International Journal of Environmental & Science Education
(2014), *9*, 247-264

Preservice Science Teachers' Perceptions of Their TPACK Development after Creating Digital Stories

Hatice Sancar-Tokmak
Mersin University

Hikmet Surmeli
Mersin University

Sinan Ozgelen
Mersin University

Received 21 July 2013; Accepted 18 December 2013

Doi: 10.12973/ijese.2014.214a

The aim of this case study was to examine pre-service science teachers' (PSTs) perceptions of their Technological Pedagogical Content Knowledge (TPACK) development after creating digital stories based on science topics drawn from the national curriculum. A total of 21 PSTs enrolled in Introduction to Computers II participated in the study. Data were collected through a demographics questionnaire, a TPACK diagram, an open-ended questionnaire, interviews, and observations. During the study, feedback was provided to participants during each step of the digital storytelling process: writing the stories, finding related pictures, matching the pictures to the stories; and preparing the digital files. The PSTs reported that their technological knowledge, pedagogical knowledge, and content knowledge improved during the course.

Keywords: digital storytelling, pre-service science teachers, science education, TPACK

Introduction

In parallel with the modernization of education programs around the world, the science education program in Turkey changed in 2004. As a result, "Science" courses changed to "Science and Technology" courses: Technology was added not only to the name of the course but also to the content, teaching methods, and presentation (MoNE, 2006). This drastic change has been very important development for science teachers as well as elementary school students. Following this reform movement in science education, the Higher Education Council also developed new

approaches for the teacher training program, facilitating a vision of education in which all students acquire science and technology literacy, regardless of their learning differences.

Student-centered, active learning approaches have been adopted in the Science and Technology Education Program, using multimedia resources to attract the participation of primary school students. Enriched course content is one step closer to students' science and technology literacy. However, to create a rich course and guide students in the classroom, educators need increased communication technology skills and competencies, such as how to operate computers and related devices, how to use software and hardware effectively and efficiently, and how to incorporate technology for classroom management applications. The use of information and communication technologies is very important in terms of science education. For many topics, computer animations and simulations can provide dynamic and interesting content. In addition, a virtual environment allows students to experience real-life activities that would otherwise be too dangerous or expensive.

Digital Storytelling and TPACK

Mishra and Kohler (2006) have described teachers' knowledge and skills about technology integration under a technological, pedagogical, content knowledge framework (TPACK). Koehler, Mishra, and Yahya (2007) later identified a transactional relationship between content, pedagogy, and technology knowledge at the core of TPACK. Graham (2011) later pointed out three main areas of knowledge content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) in addition to four combinations of these three components: technological-pedagogical knowledge (TPK), technological-content knowledge (TCK), pedagogical-content knowledge (PCK), and technological-pedagogical-content knowledge (TPACK). CK is knowledge of a subject matter; PK is knowledge about teaching practices and techniques; and TK is knowledge about standard and digital technologies (Shin et al., 2009). Mishra and Kohler (2006) defined TCK as technology and content related knowledge; TPK as knowledge about pedagogical strategies for using technological teaching; and PCK as knowledge about teaching strategies for specific content, a special amalgam of content and pedagogy. Teachers need to understand not only pedagogy and subject matter content but also student characteristics and the overall environmental context of learning (Cochran, DeRuiter, & King, 1993; Mishra and Kohler, 2006; Shulman, 1987, cited in Nakiboglu and Karakoc, 2005). TPACK describes an intersection of all forms of teachers' knowledge, with an emphasis on infusing technology. Put simply, it is the combination of TK, PK, and CK applied while teaching (Dilworth et al., 2012; Hofer & Grandgenett, 2012), enabling a teacher to connect curriculum focus, pedagogical strategies, and effective uses of digital and nondigital technologies (Chai, Koh & Tsai 2010; Dilworth et al., 2012; Hofer & Grandgenett, 2012).

Graham (2011) has advocated that the TPACK framework has the potential to provide a theoretical background for teacher education programs preparing candidates to integrate technology into instruction, especially for early childhood education. Thouvenelle and Bewick (2003) have emphasized the importance of teachers' roles in meaningful integration of technology for young children, and Li and Atkins (2004) have further indicated that adult supervision is a requirement in early childhood education. Moreover, Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, and Sendurur (2012) found that teachers' attitudes towards technology play an important role in their integration efforts. According to Ertmer, Conklin, and Lewandowski (2001), pre-service teachers' beliefs about technology will be shaped by educators who help them increase their competence in technology integration, and TPACK is believed to assist in improving technological confidence (Mishra & Koehler, 2006). Positive first hand experiences of pre-service teachers may affect their future applications of information technologies (Bhattacherjee & Premkumar, 2004).

Yuksel-Aslan (2013) has indicated that TPACK is related to the digital storytelling creation process: subject matter selection from the curriculum is CK, writing the scenario is PCK, message design is PK, selection of materials is TPK, using programs such as MS Photo Story or Moviemaker is TK, inserting a story table is TCK, and the creation of the actual story is TPACK. There are limited previous researches about the process of digital story creation and associated changes in teachers' TPACK. Coutinho (2010) described a study in which postgraduate teachers created digital stories for an Educational Technology course: teachers' experiences and feedback indicated that DS were powerful tools for combining knowledge of curricular content, pedagogy, and technology in other words, TPACK. In another study, Maddin (2012) applied the TPACK framework to a digital storytelling project in an undergraduate teacher education course, finding that reflection was an important component, that self-assessment and peer review enhance quality, and that effectiveness increased if the process was conducted in class rather than as homework. In short, as Robin (2008) has stated, the digital story development process can enhance pre-service teachers' TPACK.

Digital Storytelling and Science Education

Studies have shown that rapid changes in technology affect learning environments in schools, leading to the introduction of many multimedia technologies in the classroom (Pedretti, Smith, & Woodrow, 1998). Researchers believe that technological developments can help science teachers overcome problems that arise during instruction (Isman, Yaratan, & Caner, 2007) and have described how these technologies can be used to support science education (Hennessy et al., 2007). These studies have emphasized the importance of technology-integrated science education to construct links between scientific knowledge, to develop advanced understanding, to improve problem solving skills, to enhance students' interest in science, to establish more positive attitudes towards science, and to increase student motivation (Avraamidou, 2008; Geban, Aşkar, & Özkan, 1992; Serin, 2001; Serin, Serin, & Saygılı, 2009). Despite these benefits, science teachers are still reluctant to use educational technology in their classrooms (Isman et al., 2007). Therefore, pre-service teachers should be prepared to integrate technology into their future teaching. When Niess (2005) investigated pre-service teachers' pedagogical content knowledge development with respect to integration of technology in a multi-dimensional science and mathematics teacher preparation program, their views about integration were identified as integral to TPACK development.

Digital storytelling is an effective technological instructional tool for science education, and researchers have agreed that digital stories can be beneficial in teaching elementary school science (Gilbert, Hipkins, & Cooper, 2005; Martinelli & Zinicola, 2009). As an educational tool, digital storytelling help students organize their thoughts and critical thinking skills and by using digital stories teachers can present scientific information to the students (Lunce, 2011, Robin, 2008). Pre-service science teachers should definitely consider using this tool in their instruction. Sessoms (2008) emphasized that pre-service teachers must develop a deep understanding of the process and uses for digital storytelling to use it effectively. However, as Sadik (2008) stated: "While digital storytelling is most often associated with the arts and humanities, research indicates that it can also be an effective strategy for learning in mathematics and science" (p. 490). In other words, some limited evidence does indicate that DS can be effective for teaching science.

For that reason, the current study focused on Turkish primary pre-service science teachers' perceptions about their TPACK developments, driven by one primary research question: How do the pre-service science teachers perceive their development in the main components of TPACK during the digital story preparation activity? Following this question are four sub-questions:

1. How do the pre-service science teachers perceive their Technological Pedagogical Content knowledge development during the digital story preparation activity?
2. How do the pre-service science teachers perceive their CK development during the digital story preparation activity?
3. How do the pre-service science teachers perceive their PK development during the digital story preparation activity?
4. How do the pre-service science teachers perceive their TK development during the digital story preparation activity?

Methodology

The aim of this study was to examine pre-service science teachers' (PSTs) perceptions on their Technological Pedagogical Content Knowledge (TPACK) development after creating digital stories. A case study method was conducted, allowing for the opportunity to study a single aspect of a problem in some depth (Yin, 2003). One advantage of case study is the possibility to concentrate on a specific situation, identifying interactive processes that might be hidden in a large scale survey. Another advantage is that it allows the researcher to apply multiple methods (Bell, 1993; Denscombe, 1998). For this study, interviews, observations, and an open-ended questionnaire were combined to allow for the examination of the PSTs' opinions about the TPACK process in detail. The study took place in the second semester of the 2012-2013 academic year, and 21 out of 22 PSTs attended an Introduction to Computers II course as part of their undergraduate programs. One PST became exempt from the course in the fourth week of the semester. The class was held 4 hours a week with aims to improve PSTs' software skills, internet searching ability, and ability to use technology in instruction. For 10 weeks out of 14 of this course, PSTs created their digital stories individually.

Sampling

Two strategies were applied to define the sampling of the study: criterion sampling and intensity sampling. Criterion sampling is a purposive sampling strategy which determined that none of the participants had created digital stories before. Intensity sampling, another which is purposive sampling strategies, was applied to decide which participants would be interviewed those who had difficulty preparing the digital stories and those who did not.

According to the demographics questionnaires, 19 participants were female, and 2 were male. The average age of the participants was 20.3 (ranging from 18 to 22), and their mean GPA was 2.5. All participants had used computers for internet searching, preparing PowerPoint presentations, doing homework, following social media such as Twitter or Facebook, communicating with friends and family, watching films, listening to music, and playing games. Moreover, all the PSTs reported that they had not created any DS before the present study.

Instruments

The data sources of the study included unstructured interviews, observations, and open-ended questionnaires created by the PSTs. The unstructured interviews were conducted with 8 PSTs at the end of the digital story creation activity. Moreover, field notes were taken during every stage: writing stories, selecting pictures, and preparing the digital format using MS Photo Story. Three instruments were applied during the study: (a) a demographic questionnaire, (b) TPACK diagram, and (c) open-ended questionnaire.

Demographic questionnaire. This questionnaire asked six questions: age, gender, GPA, home computer usage, purpose for use of computers, and whether the participant had created digital stories before or not.

TPACK diagram. The TPACK diagram (Mishra and Kohler, 2006) was applied before and after the course. The PSTs were told, "Please align in which knowledge area you see yourself the most competent." The instrument was applied to see whether the pre-service teachers' perceptions on their TPACK changed during the DS creation activity.

Open-ended questionnaire. The PSTs' were asked 5 questions about the process:

1. What did you do during (a) the planning stage and (b) the preparation stage of the digital story creation activity?
2. What criteria did you consider while creating your digital story? Please explain.
3. What difficulties did you meet while creating your digital story? Please explain.
4. Please describe the digital story you created using five adjectives.
5. What sources helped you during the digital story preparation activity?

Procedure

The study lasted ten weeks. For the first two weeks, the PSTs investigated the national science curriculum and selected subject matters based on aims and goals. Table 1 shows the subject matters selected by each PST.

Table 1. Science Subject Matters Selected by PSTs

Science subject matters	Corresponding PSTs
Acid-Bases	S1
Mitotic Division	S2, S18
Compounds	S3
Solar and Lunar Eclipse	S4, S17
Force and Motion	S5, S6
Respiratory System	S7
Tissues	S8
Viruses	S9
Digestive System	S10
Organelles in Plant and Animal Cells	S11, S15, S16, S19, S21
Electricity	S12
Parts of Plants	S13
State of Matter	S14
Friction	S20

They then created their digital stories using Microsoft Photo Story 3, which supports creation, publication, and distribution. As Lowenthal and Dunlap (2010) have stated, digital storytelling has significant potential for learning and teaching; Yang and Wu (2012) have observed similar benefits from editing software such as Photo Story. In all, the reasons emphasized in the literature and the user-friendliness of Photo Story informed the researchers' selection of this tool for the study.

The DS creation included three main stages: (a) writing the stories, (b) finding and matching pictures to the stories, and (c) creating the digital stories. During each stage, the PSTs were provided with feedback (Figure 1). Misconceptions about content knowledge were corrected, and when they met difficulties with technology use (finding photos online, defining content, or using MS Photo Story), they were coached.

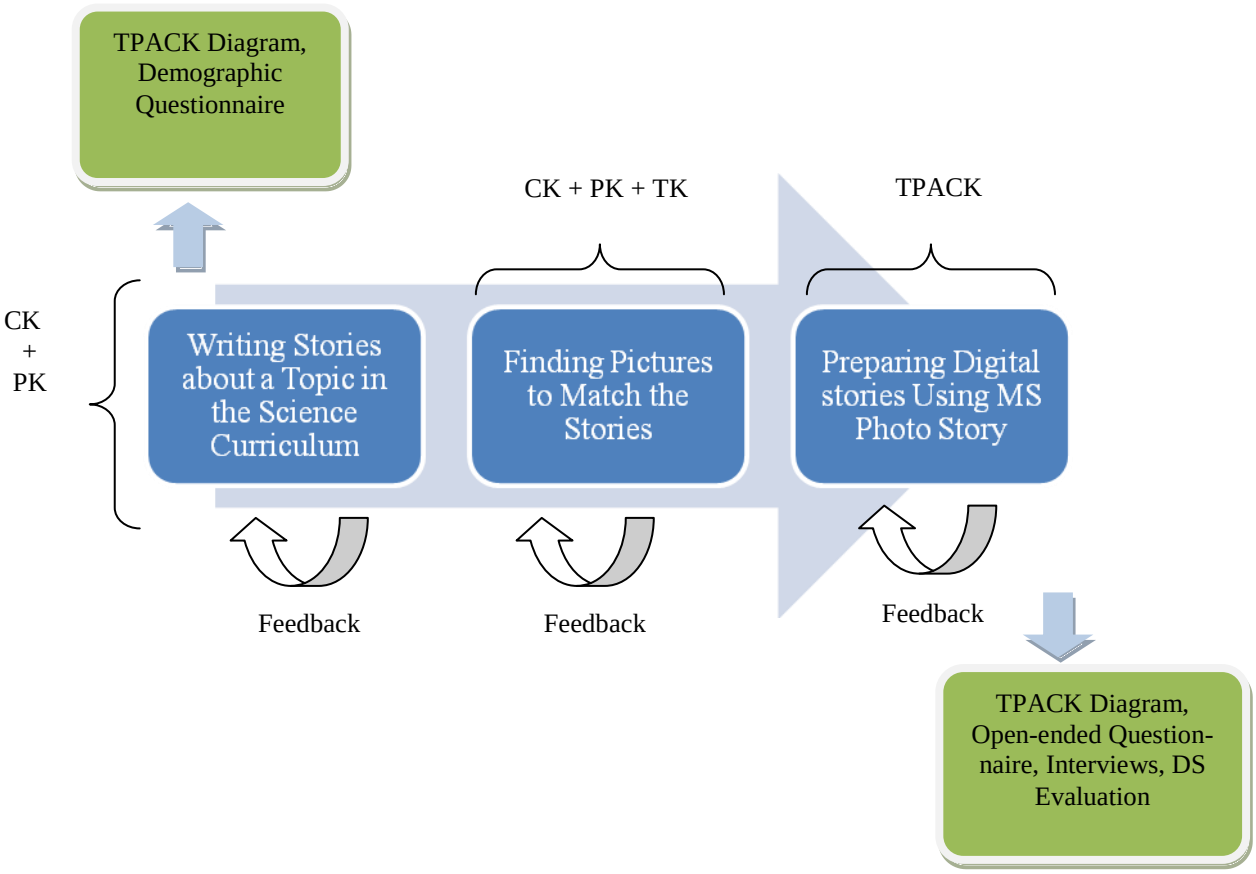


Figure 1. The three phases of the study, aligned with their TPACK component counterparts and timing of the instruments.

During these stages, instruments were applied following a pre-determined schedule (see Table 2). In the first week, PSTs' demographic information was collected via questionnaire. Then, the TPACK diagram was applied to learn which knowledge areas they self-reported their strongest. Field notes were taken during the PSTs digital story creation. The final week, the TPACK diagram was applied as a post-test. In addition, open-ended questions were administered to the PSTs to determine their opinions about their DSs and the creation process, and unstructured interviews were conducted with eight PSTs.

The procedure had three phases based on Yuksel-Arslan's (2013) DS-TPACK relationship categorization: (a) writing stories required CK and PK, (b) finding photos suitable for content, student interest, curriculum goals, and story required CK + PK + TK, and (c) combining all these elements to create the digital story required TPACK. During each step, feedback was given individually. Moreover, the instructor informed the class about incomplete information, mistakes, or unsuitable components for each step. For example, the instructor pointed out, "60% of the stories had grammar mistakes. Tense use in the stories was not

consistent: the story started with past tense, then continued with present tense and finished with future tense.

Table 2. Timing of the Instruments Applied in the Study

Instruments	Timing
Demographic Questionnaire	At the first week of the study
TPACK Diagram	At the first week of the study
Open-ended Questionnaire	At the last week of the study
TPACK Diagram (2nd time)	At the last week of the study
DS evaluation criteria	At the last week of the study
Unstructured interviews with the PSTs	At the end of the study
Field notes during the study	

It should be consistent." With regard to pictures, the instructor said, "40% of the photos found did not have appropriate resolution quality. Photos should have high resolution and be related to content."

Data Analysis

The TPACK diagram and demographic questionnaire were analyzed through descriptive statistics. After the interviews were transcribed, interviews and observations were analyzed through open coding. During data analysis, significant statements were organized as codes, and related codes were organized as themes. Finally, the open-ended questionnaire data were analyzed by applying conventional content analysis, as Hsieh and Shannon (2005) have stated that themes and codes emerge based on the text.

Validity-Reliability

Creswell (2003) has suggested different strategies to provide validity-reliability in qualitative studies. In the present study, four strategies were used:

1. Members check: The interview data were analyzed by two researchers according to Miles and Huberman's (1994) formula. The inter-coder reliability was found to be 0.82. The open-ended questionnaire was also analyzed by two researchers; inter-rater reliability was 0.94.
2. Peer debriefing: The design and procedure of the study were discussed with colleagues during every step of the study.
3. External audits: All instruments were checked and verified by four experts before application.
4. Triangulation: The triangulated methods were the open-ended questionnaire, interviews, observation, and TPACK diagram.

Results

PSTs' Perceptions of CK, and PK

PSTs perceived their CK and PK as adequate but realized they had many misconceptions and did not apply different approaches during the creation of their digital stories. At the end of the study, they stated that they had learned to present content according to student levels. Further, at the

beginning of the study, PSTs expressed having inadequate TK and TPACK but believed that they had acquired TPACK after creating digital stories.

When the TPACK diagram was initially applied, 10 PSTs thought they had CK, and 6 PSTs had PCK. Out of 21 PSTs, 16 thought they had CK and PCK knowledge. PSTs clearly viewed themselves as competent in CK and PCK from the beginning of the study. However, interviews conducted at the end of the study showed codes related to realized misconceptions and incomplete content knowledge as well as inadequate PK.

Under the heading of learning as a results of unstructured interviews, four codes emerged: presenting content knowledge according to student level, deciding the details of content presented, using analogies correctly about content, and eliminating misconceptions about content. Specifically, PSTs realized that they had provided upper level content knowledge. S13 stated:

> *While creating DS, I learned to present content according to 5th grade student level. I had provided much more detailed information in the first version of the DS. I learned I should not give all information about a subject matter to students. You cannot give the same information about a subject matter to 5th grade as you would present to 6th grade students.*

Moreover, the PSTs realized that poor analogies might lead to misconceptions. S11 explained:

> *While describing the plant cell, I said the plant cell... has a coat called a cell wall. I tried to do an analogy, but I realized with the help of instructors and friends, the students might have misconceptions... a coat can be taken off, but the cell wall cannot be changed.*

Open ended questionnaire supported interview results. Analysis results for difficulties met included trouble with student level and content presentation while creating stories and finding photos that represented content, were suitable to the story, and were level appropriate. The PSTs had difficulty creating stories for a specific grade level (PK) and representing the content through the digital story (CK). S8 wrote in an open ended questionnaire:

> *I had difficulty while creating story. It was the first step and other steps based on it. It is very difficult to decide which part of subject matter I will focus on in the story. Also, I didn't receive any information (feedback) about the subject matter in the first version.*
> *I had not given wrong or incomplete information about the subject matter in the first version.*

According to analysis, the first versions of the stories showed areas of concern regarding the content of the selected science subjects. Misconceptions were found in the areas of acid and base, obscuration and solar eclipse, compound and molecular, and larynx and pharynx. In addition, misunderstandings were found in some of the cell organelles, molecular structure, and characteristics of water. Moreover, students displayed a lack of knowledge in relation to cell organelles, characteristics of acids and bases, and gravitational forces. During the DS creation process, students were given feedback that made them aware of these issues, which were corrected. An example of one such misconception occurred during S9's digital storytelling creation process. In her pre-test, she indicated sufficient knowledge about PCK , but she was not using enough technology. After creating her digital story, she developed more thorough TPACK knowledge.

S9 presented a story on viruses. In her initial story, she emphasized the symptoms of chicken pox and viruses that cause this illness. However, she misunderstood how the body immunizes against viruses. In her initial story, after viruses invaded, the body fought with their

soldiers; viruses won the war, peace was signed, and the viruses lived in the body and protected it. In this expression, she also failed to emphasize the role of white blood cells, indicating a lack of knowledge. During her preparation, she received feedback on these limitations, and in her final version, she corrected the issues (See Figure 2 for screenshot examples of DS prepared by S9).

The 3rd photo in the DS

The 5th photo in the DS

The 7th photo in the DS

The 9th photo in the DS

Note: The DS created by S9 consisted of 9 photos, and each part of the story was vocalized on these 9 photos. The following screenshots were the 3rd, 5th, 7th and 9th photos in the DS created by S9.

Figure 2. The four screenshots of DS created by S9

PSTs' Perceptions of TK Development

The PSTs' perceptions of TK showed a different trend. At the beginning of the study, the PSTs reported low TK according to the TPACK diagram analysis. One PST expressed having TK, and two PSTs felt they had TCK. Open ended questionnaire and interview results supported TPACK diagram results; the most frequently described difficulties in open ended questionnaire involved technology use, with subcategories of setting up MS Photo Story, finding photos, recording the audio narrative of the story, and finding background music. S3 explained, "I struggled to set up

the program. I really had difficulty, but I did it at last." During interviews, PSTs indicated that they had learned using MS Photo Story, setting up a program, and searching on the internet during the digital storytelling creation activity. The PSTs learned a new program, MS Photo Story, albeit one they all described as easy to use. S15 explained:

> *It was a beneficial activity that contributed to my computer use competency. I am not much more competent; I had difficulty setting up the program. Actually I requested help from you while setting up the program, but I think that I can download and set up a program after this activity.*

Another participant, S6, indicated having TK before the course and TPACK at the end of the course. She studied the importance of electricity. In the first version of her DS, she described what life would be like without electricity. After the main character used electricity wastefully, she received a bill she could not afford to pay, and her electricity was turned off. She eventually sought help from her parents to pay the bill and learned to use electricity wisely. During the process, S6 only received feedback on her photo selection and story presentation. She had focused too heavily on some parts, and some photos did not represent the story, so she changed some photos and eliminated some details (See Figure 3 for screenshot examples of DS prepared by S6).

The 3rd photo in the DS

The 5th photo in the DS

The 6th photo in the DS

The 12th photo in the DS

Note: The DS created by S6 consisted of 12 photos, and each part of the story was vocalized on these 12 photos. The following screenshots were the 3rd, 5th, 6th and 12th photos in the DS created by S9.

Figure 3. The four screenshots of DS created by S9

PSTs' perceptions of TPACK Development

To investigate the PSTs' perceptions, the researchers analyzed TPACK diagram data, interviews, and the open-ended questionnaire results. Table 3 shows each PSTs' perceptions about their knowledge competencies before and after the course.

Table 3. PSTs' Pre and Post TPACK Diagram Results

Nickname of PST	Pre-TPACK	Post-TPACK
S1	PCK	TPACK
S2	CK	TPACK
S3	PCK	TPACK
S4	CK	TPACK
S5	PCK	TPACK
S6	TK	TPACK
S7	CK	TPACK
S8	CK	TPACK
S9	PCK	TPACK
S10	PCK	TPACK
S11	PCK	TPACK
S12	Any knowledge	TCK
S13	CK	TPACK
S14	CK	TPACK
S15	TCK	TPACK
S16	Any knowledge	TPACK
S17	TCK	TPACK
S18	CK	CK
S19	CK	TPACK
S20	CK	TCK
S21	CK	TPACK

The pre-TPACK diagram data showed PSTs knowledge competencies as CK (n = 10), PCK (n = 6), TCK (n = 2), TK (n = 1), or no competence with any knowledge component (n = 2) (see Table 3). The post-TPACK diagram data showed that most of the PSTs (n = 18) reported TPACK knowledge after preparing digital storytelling activity. Two PSTs reported gaining TCK, while one gained only CK.

The themes and subthemes which emerged from analysis of open ended questionnaire also supported the diagram data analysis:

1. Defining subject matters
2. Researching subject matters
    a. Deciding important points
3. Thinking about the storyline
    a. Student development

        i. Understandability
        ii. Attractiveness
    b. Subject matter
    c. Purpose of the story
    d. Curriculum goals
    e. Real life situations
    f. Creativity
4. Explaining the story in mind
5. Seeking opinions about the story
6. Revising the story
    a. Changing used example
    b. Changing story scenario
    c. Writing more creatively
7. Finding pictures on the internet
    a. Attractive and attention-getting
    b. Representative of the story
8. Matching pictures to the story
    a. Changing photos according to the story
9. Learning to use MS Photo Story
10. Using Photo Story
    a. Placing photos in the story
    b. Writing the names of concepts on photos
    c. Vocalizing the story
        i. Paying attention to voice
    d. Selecting background music
    e. Saving the files

Open ended questionnaire showed that the PSTs followed a procedure that improved their CK, PK, TK, and TPACK. For CK, they investigated the subject matters they chose to teach, wrote stories emphasizing important points in line with curriculum goals, and chose photos by taking into account the subject matters (CK). While creating the DS, they chose stories and pictures appropriate to student levels (PK). They used the internet to search for photos and MS Photo Story to create the DS (TK). Moreover, they made modifications to stories, photos, and background music according to feedback they received. Sources of feedback mentioned by the PSTs included friends, the instructor, the internet, and books. S7 summarized her procedures:

> *First, I studied on the subject matters that I chose to create the DS. Then, I defined the important points in the subject matters that I should emphasize in the story. In my subject matter, nose, throat, pharynx, esophagus, and lungs are the important points. So, I wrote my story according to these important points to be understandable by students. ...Then, I found photos on the internet according to my content and students' level. I matched the story and photos. I changed some photos according to feedback. Lastly, I placed the photos in Photo Story and vocalized the narration.*

In their second open-ended, the PSTs emphasized what they paid while creating the stories. Codes that emerged include creating an instructive DS (TPACK), with subcategories appropriate to subject matters and appropriate to curriculum goals; student development, with subcategories understandable and attractive; appropriate photo use, with subcategories subject matters, students, and story; grammar use, with subcategories avoiding long sentences and fluency. PSTs

paid attention to all main components of TPACK during their DS creation. In addition, they assessed DS creation elements by paying attention to the story's overall harmony. S11 stated:

> *I tried to emphasize the important points of subject matters that I tried to teach. The digital story should be instructive. I also paid attention to the photos I found, which should be related to the subject matters. It should not be too long or too short.*

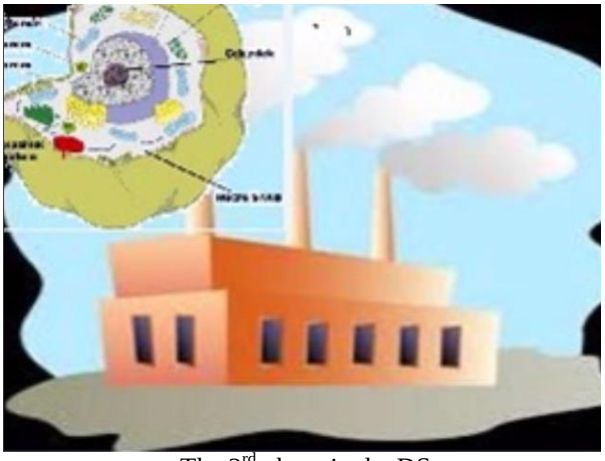
The interview results showed that PSTs combined CK, TK, and PK to create their stories. For learned themes, the researchers applied the code of presenting content according to student level. When asked their thoughts on the DS activity, codes that emerged were effective, with subcategories attractive/attention-getting and providing permanent knowledge, with further subcategories of stories and visuals; beneficial, with subcategories increasing curiosity and searching for specific information; entertaining; requiring creativity, with subcategories presenting content in other forms, combining photos with the story, thinking about the story, photos, student level, and teaching methods together, and original products; awareness about future use of DS, with subcategories using in future, realizing an alternative for teaching, and sharing DSs and integrating to instruction. According to the interviews, the PSTs also learned to teach science subject matters according to student levels by creating the DS.

The final example DS was created by S16, who did not have competency in any knowledge component before the course and reported TPACK after; the topic was animal organelles. Her first story was criticized because it was only informative text, so she rewrote it using an analogy. According to her story, the cell was fabric, and the organelles were workers. The nucleus was the director of the fabric, and the endoplasmic reticulum was the liaison between the organelles. The story included discussion about which organelle was the most critical "worker" and ended with the statement that all organelles are essential for cell functions. During creation, this PST also received feedback on photos, which were changed based on suggestions from friends and the instructor (See Figure 4 for screenshot examples of DS prepared by S16).

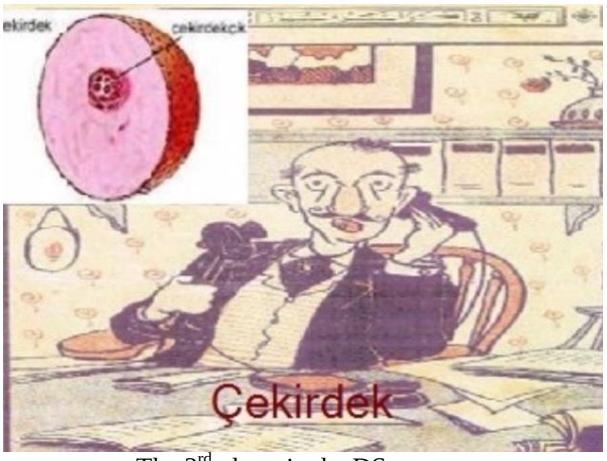
Moreover, the activity contributed to their awareness of their profession; they now understand the DS method and can use it in their own classrooms. They also planned to share their stories with each other and started an archive to use later. Another important result showed that the PSTs felt the need to be creative when combining aspects of students' levels, teaching methods, the story, and photos. S6 stated:

> *I like the activity really. We really did something. We wrote stories, found photos, used Photo Story. I enjoyed using the program; it was easy to use. DS is my product, and this activity requires creativity.*

Shortly, the open ended and interview results showed that the PSTs were satisfied by the activity, especially in the final stage of their products. Results of open ended questionnaires and observations showed positive comments from the PSTs on each others' work. In open ended questionnaires PSTs also described their stories using adjectives that aligned well with TPACK components, such as instructive (TPACK), understandable (PK), attractive (PK), colorful (PK), thought-provoking (CK), detailed (CK), original, and creative. Except from two students who did not make any change on their DS even though they had given feedback, PSTs indicated that they liked preparing stories and found them instructive.



The 2rd photo in the DS



The 3rd photo in the DS

The 5th photo in the DS

The 7th photo in the DS

Note: The DS created by S16 consisted of 8 photos, and each part of the story was vocalized on these 8 photos. The following screenshots were the 2nd, 3rd, 5th and 7th photos in the DS created by S9.

Figure 4. The four screenshots of DS created by S16

Discussion

The current case study investigated PSTs' perceptions of their TPACK development after a digital story creation activity. PSTs were provided with feedback during story writing, photo matching, and final revisions of the story. In the writing phase, feedback mainly identified misconceptions and incomplete information. Accordingly, story writing can be an educational tool to reveal inadequate knowledge. Matthews-DeNatale (2008) has defined storytelling as a meaning making process. Students reflect on what they know, leading to cognitive development. Observations, open ended questionnaire, and interviews indicated that the PSTs had trouble writing stories to present science topics. Since most of them struggled with synthesizing a story and scientific knowledge and poor storytelling preparation leads to bad digital stories (Robin, 2006), they were coached through their revisions with feedback. This process can help students learn to present ideas individually and meaningfully (Robin, 2006).

According to the interview and open ended questionnaire results, before feedback, the PSTs had not been aware of CK and PK; they believed their CK and PK were sufficient. However, after feedback, the PSTs realized their many misconceptions about the science topics (CK) and struggled to present according to the appropriate student level (PK), which was meant to be 2nd grade. However, these deficiencies are explicable: participating PSTs had not yet taken courses on curriculum, educational theories, or teaching practices. Their inadequate knowledge about course content may have led to the perception that they had sufficient CK and PK.

With regard to TK, the PSTs stated that they were not competent at the beginning of the DS creation activity. Most participants did not start to use computers until they reached university, mostly using Facebook up to that point. Most of them had never searched the internet for images or installed a new program. After the activity, PSTs had set up and used programs such as PowerPoint, Photoshop, and Paint, plus learned to use search engines. Most importantly, they alleviated future anxiety about computer-based projects. Considering these results, the DS process helped build technology skills and improve technology literacy, two key 21st century skills (Brown, Bryan, & Brown, 2005; Czarnecki, 2009).

The result of the study showed that PSTs perceived TPACK development and improvement. At the beginning of the study, they had very limited technological knowledge and TPACK. According to the results, they learned to present science subject matters as digital stories according to student level with respect to the curriculum goals. Moreover, they had to consider all these factors simultaneously. In addition they used technology to select and present pictures and audio to tell their stories. For that reason, creating a DS required creativity, which parallels findings in the literature (Robin, 2008).

In the current study, the PSTs who stated that they had CK and PCK at the beginning of the study did not show different patterns in terms of TPACK than the ones who stated they had TK, TCK or any knowledge at the beginning of the study. As explained above, the interviews and open-ended questionnaire indicated that the PSTs did not have sufficient starting CK or PCK. PSTs had misconceptions, incomplete content knowledge, and problems presenting content according to student level. In TPACK development, three forms of knowledge (CK, PK, and TK) should be integrated. Therefore to use technology effectively, a deep understanding of content and related pedagogical knowledge is essential (Dilworth et al., 2012). However, to reach satisfying and sustaining levels, the entirety of a course should be designed using a TPACK framework.

The results of this study showed consistency between data sources; results of observations, open-ended questions, and unstructured interviews were quite similar. Shortly, DS creation on science subject matters in line with curriculum goals for a specific student level prompted PSTs to synthesize three knowledge components. This study was limited to one case with 21 PSTs. The numbers of participants and cases could be increased. Moreover, for further study, experimental research should be applied.

References

Avraamidou, L. (2008). Prospects for the use of mobile technologies in science education. *Association for the Advancement of Computing In Education Journal, 16*(3), 347-365.

Bell, J. (1993). *Doing your research project*. Buckingham, England: Open University Press.

Bhattacherjee, A., G. Premkumar. 2004. Understanding changes in belief and attitude toward information technology usage: A theoretical model and longitudinal test. *MIS Quart,28*(2) 351-370.

Brown, J., Bryan, J., & Brown, T. (2005). Twenty-first century literacy and technology in K-8 classrooms. *Innovate*, *1*(3). Retrieved from http://www.innovateonline.info/pdf/vol1_issue3/Twenty-first_Century_Literacy_and_Technology_in_K-8_Classrooms.pdf

Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (2010). Facilitating pre-service teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology & Society, 13*(4), 63-73.

Cochran, K. F., DeRuiter, J., & King, R. (1993). Pedagogical content knowing: An interactive model for teacher preparation. *Journal of Teacher Education, 44*, 263-272.

Coutinho, C. P. (2010). Storytelling as a strategy for integrating technologies into the curriculum: An empirical study with post-graduate teachers. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 3795-3802). Retrieved from http://repositorium.sdum.uminho.pt/bitstream/1822/10583/1/paper_33972.pdf

Creswell, J. W. (2003). *Research design: qualitative, quantitative, and mixed approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Czarnecki, K. (2009). How digital storytelling builds 21st century skills. *Library Technology Reports, 45*(7), 15-19.

Denscombe, M. (1998). *The Good Research Guide*. Buckingham: Open University Press.

Dilworth, P., Donaldson, A., George, M., Knezek, D., Searson, M., Starkweather, K., Strutchens, M., Tillotson, J., & Robinson, S. (2012). Preparing teachers for tomorrow's technologies. *TeachTrends, 56* (4), 11-14.

Ertmer, P. A., Conklin, D., & Lewandowski, J. (2001). Increasing preservice teachers' capacity for technology integration through use of electronic models. Presented at the Annual Meeting of National Convention of the Association for Educational Communications and Technology, Atlanta, GA.

Ertmer, P., Ottenbreit-Leftwich, A., Sadik, O., Sendurur, E., Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers and Education, 59*(2), 423-435.

Geban, Ö., Aşkar, P., & Özkan, İ. (1992). Effects of computer simulations and problem solving approaches on high school students. *Journal of Educational Research, 86*(1), 5-10.

Gilbert, J., Hipkins, R., & Cooper, G. (2005). *Faction or fiction: Using narrative pedagogy in school science education*. Paper presented at the Redesigning Pedagogy: Research, Policy, Practice Conference, Nanyang University Institute of Education, Singapore.

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education, 57*, 1953-1960.

Hennessy, S., Wishart, J., Whitelock, D., Deaney, R., Brawn, R., Velle, L., McFarlane, A., Ruthven, K., & Winterbottom, M. (2007). Pedagogical approaches for technology-integrated science teaching. *Computers and Education, 48*(1), 137-152.

Hofer, M., & Grandgenett, N. (2012). TPACK development in teacher education: A longitudinal study of pre-service teachers in a secondary M.A.Ed. program. *Journal of Research on Technology in Education, 45*(1), 83-106.

Hsieh, H., & Shannon, S. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15*(9), 1277-1288.

Isman, A., Yaratan, H., & Caner, H. (2007). How technology is integrated into science education in a developing country: North Cyprus case. *The Turkish Online Journal of Educational Technology, 6*(3), 55-60.

Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education, 49*(3), 740-762.

Li, X., & Atkins, M.S. (2004). Early childhood computer experience and cognitive and motor development. *Pediatrics, 113*(6), 1-8.

Lowenthal, P. R., & Dunlap, J. C. (2010). From pixel on a screen to real person in your students' lives: Establishing social presence using digital storytelling. *The Internet and Higher Education, 13*(1), 70-72.

Lunce, C. (2011) Digital storytelling as an educational tool. *Indiana Libraries, 30*(1), 77-80.

Maddin, E. (2012). Introducing TPCK to pre-service teachers through digital storytelling. In P. Resta (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 1400-1406). Retrieved from http://www.editlib.org/p/39777.

Martinelli, J., & Zinicola, D. (2009). Teaching science through digital storytelling. In I. Gibson et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 3802-3808). Retrieved from http://www.editlib.org/p/ 31247.

Matthews-DeNatale, G. (2008). *Digital storytelling: Tips and resources.* Boston, MA: Simmons College.

Miles, M.B. and Huberman, A.M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook*. 2nd ed., Sage Publications, Newbury Park, CA

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017-1054. doi:10.1111/j.1467-9620.2006.00684.x

Ministry of National Education (MoNE). (2006). *Elementary science and technology course curriculum.* Ankara: Ministry of Education.

Nakiboğlu, C., & Karakoç, Ö. (2005) The fourth knowledge domain a teacher should have: The pedagogical content knowledge. *Educational Sciences: Theory & Practice, 5*(1), 201-206.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509-523.

Pedretti, E., Smith, J. M., & Woodrow, J. (1998). Technology, text, and talk: Students' perspectives on teaching and learning in a technology-enhanced secondary science classroom. *Science Education, 82*(5), 569-589.

Robin, B. (2006). The educational uses of digital storytelling. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference* (pp. 709-716). Retrieved from http://faculty.coe.uh.edu/brobin/homepage/ Educational-Uses-DS.pdf

Robin, B. (2008). Digital storytelling: A powerful technology tool for the 21st century classroom. *Theory into Practice, 47*, 220-228.

Serin, O. (2001). *Lisans ve lisansüstü düzeydeki fen grubu öğrencilerinin problem çözme becerileri, fen ve bilgisayara yönelik tutumları ile başarıları arasındaki ilişki* [Prospective teachers' perceptions of their own problem solving skills, their attitudes towards science and computer and the relationship between their attitudes and their achievement]. Izmir, Turkey: DEÜ Eğitim Bilimleri Enstitüsü Doktora tezi.

Serin, O., Serin, N. B., & Saygılı, G. (2009). The effect of educational technologies and material supported science and technology teaching on the problem solving skills of 5th grade primary school student. *Procedia: Social and Behavioral Sciences, 1*(1), 665-670.

Sessoms, D. (2008). Digital storytelling: Training pre-service teachers to use digital storytelling across the curriculum. In K. McFerrin et al. (Eds.), *Proceedings of the Society for Information Technology & Teacher Education International Conference* (pp. 958-960). Retrieved from http://www.editlib.org/p/27300

Shin, T. S., Koehler, M. J., Mishra, P., Schmidt, D. A., Baran, E., & Thompson, A. D. (2009). Changing technological pedagogical content knowledge (TPACK) through course experiences. In I. Gibson, R. Weber, K. McFerrin, R. Carlsen, & D. A. Willis (Eds.), *Society for information technology and teacher education international conference book* (pp. 4152-4156).

Thouvenelle, S., & C.J. Bewick. (2003). *Completing the computer puzzle: A guide for early childhood educators.* Boston: Allyn & Bacon.

Yang, Y. T. C., & Wu, W. C. I. (2012). Digital storytelling for enhancing student academic achievement, critical thinking, and learning motivation: A year-long experimental study. *Computers & Education, 59*(2), 339-352.

Yuksel-Arslan, P. (2013). Eğitim amaçlı dijital öykünün hazırlanması ve kullanılması: TPAB temelli örnek bir fen bilgisi eğitimi uygulaması. Tuğba Yanpar Yelken, Hatice Sancar Tokmak, Sinan Özgelen ve Lutfi İncikabı (eds).*Fen ve matematik eğitiminde teknolojik, pedagojik alan bilgisi (TPAB) temelli öğretim tasarımları* (ss.106-128). Ankara: Anı Yayıncılık.

Yin, R. K. (2003) *Case Study Research, 3rd edn.* London, England: Sage Publications.

Corresponding Author: Dr. Sinan Ozgelen, Associate Professor of Science Education, Department of Elementary Science Education, Faculty of Education, Mersin University, Yenisehir Campus, 33150, Mersin, Turkey. E-mail: sozgelen@gmail.com

Please cite as: Sancar-Tokmak, H., Surmeli, H., & Ozgelen, S. (2014). Preservice science teachers' perceptions of their tpack development after creating digital stories. *International Journal of Environmental and Science Education, 9*(3), 247-264. doi:10.12973/ijese.2014.214a