM (After the course)	Conformity to Goal	Conformity to learner characteristics	10
		Lucidity	6
		Usefulness	4
		Conformity to attainments	3
		Conformity to the technology used	1
	Visual Design and Visual Elements	Including visual elements	10
		Text design conformity	8
		Including animation	7
		Including videos	4
		Includingphotos-pictures	4
		Color design conformity	4
		Not straining eyes	2
	Providing Motivation	Including games	6
		Attractiveness	4
		Entertaining	4
		Not boring	4
	Content Conformity	With lecturing	5
		Containing accurate information	4
		Containing summarized information	1
		Authenticity	1
	Evaluation	Including tests	5
		Providing feedbacks	3
		Including a discussion section	1
			101

As can be seen in Table 4, the pre-service teachers mentioned about 13 properties of digital instructional materials under the themes of conformity to goal, visual design and providing motivation for 46 times before the course. The pre-service teachers emphasized the properties of digital instructional materials regarding content conformity and evaluation beside the mentioned three themes after the educational website design process (Table 5). In total of 23 properties were reported for 101 times. The increasing number of properties and repetitions may indicate that the pre-service teachers were more informed of the elements to look out for in the design of technology integration. When looking at the codes under the themes more closely, it can be seen that to which direction this change

of knowledge is. For example, the conformity to learner characteristics code emerged under the conformity to goal theme after the course and it was the most repeated code. As for the visual designs of the materials, the pre-service teachers rather mentioned about visual elements such as video and animation after the course. The role of games was emphasized under the providing motivation theme after the course. Properties regarding the materials' content conformity and evaluation are the two new themes created by the pre-service teachers at the end of the design process.

Contributions of the educational website design to pre-service teachers

Pre-service teachers' thoughts about the contribution of the educational website design process to them were coded and are presented in Table 6.

Table 6 Contributions of the educational website design to the pre-service teachers

Category	Theme	Code	Number of coding
Contributions of the Educational Website Design	Learning	Ability to use some of the software	13
		Learning material design	8
		Ability to produce projects	3
		Acquiring permanent learning	1
	Inference	Importance of repetition in learning	5
		Difficulty of teaching profession	1
		Importance of group work	1
			32

The significant increase in pre-service teachers' TPACK competencies and more detailed definitions of what properties the digital instructional materials should possess are the first indicators of the contributions made by the educational website design. In addition, pre-service teachers' thoughts about the contributions of this process are given in Table 6. The most repeated code among the contributions thematized as learning and inference is learning how to use some of the software. This finding suggests that pre-service teachers' technological knowledge improved. Learning the material design is another emphasized theme. The pre-service teachers having designed an educational website by using their technological, pedagogical and content knowledge and having been informed of how to design materials may be the proof that there was an increase in their TPACK. The inferences they had via reflection at the end of the design process are such as to guide them about future learning experiences.

Factors motivating the pre-service teachers in the design process

The data on the factors motivating pre-service teachers in the educational website design process were coded and are presented in Table 7.

Table 7 Factors motivating the pre-service teachers in the design process

Category	Theme	Code	Number of coding
Motivating Factors in the Design Process	Individual Factors	Technological prior knowledge	4
		Awareness of advancing in the right path	4
		Liking the instructional technologies	2
		Examining other groups	1
		Participating in the course regularly	1
	Receiving Support	Support from my friends	6
		Support from the instructor	5
	Usefulness	Producing a product	4
		Benefiting the teacher	3
		Benefiting the students	3

As shown in Table 7, the factors motivating the pre-service teachers in this process are gathered under three themes: individual factors, receiving support and usefulness. The most repeated motivating factors among the individual factors are pre-service teachers having technological prior knowledge and being aware of advancing in the right path in this process. Receiving support from their friends and instructors are also important factor that motivate the pre-service teachers in the process. Finally, the pre-service teachers were motivated by producing products and benefiting the teacher and students. These factors, especially receiving support and usefulness, provide important inferences about how pre-service teachers can be motivated in the design process.

Challenges faced by the pre-service teachers in the design process and their ways of coping with the challenges

The data on the challenges faced by the pre-service teachers in the design process and their ways of coping with those challenges were coded and are presented in Table 8 and Table 9.

Table 8 Challenges faced by the pre-service teachers in the design process

Category	Theme	Code	Number of coding
Challenging Factors in the Design Process	Intrinsic Factors	Not being able to use some of the software	21
		Lack of knowledge	4
		Disharmony with the project group	1
		Not being able to go down to the level of target group	1
	Extrinsic Factors	Expensiveness of the software	2
		Inappropriate environment for videos	1
		Selection of subject	1
			31

The challenges which the pre-service teachers went through the educational website design process were gathered under two themes: intrinsic factors and extrinsic factors (Table 8). It was revealed that the pre-service teachers had difficulty especially in using the software programs and this challenge was quite emphasized. The majority of the e-mails sent to the instructors were about how the problems faced by them could be solved when using the software programs. Lack of knowledge and expensiveness of the programs are also among the challenges reported by the pre-service teachers. Pre-service teachers' ways of coping with those challenges are presented in Table 9.

Table 9 Pre-service teachers' ways of coping with the challenges in the process

Category	Theme	Code	Number of coding
Ways of Coping with the Challenges in the Design Process	Receiving Support	Receiving help from the instructor	14
		Receiving help from friends	12
		Receiving help from related webpages	5
	Individual Effort	Researching through several sources	10
		Repeating what has been learned	3
		Trial and error method	2
		Examining other materials	1
			47

According to Table 9, the pre-service teachers overcame the challenges they confronted in the design process by receiving support and/or through individual effort. The most repeated ways of coping with the challenges are receiving help from the instructor and friends and researching through

several sources. Based on these findings, it can be concluded that the pre-service teacher had the biggest trouble with using the software programs and they overcame the problems by receiving help from more informed and experienced people around them and researching the sources.

Discussion

This study aimed to investigate the changes in TPACK competencies of pre-service teachers who designed an educational website and to reveal their design experiences. Firstly, it was found that there are significant differences between the pretest and posttest scores obtained from the TPACK-deep scale's design, exertion, ethics and proficiency subdimensions and the whole scale by the pre-service teachers who designed an educational website. It was also discovered that the application process had a high impact. In similar studies (Koehler & Mishra, 2005a; Chai, Koh & Tsai, 2010; Sancar Tokmak, Yanpar Yelken & Yavuz Konokman, 2013; Koh & Chai, 2014; Sancar Tokmak, 2015), it was also shown that there were significant increases in pre-service teachers' TPACK as a result of designing the materials and courses into which ICT was integrated. These findings indicate that a course adopting the learning by design approach improve teachers' competency of technology integration and TPACK.

Secondly, the change in pre-service teachers' perceptions of what properties the digital instructional materials should possess was examined. Before the course started, the pre-service teachers addressed the properties of digital instructional materials regarding conformity to goal, visual design and providing motivation while they also emphasized their properties regarding the content conformity of the materials and evaluation after the course ended. There was an increase in the number of properties which the materials should possess and the number of the repetition of these properties. In a closer look at the themes obtained, differently than the properties mentioned before the course, the pre-service teachers emphasized materials' conformity to learner characteristics, possessing visual elements such as video and animation and providing learner motivation through games. Materials' content conformity and having the evaluation elements are two new themes emerged at the end of the course. These findings may prove that the pre-service teachers became more informed of the elements to look out for in the material design in terms of technology, pedagogy and content and their schemas expanded in this sense. Similarly, it was found in the study conducted by Sancar Tokmak et al. (2013) that pre-service teachers performed different design activities (3D material, ppt presentation, website design, etc.) and their knowledge about different principles of the material design were improved at the end of the process. In another study, the students of the department of early childhood education who were designing an educational game stated that they learned the principles of game design (Sancar Tokmak, 2015). This research also revealed pre-service teachers' thoughts about what properties the digital instructional materials should have both before and after the course. Thus, the improvement of pre-service teachers' TPACK could be examined more explanatorily with the comparison of the qualitative data obtained before and after the course. In the literature reviews conducted with the TPACK studies in Turkey, it was stated that there are few studies revealing participants' TPACK development processes and studies based on qualitative data are needed (Baran & Canbazoğlu-Bilici, 2015; Kaleli Yılmaz, 2015). At this point, this study can lead the way about what kind of a data collection method can be used in related studies in future.

The contributions made by the educational website design process to the pre-service teachers were also investigated in the study. The findings showed that the pre-service teachers emphasized they firstly learned how to use some of the software programs, in other words, their technological knowledge were improved. Secondly, they emphasized that they learned the material design. In the research studies which aimed to improve pre-service teachers' TPACK through design (Koh & Chai, 2014; Koh & Divaharan, 2013), it was indicated that the participants attached more importance to their technological knowledge before the design and that importance lost its strength after the design. In this research, it is intriguing that the participants emphasized their improved technological knowledge more even though there was a significant increase in pre-service teachers' TPACK at the end of the course. The pre-service teachers having the biggest trouble with using some of the software programs

and their effort to overcome the challenges may have caused them to emphasize the component of technological knowledge at the end of the course. As well as the contributions mentioned, the pre-service teachers made some inferences such as how important the repetition is important in learning. Why the pre-service teachers made inferences for their future actions can be explained by the fact that the design process includes conscious thinking, analyzing and learning through reflection (Koehler & Mishra, 2005b).

Pre-service teachers' design experiences were investigated as well as the improvement of their TPACK. Firstly, the factors motivating them in the educational website design process were examined. It was determined that individual factors such as possessing technological prior knowledge, receiving support from friends and instructors, producing a product, and benefiting teacher and students motivated the pre-service teachers. The pre-service teachers went through a design process aiming to improve their TPACK within the framework of the learning by design approach. The learning by design approach is a constructivist approach based on the assumption that learning occurs through an action and with the interaction between the individual and the environment (Koehler & Mishra, 2005a). Learners play an active role in questioning, investigating and designing processes cooperatively to find solutions to authentic problems and produce tangible and significant products as the outputs of the learning process. The instructors play the role of facilitators and problem solvers instead of being content specialists. In this research, receiving support from friends and instructors and creating a product, which are the factors motivating the pre-service teachers, emphasize the importance of the learning by design approach. Differently from other related studies, the pre-service teachers were motivated by designing an educational website and thinking that they would benefit the teachers and students in the design process. The fact the instructors stated in the design process that the websites to be designed by the pre-service teachers might be used by teachers and students may be one of the strong factors contributing to the case. In future applications, allowing the products created by pre-service teachers for the use by teachers and students in the real classroom environment may ensure that the pre-service teachers respond to authentic problems affectively in the design process.

Challenges faced by the pre-service teachers and their ways of coping with those challenges in the design process formed another research problem. It was especially found that the pre-service teachers had difficulty in using the software programs. It was also determined that their ways of coping with challenges were receiving help from the instructor and friends and investigating several sources. Similar findings were achieved in the studies performed with pre-service teachers from different branches (Sancar Tokmak et al., 2013; Sancar Tokmak, 2015). It was interesting that the participants experienced difficulty in using the software programs although they were the students in the CEIT department. Learning different instructional technologies and software programs such as image, audio and video editing, creating animation and games and designing websites within a term may have caused the pre-service teachers to have difficulties in the design process. Since the design process of ICT integration requires the synthesis of different information and decision phases, it may cause a cognitive load on teachers (Kramarski & Michalsky, 2010). In this sense, trying to integrate learning and education with several software programs may have caused a cognitive load on the pre-service teachers in their design processes. It can be recommended for the future studies that pre-service teachers design educational materials with easy-to-use Web 2.0 technologies instead of software programs.

Conclusion

TPACK has been a developing focus of research among the teacher educators working especially in the field of educational technologies since 2005 (Chai, Koh, & Tsai, 2013). While the number of TPACK studies has been increasing (Wu, 2013), there is insufficient number of studies showing teachers' TPACK development in regard to the difference between their pretest and posttest scores (Chai, Koh & Tsai, 2010). Limited number of studies which examine development of participants' TPACK and show how this development occurs in a long application period by using different data collection tools (Kaleli Yılmaz, 2015) encouraged the researchers to conduct such a

study in a necessity. It was firstly concluded in the research that a course adopting the learning by design approach made important contributions to participants' TPACK competencies. Secondly, it was revealed that the design process expands pre-service teachers' schemas regarding the properties that digital instructional materials should possess. This improvement is considered important for showing the development of pre-service teachers' TPACK from a different aspect. Lastly, recommendations were made in the research for future practices by revealing factors that motivate and challenge pre-service teachers in the design process.

There are some limitations of this study. First, the research sample was selected with the convenience sampling method. That is why the findings obtained are limited in terms of generalizability. Secondly, the pre-service teachers did not apply their educational websites to the students in the classroom environment. This is the reason why participants' experiences of carrying out the instruction and assessing and evaluating the effectiveness of the instruction are limited. This might have affected the pre-service teachers' scores on the exertion factor of TPACK-deep scale. Therefore, it is important to allow teachers to apply their design products in real environments in addition to design activities in future studies aiming to improve their TPACK competencies. Finally, the period of 14 weeks, which is the duration of application in the research, can be too short for teachers to improve their TPACK competencies in consideration of the complex and versatile structure of technological integration in education. It is recommended by researchers to integrate different courses in the teacher training program with design activities in future studies.

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