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Prospective Mathematics Teachers' Technological Pedagogical Content Knowledge Improvement via Creating Technology-Based Mathematics Stories

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ABSTRACT

In an attempt to improve Technological Pedagogical Content Knowledge (TPACK), prospective mathematics teachers (N=52) were trained in creating technology-based mathematics teaching materials. They learned visual programming, worked in pairs and created mathematics stories, which are intended to improve fourth grade students' mathematics word problem solving. Six of the prospective teachers were willingly participated in this study and watched students completing the stories in actual classroom environments. The purpose was to show them the value of their work and provide advice with regard to improve their TPACK. They (n=6) were interviewed within a qualitative research framework. This study reveals the prospective teachers´ opinions and beliefs regarding various aspects of the projects, such as students´ interest, students´ performance, as well as the teachers´ professional, pedagogical and individual improvement. The prospective teachers are convinced that teaching by means of technology support students' learning and that technology use in the classrooms is valuable. As a result, it can be confirmed that the process helped them improve their TPACK.

Keywords:
Teacher education, visual programming, TPACK, mathematics stories, technology training

1. Introduction

Today's learners grow up in technology-rich environments and are regarded as technology natives. Thus, integrating technology in education means that it helps young learners learn in their native environment. Undoubtedly, teachers play a major role in such learning environments. Law, Pelgrum and Plomp's (2008) research with 35000 teachers from 22 different countries indicated that technology integration in education is highly related to teachers. While teachers with insufficient technology skills use technology in drill and practice style, more experienced teachers take advantage of technology in constructivist approach in their classrooms. Moreover, they develop expertise in technology use if they experience technology in conjunction with students (Liu & Szabo, 2009). According to Instefjord and Munthe (2017), prospective teachers should be trained in technology on campus and in integrating technology in schools for their future teaching practices. In this respect, preparing prospective teachers for technology integration and allowing them to use technology in educational practices (Pan & Carroll, 2002) is essential before starting to their professions.

In classrooms, within which traditional methods are used, learners experience limited activities (Rakes, Fields & Cox, 2006). This is also the case for teacher training programs that mostly classes are taught with traditional methods and accordingly prospective teachers experience limited activities. Yet, *"Teachers need to leave their teacher preparation programs with a solid understanding of how to use technology to support learning"* (U.S.

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Department of Education, Office of Educational Technology, 2017). However, learning how to use technology is not solely about learning how to use it as a tool. Instead, it is about using technology in combination with appropriate pedagogical techniques and the content (Koehler & Mishra, 2009). This concept is called as teachers' technological pedagogical content knowledge (TPACK), which yields effective results on teachers' effective technology use in the classrooms.

Technological Pedagogical Content Knowledge (TPACK) helps teachers with their integration of technology from recognizing the value of technology in educational settings to integrating technology in their education. This process requires teachers to know their content well, understand how students learn and have deep knowledge about technology use. The present study was conducted to show prospective teachers how to use technology to teach mathematics by taking advantage of pedagogical techniques in TPACK framework. In this framework, it is recommended for teachers to design, implement and evaluate instruction with technology (Niess, 2011). With this purpose, prospective teachers in this study were taught designing technology-based mathematics materials for students' mathematics learning, implemented their materials to students, watched them and evaluated the process. In an attempt to improve their TPACK, prospective teachers were trained in creating technology-based mathematics materials, for fourth grade mathematics classes content for the purpose mentioned above.

1.1. Technological Pedagogical Content Knowledge (TPACK)

Technological pedagogical content knowledge (TPACK) suggests a framework for effective teaching, which combines content, pedagogical techniques and technology. That is, technology is required to be used along with pedagogical techniques to teach content effectively. In this framework, teachers' knowledge is required in the concepts and pedagogical techniques. The concepts are represented with technology using pedagogical techniques, which help students overcome learning issues. Moreover, knowing the way of using technology to reinforce students' existing knowledge is required in TPACK framework. In order to have such knowledge teachers need to gain the three components of TPACK (Koehler and Mishra, 2009). In TPACK framework, teachers are required to design, implement and evaluate instruction with technology (Niess, 2011). As claimed by Koehler and Mishra (2009), teachers must be flexible in applying the three concepts of TPACK as technological solutions may differ from teacher to teacher, course to course and in how the teacher teaches the courses. Kaleli (2012) claims that in the scope of TPACK teachers are demanded to have sufficient knowledge of educational software and be able to determine suitable software for a target. Additionally, they need to know how to teach the content and target by using software. To improve their TPACK, teachers must be trained both in their training during college education and in-service training.

It is recommended that possible effect of technology on students' learning must be emphasized in teacher education programs (Ottenbreit-Leftwich, Glazewski, Newby & Ertmer, 2010). However, Tanak (2018) state that prospective teachers' pedagogical knowledge on their TPACK is more effective than their technological knowledge on their TPACK. Which is that, teaching only technological skills is not enough for teachers to develop TPACK. Agyei and Voogt (2011) recommends that teacher education programs must take it into consideration that prospective teachers take courses including technology related pedagogical issues. Hereby, they can experience integrating technology into their teaching in their future classrooms. Thus, they can develop positive beliefs in technology, which can predict their TPACK (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012; Cheng & Xie, 2018; Miranda & Russell, 2012).

National Council of Teachers of Mathematics, (NCTM, 2000) point out that "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (p. 24). According to Niess et al. (2009) when learning how to integrate technology in mathematics classrooms, teachers go through a developmental process. This process includes five stages as progression toward TPACK: recognizing, accepting, adapting, exploring and advancing. First of all, teachers recognize technology and its association to mathematics content. Then they develop either a positive or negative attitude toward technology use in mathematics classrooms. In the next stage they decide whether or not to teach mathematics with technology after engaging in technology related activities. In the fourth stage, teachers implement technology-based teaching-learning activities for mathematics. Lastly, teachers come to confirmation stage, in which they decide to integrate technology in mathematics classes and evaluate this decision.

Kopcha (2012) lists five barriers to teachers' technology integration in the classrooms mentioned in the literature: access, vision, beliefs, time and professional development. For professional development, he states that training teachers only in technical skills is insufficient for teachers to successfully integrate technology in education as this training is not linked to actual classroom practice. Instefjord and Munthe (2017) state that prospective teachers should be trained in technology on campus. However, they must also be trained in integrating technology in their future classrooms. Moreover, as claimed by the International Society for Technology in Education standards (ISTE, 2008) teachers must have the ability to "design, develop and evaluate authentic learning experiences and assessments incorporating contemporary tools and resources to maximize content learning in context" (p.1). For prospective mathematics teachers, teaching practice and motivation are some important factors to teach subject with technology (Yang, Ji, Zhang, Zhang & Zhang, 2018). Thus, this study brings prospective teachers, who were trained in technology on campus, and actual classrooms together to show them the value of technology in the classrooms. Eventually, the purpose was to get their views and evaluations about this experience, see how motivated they are in using technology in their future professions for teaching and learning purposes and to see if their TPACK was improved. For this aim, they created a technology-based mathematics environment to improve students' word problem solving. They learned Scratch programming in their classrooms on campus and created visual and audial animated learning environments.

1.2. Scratch Programming for Creating Mathematics Learning Environment

Scratch programming is a visual programming environment (Maloney, Resnick, Rusk, Silverman & Eastmond, 2010) developed at the MIT Media Lab by the Lifelong Kindergarten research group. As a free and open source, games, stories, simulations and interactive stories can be created with this programming language (Ouahbi, Kaddari, Darhmaoui, Elachqar, & Lahmine, 2015). Scratch enables users to create their projects in an object-oriented programming environment, in which objects can be dragged and dropped and as a result, interactive applications can be created (Pinto & Escudeiro, 2014). Moreover, learning text commands as in the other programming languages is not necessary. Users do not have to have deep programming knowledge in order to create their projects in Scratch, either. All the commands as visual programming blocks (e.g., motion, sensing, and sound) are on Scratch and users can drag and drop them to create their own projects (Nikou & Economides, 2014; Resnick et al., 2009). It is an easy program to use for anyone no matter her/his age or background (Marcelino, Pessoa, Vieira, Salvador & Mendes, 2018).

In the literature, Scratch programming has been used as a tool to teach programming (e.g. Kalelioglu & Gülbahar, 2014; Wang, Huang & Hwang, 2016), investigate students' views about programming (Yukselturk & Altiok, 2017), see how students with different level of mathematics achievement implemented, perceived and evaluated Scratch programming activities (Han, Bae & Park, 2016), and have high school students create simple games so that they would learn programming basics while learning creativity (Ouahbi et al., 2015). In the literature, the use of Scratch is mostly related to designing technology-based environments, the ability of writing computer codes and learners' perceptions of computer programming. All these uses show that this visual programming tool is used for technology creation process. This situation gave the idea that this ability can be gained to prospective teachers in terms of the technology component of TPACK framework in this study.

In this respect, prospective teachers, who had no programming experience, created their own technology-based materials to teach mathematics with Scratch. Their projects were intended for 4th grade students' word problem solving. There are many studies in the literature using Scratch as a tool to teach programming (e.g. Kalelioglu & Gülbahar, 2014; Wang, Huang & Hwang, 2016; Yukselturk & Altiok, 2017). In this study, prospective teachers as programmers have designed their technology-based learning environments with Scratch. The purpose was to help them see the value of their work in actual educational settings. More precisely, mathematics prospective teachers learned a technology related skill, computer coding with which they designed a technology-based learning environment, and observed students' learning in this environment. With this purpose, the following research questions were examined in the present study:

1. What are prospective mathematics teachers' thoughts and feelings about the process, from training to implementation, and its contributions?
2. Do prospective mathematics teachers have any suggestions towards this teaching and learning process to teachers, teacher-candidates and researchers?

2. Method

2.1. Procedure

Mathematics prospective teachers from a faculty of education participated in this study. They mostly have classes with traditional teaching methods and rarely witness technology use in education. Technology-based teaching mostly is provided in PowerPoint presentations, educational social media (e.g., Edmodo) or game-based quiz programs (e.g., Kahoot) only when the instructor of the course use it. Accordingly, they properly do not see the benefits of technology for teaching-learning practices. Thus, it was aimed to give prospective teachers the chance of observing the benefits of technology in classrooms. A case study approach was utilized in this study. McMillan (2012) define as "an in-depth analysis of one or more events, settings, programs, social groups, communities, individuals, or other bounded systems in their natural context" (McMillan (2012, p. 279). Within this approach, mathematics prospective teachers learned a visual programming language, Scratch programming, as well as pedagogical approaches to teach mathematics by using technology in their Computer-Based Mathematics Teaching course. They observed students learning mathematics by the use of technological materials they created. Specifically, the purpose was to give them the sense of ownership of the technological tools so that they can pay full attention to students' interaction with the tools. By this way, it was aimed to improve their TPACK.

First of all, prospective teachers were trained in visual computer-programming, Scratch programming, on campus for four weeks. During this period, they learned how to use Scratch programming to create visual-audial environments using visual objects. Without needing text-based computer-programming knowledge, prospective teachers learned creating computer-based activities by dragging and dropping visual objects (e.g. motion, sound, sensing, control objects). They practiced Scratch programming with the weekly homework assignments. When they satisfactorily learned Scratch programming, they started building their final projects. They were then informed that their projects would be applied to fourth graders and asked whether they were willing to observe the learning atmosphere. As a result, six prospective teachers watched fourth grade students solving mathematics word problems in the animated stories in students' classrooms. Fourth grade students completed the animated stories in the computer lab of their schools. Prospective teachers watched fourth-grade students while the students individually were completing the projects. Prospective teachers were then interviewed about the process, from designing to applying, with semi-structured interview questions. The interviews were completed after the whole process, including the training on campus and the implementation process in the actual classrooms were completed. Their answers to the questions were coded and analyzed applying a content analysis.

2.2. Participants

The prospective teachers were at their final years in the department of Mathematics Education in a faculty of education. These participants were selected because they were about to graduate, ready for teaching and took all the required courses in mathematics education. The average age was 22. All participants were female because only female prospective teachers were willing to be involved in the study. None of them had computer coding experience before the study.

2.3. Materials

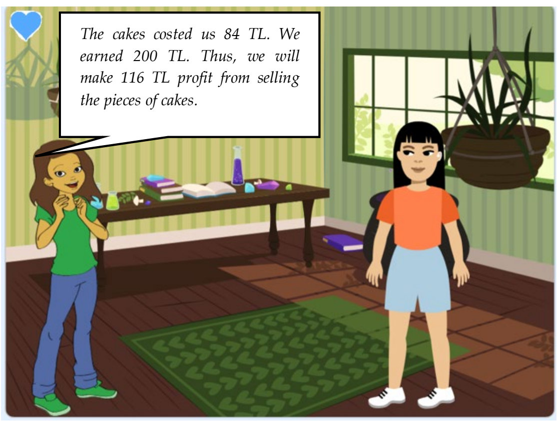
2.3.1. Animated Mathematics Stories. The prospective teachers (*N* = 52) created mathematics stories on Scratch programming in pairs. For the purpose of the study, two of these stories were used in actual classroom environments (see Figures). The selection was made based on the projects with good quality. That included projects with no error, narrated well and complete. Scratch application is required for the animated mathematics stories to work on computers. These projects were created around a story, in which mathematics word problems were embedded. In a context, prospective teachers asked to write their stories in which story characters encounter mathematics word problems within the context of the stories. A sample mathematics word problem was as following:

"Today I made 32 pieces of cake. You told me you want to buy half of these minus 10 pieces. So how many pieces do you want to buy?

Prospective teachers designed their projects, which provided feedback based on students' individual answers. Feedbacks were explained in conversation format for the questions. For the problem above, the feedback was as following:

"To calculate the number of pieces, we are supposed to divide the number of total pieces in half first. The result is 32/2 = 16 pieces. Then, we need to subtract 10 pieces from 16 pieces. As a result, you will buy 16 - 10 = 6 pieces of cake"

The story was narrated by prospective teachers including the plot and conversations between the characters and then recorded on Scratch programming. Story related pictures, background images and characters were all inserted in the projects by prospective teachers during their project creations. They also used an answer dialog box for to enter answers.



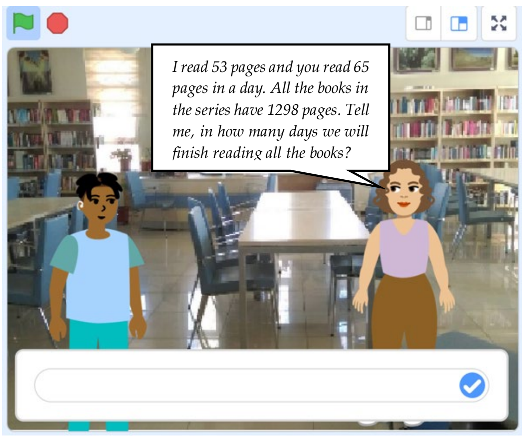


Figure 1. *Sample screen-shots of the prospective teachers' projects*

2.3.2. Interview Questions. Prospective teachers answered three main questions with related sub-questions.

The questions were all open ended. The first question was about their thoughts and feelings before, during and after implementing their projects. The second question was about the contribution of the process individually, professionally and pedagogically. Finally, the last question was about their suggestions to teachers, prospective teachers and future researchers related to the process. They were asked to fill out a paper-based question form to answer these questions. For the validity of the questions, two experts in the area were asked for their opinions. Based on their feedbacks, the question form took its final shape. Prospective teachers' answers were coded with a content analysis by two independent coders. Inter-rater coders' reliability was calculated with the Miles & Huberman Formula (1994): Number of Agreements / (Number of Agreements + Disagreements. The result was 0.82. The result showed that the coding was reliable.

3. Results

3.1. Prospective mathematics teachers' views about the process

3.1.1 Thoughts and Feelings Before, During and After Implementing the Projects to Students

Prospective mathematics teachers (*n=6*) were asked what they thought and how they felt before, during and after applying their projects to the 4th grade students. Their answers were coded, the inter-rater reliability was completed and the results were summarized below in table 1.

Table 1. Prospective teachers' thoughts before/during/after the process

Thoughts/feelings before the implementation									
PT#	*Incentive*	*Permanent learning*	*Functionality*	*Stories and Math*	*Misperception*	*Pleased*	*Nervous*	*Curious*	*Excited*
PT1				✓					✓
PT2	✓						✓		
PT3	✓	✓						✓	
PT4			✓		✓	✓			
PT5		✓	✓		✓		✓		
PT6							✓		

Thoughts/feelings during the implementation									
PT#	*Willing student s*	*Effective*	*Individual differences*	*Attractive/ Interesting*	*Likeable*	*Intriguing*	*Beneficial*	*Successful*	*Exciting experience*
PT1		✓							
PT2	✓				✓			✓	
PT3			✓	✓		✓			✓
PT4	✓						✓		
PT5			✓						
PT6	✓	✓							

Thoughts/feelings after the implementation										
PT#	*Increas e/ interest*	*Works*	*Delighting*	*Attractive*	*Minimizes boredom*	*Catchy*	*Useable*	*Must be sufficient*	*Out of traditional*	*Must be fluent*
PT1	✓	✓								
PT2			✓							
PT3				✓	✓	✓				
PT4	✓						✓			
PT5								✓		✓
PT6									✓	

Before the implementation process, the prospective teachers stated that they were anxious if their projects would be beneficial on students′ learning. They said they wondered whether students would see this environment as a game instead of a learning environment and find it interesting. For some candidates, preparing the program was fun, they thought that what they designed would be beneficial and lead to permanent and active learning as long as students would take it seriously. Some of the prospective teachers' thoughts were as followings:

"I was excited about the idea of bringing the animated stories and mathematics together." (PT1). *"I was wondering if students would arouse interest in our program"*. (PT3)

During the implementation stage, participants stated that fourth graders, who used their projects, seemed interested in the activities. Studying mathematics in an animated story environment was of interest to the students because they seemed they liked the whole activity. They added that this learning environment was beneficial and successful for students. For them, visual and audio problem-solving environment has produced an effective learning environment. However, students' individual differences might be effective in their level of interests and mathematical learning in such environment. Some of the prospective teachers' thoughts were as followings: *"I think students, who like animations and have more sense of wonder paid more attention and understood its purpose better"* (PT5). *"I saw that students were willing to work on the projects and that it was beneficial"*. (PT4)

After the implementation, prospective teachers said they observed that animated stories had worked, drawn interest and pleased students. The projects were delighting, catchy and attractive to the students and reduced students' boredom. Visuals in the projects were effective on this result. For these reasons they recommended that teachers should use such learning environments in educational settings as a learning activity. However, such projects must be sufficiently designed. For example, both the story and the animation must be fluent for students not to get bored. So that they may get the most benefit. Some of comments were as follows:

"Students liked the programs, watched them with pleasure however some of them got bored when answering the questions because the number of questions were too many for those". (PT2) *"It made us happy seeing our program has worked".* (PT6)

3.1.2. Individual, Professional and Pedagogical Contribution of the Process. Prospective teachers were asked whether the process has contributed to them individually, professionally and pedagogically. Their answers were coded and summarized in table 2:

Table 2. Prospective teachers' thoughts about individual/professional/pedagogical contribution of the process

Individual contribution of the process

PT#	*Disciplined group work*	*Responsibility*	*New learning experience*	*Gaining new knowledge*	*Learning student attention*	*Creativity/ different perspective*	*Digital learning*	*Reflective thinking*
PT1	✓	✓						
PT2			✓					
PT3			✓	✓				
PT4					✓			
PT5	✓	✓				✓		✓
PT6							✓	

Professional contribution of the process

PT#	*Teaching fun mathematics*	*Contemporary teaching*	*Improved self*	*Coding*	*Uncommon teaching*	*Adapted teaching*	*Learning students' level*	*Visualized teaching*
PT1	✓	✓						
PT2			✓		✓			
PT3				✓		✓		✓
PT4				✓				
PT5	✓			✓	✓			
PT6							✓	

Pedagogical contribution of the process

PT#	*Persistent knowledge*	*Multiple intelligence's need*	*Students attention*	*Getting to know age group*	*Students' perception*	*Feedback*	*Nontraditional teaching*	*Active learning*	*Class manag ement*
PT1				✓					
PT2		✓							
PT3	✓		✓						
PT4					✓	✓			
PT5							✓		✓
PT6	✓							✓	

For their individual gains, prospective teachers reported that this learning environment helped them get group work habit and take responsibility in a disciplined way. Creating a new learning environment was a new knowledge for them that they would use it in their future work life. They learned how to catch students' attention to a learning material, they said. Additionally, they stated their creativity and reflective thinking ability have improved. They also reported they personally improved digitally.

"*I got a wider knowledge in computer programs and coding. I learned about the best voice recording programs and how to create higher quality records*". (PT6) "*I have learned Scratch programming. I have got a new knowledge now to answer technology related questions in our profession…*". (PT3)

As professional contributions, prospective teachers claimed that they learned teaching mathematics in an entertaining way, forming a creative teaching environment and how to code. This learning environment is suitable to the technology age we are in, which caused them to improve their professions. They reported they would apply their knowledge from this learning experience to any mathematical topic, which requires visual aid. Additionally, one of the benefits of this learning activity was to do research and accordingly learn how to prepare problems based on students' level. Some of the answers were as following:

"*We've never been taught mathematics in such a way. I understood mathematics can be made fun and instructive, thanks to this project…*" (PT5). "*It has caused me to present mathematics in an entertaining way. I have learned how to address technology-age children*". (PT1)

As for pedagogical contributions, prospective teachers stated that with this method, they had a chance to get know the related age group, their perceptions and how to answer to the need of students with different intelligence types. They said they learned a teaching method catching students' attention, increasing knowledge persistence, ensuring active learning and providing functional feedback based on students' needs. More importantly, they said they learned a new way of teaching, which might be a replacement for outdated traditional methods. As students paid attention to the learning material, they believed it contributed to classroom management, as well. Some of the comments were as follows:

"*I learned student perception, how to react to their questions, in what aspect to make explanation*". (PT4) "*It helped me (seeing) explaining the course based on not only logical-mathematical knowledge but also other intelligence types*". (PT2) "*It (this process) made me feel like so glad I am a teacher*". (PT5).

3.1.3. Suggestions for others. Prospective teachers were asked whether they would make any suggestions to teachers, prospective teachers and researchers. Their answers were coded and summarized in the table below:

Table 3. Prospective teachers' suggestions to teachers/teacher candidates/researchers

Suggestions to Teachers

PT#	*Openness to innovations*	*Must be used*	*Technology knowledge*	*Planning*	*Student attention*	*Audio visual and intellectual teaching*	*Active learners*	*Problem solving*	*Mathematics attitude*
PT1			✓	✓					
PT2		✓			✓				
PT3		✓							✓
PT4	✓								
PT5	✓		✓						
PT6						✓	✓	✓	

Suggestions to Teacher Candidates

PT#	*Learn/ Use*	*Openness to innovations*	*Willingness*	*Permanent learning*	*Non-traditional methods*
PT1			✓		
PT2					
PT3					
PT4	✓	✓			
PT5	✓	✓			
PT6	✓			✓	✓

Suggestions to Researchers					
PT#	*Improve/ create*	*Inform*	*Carefulness*	*Teach/Help*	*Course objectives*
PT1		✓	✓		
PT2					
PT3	✓				
PT4	✓				
PT5	✓				
PT6				✓	✓

Prospective teachers suggested that teachers must use technology, be open to innovations in educational settings and must not be stuck only with the traditional methods. This requires having technology knowledge. This learning method catches students' attention and therefore teachers can use this learning method to make students like mathematics. They must provide audio-visual learning environments, in which students can learn problem solving and be intellectually active. However, they must plan everything beforehand not to have any problem during the implementation of their digital products. Their suggestions to teachers were as following:

"*I recommend teachers to use such learning environments. This is a usable method for overcoming mathematics anxiety*" (PT3). "*Teachers must have technology knowledge. Additionally, they should take any possible failure into consideration that might occur during teaching-learning process*" (PT1).

For recommendation to prospective teachers, the participants recommended that they must learn programming, create their projects and use them. They must learn using such learning environments so that they would provide their students with permanent learning. This result could be gained in an entertaining learning setting. They must use non-traditional methods such as their projects, improve themselves, provide such permanent learning environments and must be willing for such new environments:

"*I recommend that prospective teachers must learn these kinds of tools*" (PT4). "*If they use such tools learning will be permanent. Students could both be entertained and learn*" (PT6).

For researchers in such environments, prospective teachers stated researchers must increase the number of such studies and improve traditional methods. Additionally, they should be well aware of that this process requires time and endeavor. Thus, those they work with should be well informed. Moreover, they must check the mathematics curriculum course objectives well, when creating their projects. Otherwise they might not get the intended result:

"*It would be a good idea to increase the number of these types of researches as it is an important method to make mathematics concrete…*" (PT3). "*Researchers must complete rich and creative studies based on more complicated problems*" (PT5).

4. Discussion

Student teachers mostly are trained with traditional methods during their education. They witness only limited number uses of educational technology tools only if the instructor of their classes uses such tools. Moreover, they mostly don't take benefit of technology in their class assignments if they are required to give presentations. In this respect, it was aimed to improve prospective teachers' technology views in a positive way, which requires appropriate pedagogical methods to teach content by using technology. TPACK framework helps with teachers' professional development through technology use in a constructivist approach where technology is not utilized as an add-on tool (Koehler & Mishra, 2009). Therefore, it is necessary for teachers to have the knowledge of how students learn, their content and technology in TPACK framework. In this study, in a case study approach, mathematics prospective teachers learned a visual computer programming tool to create their own technology-based mathematics learning materials and watch students using these materials. Specifically, the purpose was to give them the sense of ownership of the technological tools so that they can pay full attention to students' interaction with the tools. For this purpose, prospective teachers were trained on campus in a visual computer programming tool, Scratch programming, for four weeks. They learned how to code as well as designed small activities and created animated stories, in which mathematics is integrated. The prospective teachers then had a chance to watch fourth graders in their classrooms completing their materials. Upon the experiment was completed, they were interviewed with semi-structured interview questions.

Educators have insufficient training in the pedagogical use of technology. However, teachers' technology related pedagogical beliefs are shaped with their insights in different kind of devices, software and their benefits (Mertala, 2017). In this study, prospective teachers created a technology-based learning environment as programmers, applied it to students and saw its benefits. In the TPACK framework, technology is required to be used along with pedagogical techniques to teach content effectively (Koehler & Mishra, 2009). Prospective teachers claimed they recognized the pedagogical use of technology in teaching mathematics. They became familiar with the related-age group, a non-traditional teaching method, how to draw students' interest and how to provide feedback. It can also be told from the projects they designed. While creating the projects, they paid attention to students' age level in the story context and visuals, provided feedback and inserted catchy objects for students. Their comments about learning how to teach mathematics by means of technology and how to pedagogically take benefit of technology to teach mathematics are related to TPACK. As a result, it can be claimed that their TPACK improved.

Niess et al. (2009) state five stages as progression toward TPACK: recognizing, accepting, adapting, exploring and advancing. The interviews with prospective teachers showed that throughout the process they believed students liked the mathematics learning environment, were interested in the activities and believed that it was a success. This was related to recognizing stage. Also, they believed this technology-based learning environment is beneficial because it draws students' attention, may decrease students' mathematics phobia and should be used in educational settings. This was related to accepting stage and pedagogical knowledge component of TPACK. They believe the process improved them professionally; they gained new knowledge, learned teaching mathematics in an entertaining and creative way, and intend to apply their new knowledge to other mathematical concepts. This was related to adapting and exploring stages. They did not start teaching yet however it is clear that they have the intention for technology integration in their teaching. Consequently, the result is consistent with the Niess et al. (2009) five-stage developmental process for teachers' TPACK. Prospective teachers in this study came to believe that teaching mathematics in a technologically enhanced environment is beneficial and have positive feelings about technology integration in future. They believe technology-based teaching should be used in mathematics classrooms.

This study links theory and practice. The prospective teachers didn't only learn to design digital materials for their future classroom settings. They also learned how and why to use them, which confirms the practicability of this study. Teacher education is seen "too theoretical" (Sjølie, 2014, p.729) and detached from schools. Thus, this study suggests to apply this applicable approach for prospective teachers in their future work place. Prospective teachers stated that this technologically enhanced learning environment is suitable to the technology age we live in, as it is more related to real-life situations and especially helpful, which can be credited to the visual aids. Accordingly, the process used in this study showed a method to connect teacher education to schools to improve prospective teachers' views of technology.

Ertmer, Ottenbreit-Leftwich, Sadık, Şendurur and Şendurur (2012) in their study with award winning technology-user teachers reported that teachers' attitudes, beliefs, knowledge and skills in technology prevents teachers from using technology. Miranda and Russell (2012) in their study with over 1000 teachers revealed that teachers' technology use is affected by their beliefs about the advantages of technology for teaching purposes and knowing the significance of using technology in classrooms. In the present study, the interviews with the prospective teachers revealed that they believe they learned teaching mathematics in a fun way with the use of technology, gained coding skills, learned a visualized teaching and digital teaching methods with the use of technology. They believed they learned technology by creating technology-based materials, witnessed the use of technology process while students were completing their technology-based materials, learned pedagogical use of technology and improved their technology skills. As a result, it can be claimed that barriers mentioned in the literature can be removed with such action as in the present study and the prospective teachers can develop positive beliefs toward technology. Their positive beliefs in technology can predict their TPACK (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012; Cheng & Xie, 2018; Miranda & Russell, 2012), as a result we can claim that their TPACK improved.

Petko (2012) suggest that teachers use technology more in their classrooms based on five circumstances. First one is that teachers must believe that computers improve learning. Teachers' unwillingness for technology integration in education is a result of their skepticism and concern in using technology (Hoffmann & Ramirez, 2018). During the implementation of student teachers' projects, it was observed that fourth grade students showed interest to the technology-based mathematics learning tools. The students wanted to continue to the projects and even asked if there are more projects they can complete. Prospective teachers seemed very happy about students' reactions. They claimed fourth graders enjoyed the activity and believed that their computer-based mathematics projects were beneficial. Additionally, they believed such learning environments would decrease students' negative feelings and increase positive feelings about mathematics. Prospective teachers recommended teachers that technology must be used in educational settings rather than only traditional methods. For their peers, they recommended they must learn designing technology-based materials aligned with curriculum objectives to support students learning. Accordingly, it can be claimed that prospective teachers believe technology improve learning, yields effective results on students' learning and as a result they don't have skepticism about the use of technology. As their beliefs stimulate their intention for using technology (Rehmat & Bailey, 2014), the process used in this study may affect their technology use intentions in their future classrooms.

ISTE (2018) requires teachers' ability to design, develop and evaluate realistic learning practices. In addition, in TPACK framework, teachers are required to design, implement and evaluate instruction with technology (Niess, 2011). With these requirements are in mind, prospective teachers designed technology-based mathematics learning projects, implemented these projects to students and evaluated technology-based learning environments in this study. They emphasized audial, visual and animated teaching elements as important elements in technology-based learning environments. According to the prospective teachers, students' multiple intelligence activities can be supported in technology-based teaching environments, which are both entertaining and instructive. It can be recommended that in TPACK framework it would be valuable to give prospective teachers the opportunity to design, develop and evaluate technology-based learning contexts in classrooms even before they become a teacher. Such an opportunity provides students with recognition of important elements in a technology-based environment that promotes students' learning.

The prospective teachers were trained in Scratch programming, which is a visual programming tool, to create technology-based mathematics projects and their project work was brought into actual classroom environments. Teachers' attitudes with no anxiety towards technology integration and their technology skills yields teachers in using technology in their classrooms (Agyei & Voogt, 2011). Based on related literature, teachers must be well trained in technology (Thomas & Knezek, 2008) and this training is the responsibility of teacher education programs (Instefjord & Munthe, 2017). The purpose in this study was to put this aim into practice and to recommend faculties of education the integration of such methods, like the one in this study, in their curriculum. At the beginning of the process, prospective teachers were told that their projects were to applied to students and they would have a chance to watch those students completing their materials. During this time, it was observed that they were curious and nervous about the process. Moreover, when the process has been completed they seemed very glad that they witnessed what they have done was interest to students and their comments revealed the nature of their positive experiences. For example, they were skeptical about the benefits of their projects on students learning before starting to the experiment. After the experiment, they came to believe that it was an exciting experience to have students learn mathematics by means of their projects. Based on the above-mentioned literature, it can be concluded that they can overcome technology integration anxieties and as a result integrate technology in mathematics education.

As part of their training, prospective teachers are obliged to classroom observations in schools, mostly in their final years at college, as the Ministry of National Education requires it. They usually complete this process in their content area and observe traditional methods teachers use in the classrooms. They rarely observe teachers using technology in their classroom. However, all schools aren't equipped with technology in the classrooms. For this reason, all teacher candidates may not have a chance to observe technology use in education. The present study suggests that faculties of education must provide teacher candidates the opportunity to observe technology use for educational purposes. Technology integration in schools is recommended and governments invest a considerable amount of money on technology integration. Unfortunately, if teachers are not interested in and knowledgeable about technology, technology integration in schools makes no sense. Therefore, it is strongly recommended that prospective teachers must be equipped with technology skills which thy can apply meaningfully in their content areas and thus improve student learning and performance. This study shows such action and its results.

5. Conclusion

Considering the fact that teachers' technology integration in education is related to their beliefs in the benefits for enhancing student learning in such environments, the results of this study are most relevant. The prospective teachers are convinced that teaching with the use of computers support improved learning and that what they have done was valuable. Additionally, they evaluated the materials based on students' pedagogical and learning needs. Their thoughts started with a certain degree of apprehension of whether what they have prepared would be beneficial. However, throughout the process they gained confidence in it being useful. They corroborated that they gained new knowledge and would apply it in the future. As a result, it can be confirmed that the process helped them improve their TPACK.

The process used in this study shows a method to connect prospective teachers' education to schools to remove barriers, which may prevent them from integrating technology in their future mathematics classrooms. This method can allow them to develop positive beliefs towards technology and as a result improve their intentions. Judging and deciding important technology-based learning elements to improve students' mathematics learning are other benefits of this method. For prospective teachers to teach mathematics by means of technology effectively, taking the benefits of TPACK is recommended. As a result, teacher education programs must help prospective teachers to develop technology skills accompanied by pedagogical and content knowledge so that they can effectively integrate technology their future classrooms. In this respect, this study showed a method to be used in teacher education programs.

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