Journal of Social Sciences of Mus Alparslan University

anemon

Derginin ana sayfası: http://dergipark.gov.tr/anemon

Araştırma Makalesi ● Research Article

Development of Tpack: The Impact of Digital Storytelling

Teknolojik Pedagojik Alan Bilgisinin Gelişimi: Dijital Öykülemenin Etkisi

Tuğba Uygun*

Abstract: It may be important to provide preservice mathematics teachers with opportunities to acquire necessary knowledge and skills about digital stories and use them effectively in their classrooms by enhancing their professional development. Hence, the study focused on how professional development workshops about digital storytelling impacted 60 preservice middle school mathematics teachers' (PMSMTs) technological pedagogical content knowledge. The present study was conducted in the context of four professional development workshop series focusing on digital storytelling based on four main objectives. In the study designed based on multiple case study, the data were collected via videotapes of the workshops, interviews and artefacts produced by the preservice middle school mathematics teachers. The data were analysed using the framework formed through the study. The findings of the study showed that these workshops enhanced the development of the preservice middle school mathematics teachers on technological pedagogical content knowledge in relation to digital storytelling. They represented the content knowledge, technological content knowledge, and technological pedagogical content knowledge in their lesson plans designed by using their digital stories. Moreover, specialized technological pedagogical content knowledge for digital storytelling could be formed to enhance their preparation of the lessons using these stories.

Keywords: Digital Storytelling, Mathematics, Professional Development, Technological Pedagogical Content Knowledge

Öz: Matematik öğretmen adaylarının mesleki gelişimlerini artırarak dijital öyküler hakkında gerekli bilgi ve becerileri edinmelerine ve sınıflarında etkin bir şekilde kullanmalarına olanak sağlanması önemli olabilir. Bu çalışmada, öğretmen adaylarının teknolojik pedagojik alan bilgilerini geliştirmelerine yardımcı olmak amacıyla dijital öykülerle ilgili olarak tasarlanan çalıştayın öğretmen adaylarının mesleki gelişimlerine etkisi araştırılmıştır. Bu nedenle, çalışma, dijital öyküleme anlatımı ile ilgili mesleki gelişim atölyelerinin tasarlanmasını temel almaktadır. Bu çalıştaya ve çalışmaya 60 ilköğretim matematik öğretmeni adayı katılmıştır. Ardından, dijital öyküleme temel alınarak gerçekleştirilen çalıştayın katılımcıların teknolojik pedagojik alan bilgilerini nasıl etkilediğine odaklanmıştır. Bu çalışma, dört ana amaca dayalı olarak dijital öyküleme anlatımına odaklanan dört mesleki gelişim atölyesi dizisi bağlamında yürütülmüştür. Çoklu durum çalışmasına dayalı olarak tasarlanan çalışmada veriler, ortaokul matematik öğretmen adayları tarafından yapılan atölye çalışmaları, görüşmeler ve eserlere ait kayıtlar aracılığıyla toplanmıştır. Veriler, çalışma sürecinde oluşturulan analiz çerçevesi kullanılarak analiz edilmiştir. Araştırmanın bulguları, bu çalıştayların ortaokul matematik öğretmen adaylarının dijital

* Doç. Dr., Alanya Alaaddin Keykubat Üniversitesi, Eğitim Fakültesi, Matematik ve Fen Bilimleri Eğitimi Bölümü
ORCID: 0000-0001-5431-4011, tugba.uygun@alanya.edu.tr
Cite as/ Atıf: Uygun, T. (2022). Development of tpack: The impact of digital storytelling. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi*, 10(2), 595-614. http://dx.doi.org/10.18506/anemon.1056200
Received/Geliş: 11 January/Ocak 2022
Accepted/Kabul: 05 August/Ağustos 2022
Published/Yayın: 30 August/Ağustos 2022

e-ISSN: 2149-4622.

öyküleme anlatımı ile ilgili teknolojik pedagojik alan bilgisi geliştirmelerini geliştirdiğini göstermiştir. Alan bilgisi, teknolojik alan bilgisi ve teknolojik pedagojik alan bilgisini dijital öykülemelerden yararlanarak hazırladıkları ders planlarında temsil etmişlerdir.

Anahtar Kelimeler: Dijital Öyküleme, Matematik, Profesyonel Gelişim, Teknolojik Pedagojik Alan Bilgisi

Introduction

Sometimes, it is seen that mathematics teachers tell stories about mathematics, mathematicians, or history about discovery of mathematical concepts in order to make their lessons attractive and easy to understand. By doing so, both the narrator and listeners believe that such a method perceived interesting in everyday life will certainly have the same effect in mathematics attracts these teachers (Zazkis, Liljedahl & Sinclair, 2009). Hence, digital stories as a kind of teaching tool having significant positive effects on students by enhancing their motivation and understanding (Bratitsis, 2017; Bratitsis, Kotopoulos & Mandila, 2012) can also be an effective method in mathematics teaching. What makes storytelling so effective is that the stories can direct people to draw a picture in mind, to consider about details of incident rather than to present a ready-made photograph to them (Macquire 1998). In this respect, the stories provide more vivid, powerful, and memorable images in mind of listeners and help them make sense by directing them to think, dream and learn (Egan 1988; Haven 2000). By using the stories, people can also share and construct their understanding and perceptions about their experiences. In other words, the stories help the people structure their knowledge and place them in their minds by providing relational understanding, creating personal truths, communicating, and learning (Bruner 1996; Schank 1990). Nowadays, many developments in the field of technology are reflected in many areas such as education and even in the stories. With the advent of technology, the stories have gained a new dimension and become more effective by attaining the properties of mobility and sound features so that they have been named as digital story (Lathem 2005). Hence, digital stories represent a way for communication of individuals' knowledge, experiences, learning, feeling and thoughts by telling a story created with technological software (Behmer et al. 2006; Rudnicki 2009). Digital stories can be explained as a way helping individuals share their understanding, feelings, and beliefs by adopting them into a story context described by time, location, characters, and actions in an attractive way by facilities of technology. With the help of images and sounds, the emotional effects of the stories have been increased and the transmission of messages to listeners has been facilitated (Malita & Martin 2010). As a funny way of transmission of messages, it can provide useful opportunities for teachers to enhance their teaching.

By using digital stories, mathematics teaching can be performed in an effective and funny way because it ehances learning (Malita & Martin 2010), facilitates the organization of complex situations (Van Gils, 2005), and provides an interesting way of demonstration (Rijnja & Van der Jagt 2004). Moreover, a tendency on the research about the usage of digital stories in mathematics education has been observed. To line with this view, it can be stated that teachers knowing how to create and integrate digital stories as a technological media into their lessons can enact their teaching using digital storytelling effectively since the use of technology does not always guarantee the existence of effective integration of technology into lesson (Niess et al. 2009). Moreover, previous researches show that teachers tend to have difficulty and deficiency in knowledge and skills in integrating technology into their lessons (Eby, 2001; Ertmer et al., 2003). At that point, teacher education programs are important since mathematics teachers could acquire necessary knowledge and skills through their preservice years (Angeli & Valanides 2009; Chai et al. 2010; Mouza et al. 2014; Niess, 2005). With this motivation, this study focused on the professional development of preservice teachers about acquiring necessary knowledge and skills to create and use of digital stories as a kind of teaching tool in designing lessons. Considering that the digital stories are a kind of technological media and cannot be used indiscriminately in lessons, the teachers and preservice teachers must have pedagogical and content knowledge as well as relevant technological knowledge to effectively use the digital stories in their classrooms. To line with this view, the extension and detailing of TPACK representing the combination and intersection of content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK),

technology knowledge (TK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK) based on the context of digital storytelling with the related technological software can enhance the professional development of preservice mathematics teachers. In other words, the professional development on TPACK related to digital storytelling can help the PMSMTs successfully integrate digital storytelling into their designed lessons. In other words, by helping preservice mathematics teachers improve their knowledge and skills about preparing digital stories with the help of characteristics of TPACK, they can design effective lessons using digital stories to enhance student learning and understanding. Moreover, their lessons can be adjusted based on the feedback provided based on the characteristics of TPACK. TPACK framework was also used in order to analyse and report development of preservice mathematics teachers' designing lessons supported by digitial stories. However, although many researches about using digital stories in lessons have been made, there has been little research paid attention on professional development about using digital storytelling. Consequently, the impact of workshop on digital stories for the PMSMTs' professional development was explored. Hence, the following research problems were examined:

- What TPACK do the PMSMTs have about digital storytelling?
- How is their TPACK about digital storytelling externalized through professional development workshop?

Theoretical Framework

Digital Storytelling in Teaching and Learning

In the literature related to the digital storytelling, there are studies representing positive effects on learning of students from different grade levels for various subjects (Hibbing & Rankin-Erikson 2003). Previous researches show that digital storytelling take beneficial role in teaching process as an effective tool encouraging learning and communication of students to share and demonstrate their understanding (Banaszewski 2005; Çetin, 2021; Hofer & Swan 2005; Tally & Goldenberg 2005) by developing 21st century skills (Gürsoy, 2021). It is also stressed that digital stories can be an effective way to comprehend content of course, reconcile and understand concepts by linking real life, to create artistic products, to develop modelling skills and to eliminate students' misconceptions about mathematical concepts such as fractions (Chung 2006; Karaoğlan-Yılmaz et al. 2018; Sadik 2008). In addition, previous researches show that stories can improve students' problem solving skills because the cases taken from daily life can be used to enhance solution process (Jonassen 2003; Schiro 2004). Moreover, Lasica (2002) explains that preservice teachers could effectively learn necessary knowledge and skills about creating digital stories in a short time period with high level perceptions of the use of educational technologies and being open to the idea of adapting the developments in educational technologies. Robin (2006) adds that digital stories could be a new learning model for preservice teachers and provide a different method for designing a technology-supported teaching environment by connecting curriculum and real life.

In the literature, studies focusing on using digital storytelling in the field of mathematics education and teacher education are needed to be conducted (Kearney, 2009). The previous studies mostly focus on the effect of the use of digital stories on students (Karaoğlan-Yılmaz et al. 2018). Furthermore, the previous research in the literature emphasize that the digital stories are sometimes not designed to affect students in terms of learning mathematical concepts, or that preservice teachers may be more likely to focus on technological aspects than other types of knowledge and ignore other information (Samaras & Fox 2013; Istenic Starcic et al. 2016). Therefore, studies are necessitated to encourage the use of digital storytelling in mathematics teacher education especially for the development of preservice teachers' professional development in digital storytelling.

TPACK about Digital Storytelling and Professional Development

By considering the connection among technological, content, and pedagogical knowledge, a frame focusing on the effective use of technology in mathematics lessons and blending technology,

pedagogy and content knowledge has been designed (see Figure 1). This frame is referred to by Mishra and Koehler (2006) as technological pedagogical content knowledge (TPACK). By this framework, technology can be integrated into mathematics lessons effectively by the combination and intersection of content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technology knowledge (TK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK). Koehler and Mishra (2009) have defined this frame as performing effective teaching with the help of technology using knowledge about using pedagogical techniques, representing concept via technology, students' understanding related to concept and constructing new epistemologies.

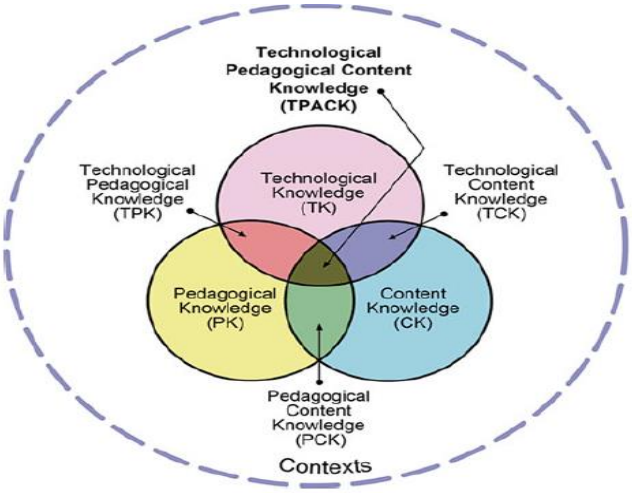


Figure 1. The TPACK framework by Koehler and Mishra (2009, s. 63)

Teachers having high level of TPACK knowledge can use technology consciously in their lessons and can teach more effectively by predicting how students can learn better with technology (Preiner 2008). In addition, teachers use mathematics teaching strategies, multiple representation techniques and related technological software when transferring mathematics curriculum to their students (Niess 2011). By increasing importance of TPACK with technology, the studies and published standards emphasize the necessity of professional development of teachers so that they can design technologically-rich lessons (Niess et al. 2009; NCATE 2008). However, it is seen that teachers' improvement of TPACK is not as fast as technological development due to the complexity of this frame (Mudzimiri 2012; Niess et al. 2009). Professional development opportunities can have great importance on helping preservice teachers acquire necessary knowledge and skills to develop TPACK (Angeli & Valanides 2009; Chai et al. 2010; Koehler & Mishra, 2008; Mouza et al., 2014; Niess, 2005). In this way, mathematics teachers who use TPACK effectively in their lessons can be trained (Kinuthia et al. 2010). In this study, this framework was used since it could provide a beneficial way of teaching how to integrate technology into mathematics lessons for teacher education programs.

In the current study, it was focused on the PMSMT's TPACK of digital storytelling having beneficial implications and usage in teaching mathematics. However, it cannot be stated that using digital storytelling in the lesson plan ensures implementing TPACK effectively. Hence, the PMSMT may need specialized TPACK on digital storytelling to effectively design lessons and integrate their teaching practices. Therefore, it is necessitated to provide their professional development to meet this need. To line with this view, workshops were established, and the PMSMT's specialized TPACK was examined in order to enable them to create beneficial digital stories and integrate them into lessons effectively. Hence, the present study focused on the process of identifying and developing detailed TPACK for creation of digital stories that can be used in mathematics education and the design of the lessons in which these stories took place effectively)

Method

Because the fact that the cases are explored in detail by considering and connecting all dimensions in their own nature and the conditions in which they occur by making comparisons among them in the multiple case study (Creswell 2009; Merriam 2009), the current study was designed using multiple case study research design. The current study focused on the digital stories created by preservice middle school mathematics teachers' (PMSMT) identification and development of TPACK through professional development workshops aiming to teach how to create digital stories and integrate them into lessons by gathering detailed information in various ways. Ethical permissions were provided.

Participants

In accordance with the aims of the current study, the study was conducted to 60 junior students enrolled in the elementary mathematics education program. Of these participants, 38 were female and 22 were male. The participants were selected by using criterion sampling strategy. As the focus of the research is on the mathematical and pedagogical as well as the technological aspects of the creation of digital stories, the participants were expected to be familiar with these knowledge types. Hence, the PMSMT who had taken the courses of "Educational Technology and Material Design" and "Teaching Principles and Strategies" were selected for the current study.

Professional Development Workshop

The current study was conducted in the context of four professional development workshop series paying attention on digital storytelling. The professional development workshops were designed based on four characteristics; supporting the PMSMT in (1) learning how to use Powtoon as needed technological tool, (2) writing stories, (3) creating digital stories, and (4) designing lessons by digital storytelling and revising based on reflections. The implementation of all of the series of workshops lasted 48 hours in six days including 8 hours in each day.

The first workshop was performed using activities and tasks that were organized to get necessary information about using Powtoon. The PMSMT were first informed about using Powtoon and its various applications, and activities were performed to learn how to use the program. This process was carried out in the computer laboratory in eight hours. In the second workshop, after the PMSMT started to use Powtoon effectively, they were given training on story and story-writing. Story-writing education process was performed by providing information about narration, elements and structure of the story, narratives used in the story, characteristics of a good narration and processes of narrative. Then, sample stories were examined and analyzed. The story-writing education process was carried out in eight hours. After these trainings, the participants were asked to examine the middle school mathematics curriculum. This review process was carried out as homework. The PMSMT determined the particular mathematical topics, concepts and objectives to prepare their digital stories and lesson plans. The third workshop was started with the activities and tasks related to the PMSMT's mathematical stories and the processes shown in Table 1 and performed in twenty-four hours. The PMSMT were asked to write a story about the objectives of the mathematical concept selected from the middle school mathematics curricula. The PMSMT who wrote their stories shared them with each other, and then all of them came to the class reading the stories. Discussions were made about the stories read and revisions were suggested if necessary. Then, they transformed the revised form of the stories into digital stories using Powtoon by selecting the necessary criteria and items for the stories. The process of creating digital stories of the PMSMT was carried out in twenty four hours following the steps suggested by Kearney (2011), as shown in Table 2. The prepared digital stories were shared with other participants, and then they discussed about these digital stories and feedback was provided. Afterwards, the PMSMT were asked to design a lesson based on the selected objective using the digital stories reorganized in accordance with the feedback. The lesson plans prepared by using digital stories were shared with other participants in the group and discussed by the group including the researcher and participants. This group talked about the use of lesson plans in the classroom and made recommendations about their correction. The processes of giving training and collecting data were performed by the researcher. Data about training

processes recorded using video cameras were transcribed verbatim. Also, the digital stories and lesson plans were collected by the researcher.

Table 1. Description of Professional Development Workshop

Session	Agenda	Homework
Session 1, 8 hours	Learning to use Powtoon	Try to design contexts arbitrarily using functions of Powtoon
Session 2 8 hours	Learning to write story, Analyse samples of mathematical stories Determine the mathematical concept and related items used in the story	Analyse middle school mathematics curricula Make examination for elements of story such as time, location Write mathematical story
Session 3 24 hours	Creating digital storytelling (by following the steps modified based on the study of Kearney (2011) in Table 2) Share mathematical stories and digital stories Presentation of mathematical stories and digital stories Analyse mathematical stories and digital stories Full class discussion Make revisions	Design lesson plans using created digital stories
Session 4 8 hours	Share lesson plans Presentation of lesson plans Analyse lesson plans Full class discussion Make revisions	Enact lesson plans by microteaching if it is applicable

Table 2. Design process of digital storytelling proposed by Kearney (2011)

Process of writing and creating digital stories	Media	Creating the environment
Process of determining mathematical part	Middle school mathematics curricula	The topic, concepts and objectives were determined to be used in digital story-telling
Building mathematical narratives including scenarios for digital stories	MS Word	PMSMT made connection of the concept and objective with real life, history, or other disciplines, organize the event and determine the characters, plot, and time. They built mathematical narratives appropriately depending on writing process and elements and using determined concepts and objectives. Narrative had clear beginning, middle and end.
Story board	MS Word Powtoon	The scripts (highlights of the narrative) were established.

		Elements of stories including place, timing, people, and events were detailed. How to interact them with each other was explained clearly in detail. Also, visual and audio effects including pictures, photographs, videos, and audio-recordings to be used in digital storytelling were examined and identified.
Creating digital stories	MS Word Powtoon	Identified items were combined to form digital stories based on identified objectives, prepared mathematical stories and scenarios.
	Identified visual & audio effects	Digital stories were formed by using items economically, consciously and properly based on the narratives.

Data Collection and Data Analysis

The research took place in forty-eight hours. According to Harris, Grandgenett, and Hofer (2010), the data can be collected in order to assess TPACK through three sources; "self-report (via interviews, surveys, or other generated documents, such as reflexive journal entries), observed behavior, and teaching artefacts, such as lesson plans. Since teachers' knowledge is typically reflected through actions, statements, and artefacts. . ." (p. 3834). At the end of the training, the PMSMT prepared lesson plans using digital stories and these lesson plans were collected for examination based on the purposes of the study. Afterwards, the lesson plans, stories and digital stories were collected. Then, all of the data obtained in various ways and documented were examined by the researcher using the content analysis technique from qualitative data analysis techniques. In this process, the researcher has determined various categories and themes related to the analysis of the collected data. The categories and themes identified in the study were rearranged as in Table 3 using the theoretical frameworks proposed by Bowers and Stephens (2011), Niess (2007) and Hervey (2014); and the data of the current study in order to determine specialized TPACK for digital storytelling. For example, the codes of having mathematical efficiency, mathematical appropriateness, being related to mathematical concept and using procedural and conceptual skills in balanced were determined, and they were placed under the theme of mathematical appropriateness. They were thought as being related to content knowledge so these categories were designed to be used under the title of content knowledge of the theoretical framework. Moreover, when the PMSMT's digital stories and the lesson plans were examined, it was observed that they did not focus solely on technological knowledge or only technological pedagogical knowledge. Hence, these two types of knowledge did not take place in the framework of the current study and the revised form of the framework was prepared as in Table 3. Then using this prepared framework data were re-analyzed, and the findings were explained with the help of this framework. In order to provide the validity and reliability of the study, data triangulation strategy was performed so the data were collected by the ways as suggested by Harris, Grandgenett and Hofer (2010). Also, the data analysis process was made by the researcher and an academician having the degree of PhD. in mathematics education. They independently coded the data and then, they identified common codes and themes with 90% through their meetings. The remaining 10% dissimilar part of the codes and themes was discussed and used by providing consensus. In addition, member checking strategy was used. The comments of the PMSMT about the implications made through data analysis were found out through interviews.

Table 3. Theoretical framework used for data analysis proposed by content analysis and study of Bowers & Stephens (2011), Niess (2007) and Hervey (2014)

Knowledge Domain	**Descriptors**
Content Knowledge (CK)	Identifies the concept based on mathematics curriculum
	Prepares the mathematical story (including objective, selecting and organising the elements of story appropriately)

	Evaluates mathematical efficiency of the story (Sufficiency of mathematical knowledge, mathematical appropriateness, relation with mathematics, procedural and conceptual information, using skills in balanced)
Technological Content Knowledge (TCK)	Represents the descriptors defined in domains of TK and CK
	Understands benefits of Powtoon to represent subject domain
	Uses Powtoon to simulate identified part of content
	Transforms mathematical stories into digital stories by Powtoon
	Produces storyboard/script appropriately based on mathematical stories
	Recognises challenges in producing digital-stories and provides alternatives to eliminate
Technological Pedagogical Content Knowledge (TPACK)	Analyses, manages, and make appropriate selections on usage of descriptors in all domains in a dynamic equilibrium
	Prepares digital story appropriately based on related objective, student knowledge and instructional strategies by Powtoon
	Organises digital story and lesson plan appropriately based on developmental process of students and related objectives (Characters, places, scenario, symbols, and messages)
	Prepares lesson plan providing the learning environment based on the usage of digital stories effectively
	Uses digital story to provide students engage in exploring, thinking and understand content
	Provides opportunities to develop high-level thinking activities such as problem solving to learn concept by digital story as a learning tool

Findings

The lesson plans and digital stories prepared by the PMSMT were examined in terms of each dimension of TPACK (see Table 2) and the findings were indicated in headings referring to these knowledge domains. When the PMSMT's digital stories and the lesson plans were examined, it was observed that they did not focus solely on technological knowledge or only technological pedagogical knowledge. Therefore, it is determined that there are not any preservice teachers representing just these knowledge domains. The most important reason for this finding could be that the middle school mathematics curriculum was examined and the participants were asked to select the concepts and objectives that they could prepare their digital stories. The mathematical story and the digital story were prepared after the mathematical knowledge was determined. Hence, it can be said that all the participants used and represented different forms and levels of content knowledge in their digital stories and lesson plans. When the digital stories and lesson plans that were prepared were examined, it was observed that 10 PMSMT were at Content Knowledge Level, 14 PMSMT were at the level of Technological Content Knowledge Level and 36 PMSMT were at TPACK Level.

The idea why the PMSMT's digital stories and lesson plans were examined in the specified knowledge levels was explained under the following headings. The aim here was to elaborate in detail how the PMSMT used and integrated their knowledge in designing digital stories and preparing lesson plans.

Content Knowledge

The PMSMT's digital stories, which mainly include content knowledge in the lesson plans, were used to inform students about the target, to draw their attention, to explain them the path of teaching process and to visualize the solution. Only digital stories focusing on accurate and sufficient information about mathematical concepts were accepted in this category of knowledge domain. The content was

explained in a proper and correct way in these digital stories. In addition, they were created using such a low level of traits of the Powtoon. For example, they were composed of few storyboards, and formed using limited level of motion, audio, and picture insertion property of Powtoon. For example, there is a sample of digital storytelling of "Levent's Pizza" in this knowledge level in Figure 2 (summarized in Appendices-Story 1).

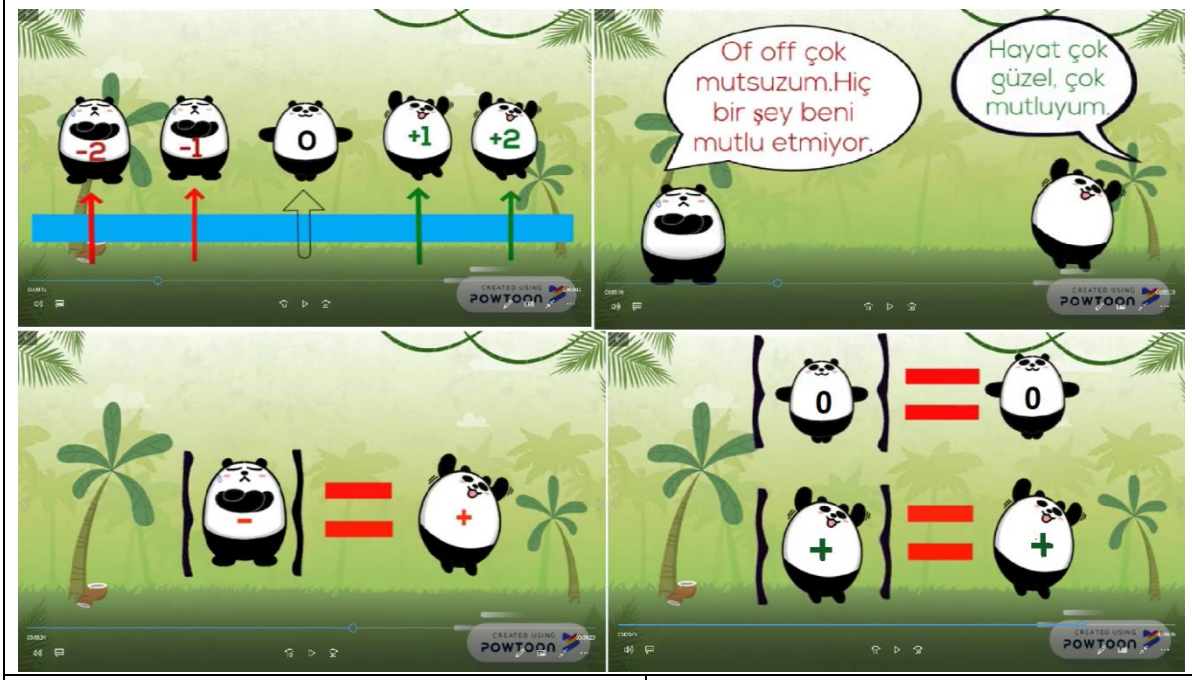
Because Seda Teacher order pizzas for whole class…	Let the radius of this cylinder be Z
Let the altitude be A.	πzza is acquired. It is read as PIZZA.

Figure 2. Screenshots of the digital story about volume formula of cylinder "Levent's Pizza"

This digital story was prepared with the aim of making the volume formula of cylinder more permanent in mind. In the interview, S12 explained that this digital story was designed in order to make the formula easy to remember and understand using its elements such as radius, altitude. Hence, remembering remindful samples rather than acquiring conceptual understanding about the subject was encouraged in the lesson. In addition, pedagogical activities such as supportive discussion topics, questions to enhance understanding of the content were not provided in the lesson plan. In this respect, the digital story had deficiencies in pedagogical aspect. In addition, the features of the program were used at a limited level in the digital story. Due to the nature of the story, the motions or emotion of the characters was not considered to be necessary since it was not at the forefront of the narrative. Only the process of relating formula and the pizza were visualized. Because Powtoon's dynamic features were used at limited extent emphasizing visualization purposes, the digital story had technological shortcomings. When the lesson plan using this digital story was examined, it was seen that S12 planned to tell the students the formula of the volume of the cylinder after reminding about the cylinder. She planned to use this digital story to help students reinforce and remember this formula before starting to do the exercises necessitating to use the formula. She ignored the tasks, activities, questions, pictures or explanations providing the opportunities encouraging the necessary knowledge and skills needing for reasoning about the volume. In this respect, it could be stated that there were deficiencies in the digital story and lesson plan in pedagogical aspects. After the discussion period, S12 could not improve the lesson plan and the story in terms of pedagogical and technological aspects and no revisions were made on them. For this reason, this kind of samples were evaluated in the Content Knowledge Level before and after the discussion process.

Technological Content Knowledge

The PMSMT with technological knowledge were able to transform the stories having mathematical competence into digital stories by using Powtoon effectively. In other words, using this program effectively, the story with rich mathematical content were transformed into a digital story. However, in the process of creating these digital stories and using them in lesson plans, pedagogical aspects were considered at limited level. Ignoring the pedagogical aspects of the lesson plan, there were mathematical content and the efficient use of the properties of the Powtoon. For example, in the digital story of "Country of Integers" represented in Figure 3, the mathematical concept of absolute value was explained focusing on using emotional feelings (in Appendices-Story 2).



Of off. I am very sad. Nothing makes me happy.	Life is so beautiful. I am very happy.

Figure 3. Screenshots of the digital story about absolute value by "Country of Integers"

In this digital story, the PMSMT introduced the story and time as the elements narrative in her story as a country of integers, introducing the happy, unhappy, and insecure pandas who were residents of the country and characters of the story. Here, S47 used the green colour and the plus sign to show the happy pandas for positive integers; the red colour and the minus sign to show the unhappy pandas for negative integers, and the black number for the zero number. In this way, the mathematical concept of integers, which is the preliminary learning of absolute value, was introduced correctly as in Figure 3. After this distinction and reminder, the target point began to be told. It was shown that people could be happy by changing their unhappy feelings; meaning that their minus signs could turn into the plus sign, but this could only be achieved with great bars. In this knowledge category, this digital story was evaluated in Technological Content Knowledge domain because of using integer concept correctly and the importance and significance of the absolute value sign with the efficient use of the motion, image, and sound characteristics of Powtoon for all integers. The emotional feelings of the characters in the story were illustrated effectively by the use of sound and visual features by mobilizing characters. In this story, due to using the features of Powtoon efficiently, it could be stated that technological knowledge could be used while designing this digital story. S47's lesson plan was evaluated in this category in terms of displaying the integers and representing the relevant parts of the digital story while teaching the absolute value. However, to ignore the questioning or explanations encouraging students' understanding through the use of the digital story, indicated that there were deficiencies in terms of pedagogical aspect. In the beginning of the lesson, it was planned to start the lesson with questions about happiness, unhappiness, and situations to feel happy or unhappy. Then, it was seen that he was planning

to start teaching the subject by watching the digital story. In the interviews, by the digital story, he emphasized that he planned to summarize the story and mention about the absolute value subject and make exercises in the lesson plan. In addition, in both pedagogical and technological aspects, explanations were added as sound and when used in the classroom, some bubbles were shown in the case of the existence of students that could not hear them. Moreover, during the interviews, the S47 focused more on understanding the reasonableness of the subject than on understanding and acquiring conceptual knowledge. Therefore, he expressed his views regarding the use of digital stories in this direction. S47 therefore ignored most pedagogical aspects and he just used general pedagogical knowledge such as classroom management rules. In order to help students to comprehend the subject and to help them understand the digital story, the methods and clues that the student would examine the story and the subject in depth were ignored. As pedagogical knowledge was used at limited extent, such stories were evaluated in the category of Technological Content Knowledge.

Technological Pedagogical Content Knowledge

The PMSMT evaluated in this knowledge domain prepared their digital stories and lesson plans by using and associating their content knowledge, technological knowledge, and pedagogical knowledge. The digital stories categorized under this heading were used in the lesson plans designed by focusing on the conceptual aspect of the subject efficiently. In addition, in the lesson plans, the questions were prepared to be asked to teach the subject before, during, and after the digital stories were watched to help the students understand the content. In other words, digital stories were considered as the main tools to be used in teaching and the lesson plans were prepared based on this view. In addition, most of these stories have been created by originating from the literature, history, fairy tales and other disciplines such as science. For example, the mathematical subject of absolute value was explained with the story of Ferhat and Şirin; the sets of numbers were transformed into digital stories with the subject of gene in science; the property of zero as being absorbing element in multiplication with black hole as the issue of astronomy in the sciences; and ratio was told with a situation related to forming the map of a city gotten in Ottoman history. For example, using the story of Ferhat and Şirin as one of the famous literary works, S56 explained the concept of absolute value by modifying this story (Appendices-Story 3) in Figure 4.

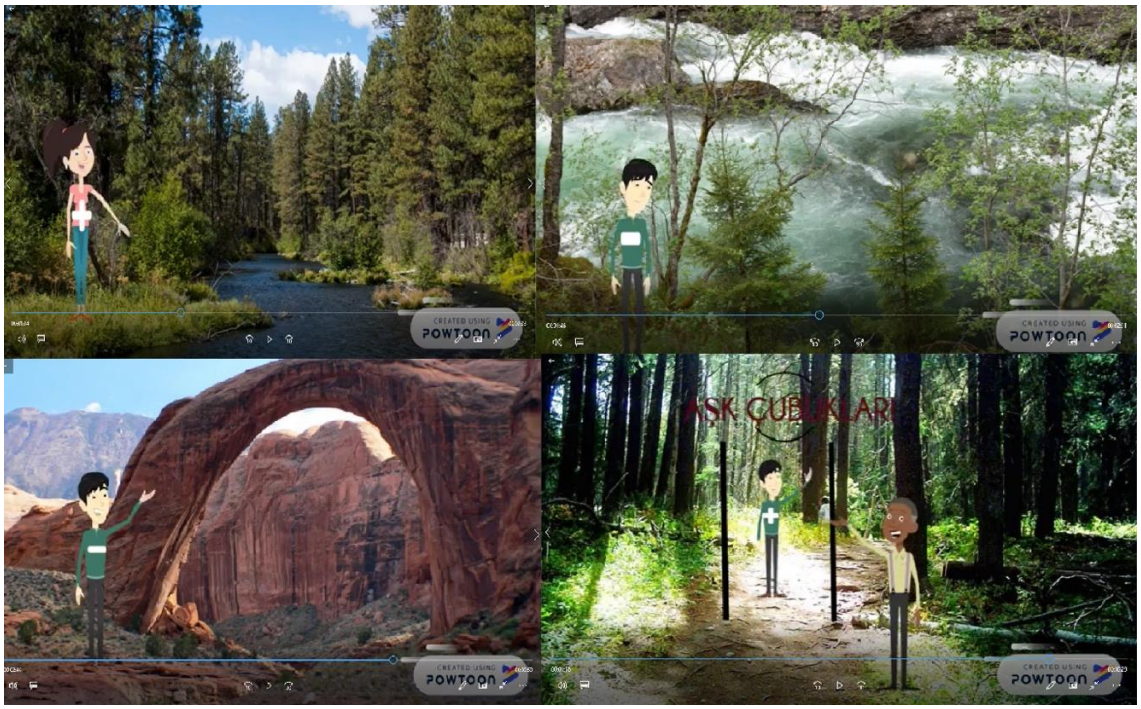


Figure 4. Screenshot of the digital story about absolute value by "Ferhat and Şirin"

This digital story was created being inspired from the story of Ferhat and Şirin in the literature. S56 described the concept of integers by relating the enemy families of Ferhat and Şirin with their hostile status. In addition, in order to emphasize the meaning of the absolute value, Ferhat and Şirin's houses were in the opposite direction but in equal distances to the zero point. In addition, it was planned to discuss these contexts and the questions that could be asked to students were prepared in the lesson plan. The concept of absolute value was also explained by getting the plus sign of Ferhat. These sections were also supported by student discussions and sample exercises in the lesson plan. In addition, the features of the program were used effectively in the creation of the story. The movements, emotions, speeches and sounds of the characters were used appropriately. Therefore, content, technological and pedagogical knowledge were used effectively in designing this digital story and lesson plan.

In another example for this knowledge domain, S6 organized her digital story of "Peace Aerial Ropeway" in Figure 5 (Appendices-Story 4) and lesson plan in order to teach addition operation on integers. In the beginning part of the lesson plan, it was planned to introduce the prepared concrete material (see Figure 6) to the students, to ask the question of whether they get on aerial ropeway and to watch a particular part of the digital story or not. The digital story was described with the relation of the opposite parts of the integers as positive and negative with the enemy cities in order to remind the concept of integers. After viewing this part of the story, it was planned to form discussion about this relationship between the integers and the questions that could be asked through whole class discussion were stated in the lesson plan. In addition, she used the number line logic from the modelling methods used in the operations performed on the integers and learned in the Special Teaching Methods course in this digital story. The number line method was associated with the aerial ropeway and its route. Moreover, in the placement of the numbers on the aerial ropeway, the subject about the comparison of integers was used by the idea of positioning the houses in the city from the foothills to the top of the mountain as shown in Figure 5. Hence, it was planned to focus on this issue by watching related part of the digital story in whole class discussion so that it was aimed to help the students reinforce their understanding about the concept of positive and negative numbers, and the relationship between them. After completing the whole class discussions about them, S6 planned to begin teaching addition on integers. By watching the particular part of the digital story about running rules of the aerial ropeway, it was aimed to focus on the relationship between these rules and addition on integers in the lesson plan. The digital story also showed a number of samples for addition operation on integers. Here, the aerial ropeway model as a concrete material (see Figure 6) was planned to be used by the students to perform a number of exercises for addition operations on integers and to help them acquire conceptual and procedural knowledge on this model more effectively. Using the context of aerial ropeway in the digital story, various exercises related to the addition on integers to be performed by using the aerial ropeway model were stated in the lesson plan.

Figure 5. Screenshot of the digital story about operations on integers by Peace Aerial Ropeway

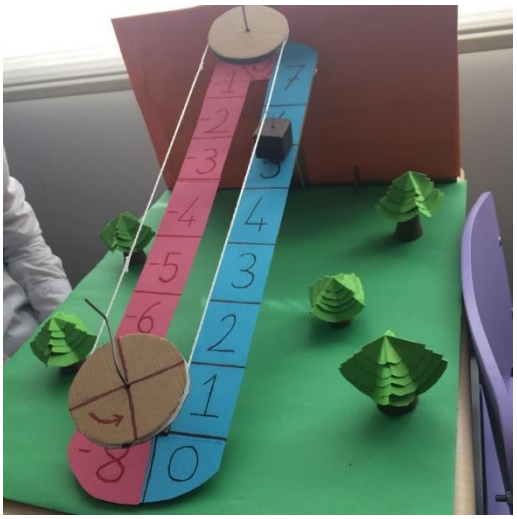


Figure 6. Aerial ropeway material for addition operation on integers

This digital story was designed about the mathematical concept of addition on integers using the properties of Powtoon effectively such as adding motion, image, and sound with the help of technological knowledge. It was supported with the help of the concrete material prepared appropriately based on this story in the lesson plan. Moreover, the process of transferring mathematical content seems to be planned in a way that supports student learning with effective pedagogical aspects. Given these explanations, it could be stated that S6 represented the characteristics of specialized TPACK knowledge level in preparing the digital story and the lesson plan effectively. Also, it can be stated that he could use digital stories as learning tool to help student to understand the concept, analyse it, and develop thinking about the content by providing pedagogical facilities.

Discussion and Conclusion

Various digital stories were created and brought together in the current study. In this process, the preservice middle school mathematics teachers (PMSMTs) were given a training about story-writing, using Powtoon and creating digital story. The study could be important in terms of combining two different disciplines of literature and mathematics by the acquisition of the necessary information about

writing story as one of the most important strategies of literature, and communication and using them in mathematics education. The PMSMT were encouraged to develop themselves in the professional improvement by acquiring necessary knowledge and skills related to story-writing and using it in mathematics education with the help of technology.

It could be stated that the professional development workshops related to digital storytelling could be useful to provide the PMSMT opportunity of transferring the content of the mathematical concept into the design of the lessons. In addition, the views that digital stories are useful in organizing knowledge (Hwang & Huang 2012), and they provide an effective and interesting way to visualize the information (Çetin, 2021; Rijnja & Van der Jagst 2004). However, it was observed that the PMSMT had difficulty in connecting content knowledge with other knowledge levels in designing the lessons including digital stories, such as technological and pedagogical knowledge, and some of them could not effectively associate the content, pedagogical and technological knowledge. This finding is in line with findings of previous studies in which it is stated that preservice teachers do not use all of the necessary kinds of knowledge or integrate them effectively when designing technology-supported lessons (Samaras & Fox 2013; Istenic Starcic et al. 2016). More specifically, it was seen that the PMSMT could have the opportunity to represent their knowledge and skills they had about mathematics education and evaluate them in the context of the design of technology-supported learning environments with the help of digital stories and the lesson plans. This finding is in line with the findings and recommendations of the earlier studies focusing on the reflection and analysis of the learning process of preservice teachers in the context of the digital stories (Bull & Bell 2005; Hofer & Swan 2005; Sharp, Garafolo & Thompson 2004).

Through the professional development workshops, it could be stated that the PMSMT's learning skills were developed by the processes of training and preparing the lesson plans and digital stories. Here, the PMSMT had the opportunities of making abstract mathematical concepts more concrete with digital stories (Sharp et al. 2004), learning how to enable students to think about concepts (Harel & Papert 1991) and the use of digital stories designed to construct conceptual knowledge (Alterio 2002). Also, it could be stated that digital stories provided effective and useful opportunities for using the theoretical knowledge acquired in teaching and learning in the process of making abstract concepts concrete and reasoning on it. This finding of the research is in line with the studies that emphasize the connection of learning theories and teaching method with the mathematical concepts (Hall & Hudson 2006; Kim 2006; Ugoretz 2006). In this respect, it is recommended that it is important to provide opportunities for professional development in making these connections as represented in the current study.

The digital storytelling could be seen as an effective way of showing important examples for relating mathematical knowledge with knowledge of other disciplines such as literature and science. For example, the famous Ferhat and Şirin story was used to teach the mathematical concept of absolute value, and the absorbing property of zero on multiplication operation was explained by originating from the black holes in the space. In this respect, it could be stated that the digital stories were useful for the PMSMT in terms of making connection between mathematical concepts and other disciplines as explained in previous studies (Hall and Hudson 2006; Kim 2006). Even with this connection, it can be stated that mathematical concepts have become more interesting and concrete (Huge-Black, 2014; Nam, 2017). In addition, the PMSMT's awareness of the deficiencies in digital stories and lesson plans based on knowledge levels could be ensured in the processes of training. These findings can be supported by the findings and recommendations of previous studies in the literature (Sharp et al. 2004; Harel & Papert 1991; Bull & Bell 2005; Hofer & Swan 2005; Jakes & Brennan 2003; Salpeter 2005; Weis 2002). In accordance with these findings, it can be stated that the process of learning about formation of digital-storytelling and designing lesson plans by these stories can encourage the PMSMT's development of pedagogical, technological, and content knowledge. Hence, the professional development workshops provided the PMSMT for creating digital stories and lesson plans can be useful to be used in teacher education programs since this process could provide the opportunity of associating the knowledge acquired through different courses such as educational technology, field, and methodology like it is

suggested in earlier studies (Mouza et al. 2014; Istenic et al. 2016). The current study is limited to design of the lessons using digital storytelling. Further research should explore enactment of these lessons in the classrooms. Also, further research should examine the impacts of these professional development workshops on inservice mathematics teachers' TPACK about digital storytelling including their implementation in their classrooms. Also, the workshops can be extended using the analysis of their implementation of lessons using digital storytelling.

There is no conflict of interest for the current study.

Ethical permissions were provided.

References

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: advances in technology and pedagogical content knowledge (TPCK). *Computers & Education, 52*, 154–168. https://doi.org/10.1016/j.compedu.2008.07.006

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences, 13*(1) 1-14. https://doi.org/10.1207/s15327809jls1301_1

Behmer, S., Schmidt, D. & Schmidt, J. (2006). Everyone has a story to tell: Examining digital storytelling in the classroom. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2006* (pp. 655-662). Chesapeake, VA: AACE.

Bowers, J. S. & Stephens, B. (2011). Using technology to explore mathematical relationships: A framework for orienting mathematics courses for prospective teachers. *Journal of Mathematics Teacher Education, 14*(4), 285-304. https://doi.org/10.1007/s10857-011-9168-x

Bruner, J. (1996). *The Culture of Education*. Cambridge, MA: Harvard University Press.

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

Chang CY. (2001). Comparing the impacts of a problem-based computer – assisted instruction and the direct-interactive teaching method on student science achievement. *Journal of Science Education Technology, 10*(2), 147–153.

Chung, S. (2006). Digital storytelling in integrated arts education. *The International Journal of Arts Education,* 33-50.

Cobb, P. (2000). Conducting classroom teaching experiments in collaboration with teachers. In A. Kelly & R. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 307–334). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9-13. https://doi.org/10.3102/0013189X032001009

Cobb, P., Stephan, M., McClain, K. & Gravemeijer, K. (2011). Participating in classroom mathematical practices. In Sfard, A., Yackel, E., Gravemeijer, K., & Cobb, P. (Eds.), *Journey in mathematics education research* (pp. 117– 782163). Netherlands: Springer.

Çetin, E. (2021). Digital storytelling in teacher education and its effect on the digital literacy of pre-service teachers. *Thinking Skills and Creativity, 39,* 1-9.

Davis, M. & Waggett, D. (2006) Enhancing pre-service teachers‟ reflective practice via technology competencies and e-portfolio development. *Society for Information Technology and Teacher Education.* Retrieved on November 10, 2021 from http://www.uvm.edu/pt3/?Page=papers.html&SM=researchsub.html.

Egan, K. (1998). *The educated mind: How cognitive tools shape our understanding.* Chicago: University of Chicago Press.

Gürsoy, G. (2021). Digital storytelling: Developing 21st century skills in science education. *European Journal of Educational Research, 10*(1), 97-113. doi: 10.12973/eu-jer.10.1.97.

Hall, L. & Hudson, R. (2006). Cross-curricular connections: Video production in a K-8 teacher preparation program. *Contemporary Issues in Technology and Teacher Education*, *6*(3), 328-341.

Haven, K. (2000). *Super simple storytelling: A can-do guide for every classroom, every day*. Englewood, CO: Teacher Ideas Press.

Hervey, L. G. (2014). Between the notion and the act: Veteran teachers' TPACK and practice in 1:1 settings. In C. Angeli & N. Valanides (Eds.), *Technological pedagogical content knowledge* (pp. 165-189). New York: Springer.

Hibbing, A.N., & Rankin-Erikson, J. L. (2003). A picture is worth a thousand words: using visual images to improve comprehension for middle school struggling readers. *Reading Teacher, 56*(8), 758-770.

Hofer, M. & Swan, K. (2006). Digital storytelling: moving from promise to practice. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference, March 19* (pp. 679-684). Chesapeake, VA: AACE.

Istenic Starčič, A., Cotic, M., Solomonides, I., & Volk, M. (2016). Engaging pre-service primary and preprimary school teachers in digital storytelling for the teaching and learning of mathematics. *British Journal of Educational Technology, 47*(1), 29–50. https://doi.org/10.1111/bjet.12253

Jonassen, D. (2003). Using cognitive tools to represent problems. *Journal of Research on Technology in Education, 35* (3), 362-382. https://doi.org/10.1080/15391523.2003.10782391

Karaoğlan-Yılmaz, F. G., Gökkurt-Özdemir, B., & Yaşar, Z. (2018). Using digital stories to reduce misconceptions and mistakes about fractions: an action study. *International Journal of Mathematical Education in Science and Technology*, *49*(6), 867-898. https://doi.org/10.1080/0020739X.2017.1418919

Kearney, M. (2009). *Investigating digital storytelling and portfolios in teacher education*. Proceedings of Ed-Media 2009 World Conference on Educational Multimedia, Hypermedia and Telecommunications. Edited by: Fulford, C. and Siemens, G. pp.1987–96. Chesapeake, VA: AACE.

Kearney M. (2011). A learning design for student-generated digital storytelling. *Learn, Media Technology, 36*(2), 169–188. https://doi.org/10.1080/17439884.2011.553623

Kim, H. (2006). How do we change preservice teachers' perceptions of scientists using digital storytelling. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2006* (pp. 689-691). Chesapeake, VA: AACE.

Kinuthia, W., Brantley-Dias, L., & Junor-Clarke, P. A. (2010). Development of pedagogical technology integration content knowledge in preparing mathematics preservice teachers: the role of instructional case analyses and reflection. *Journal of Technology and Teacher Education, 18*(4), 645-669.

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on Innovation & Technology (Eds.), *Handbook of technological pedagogical content knowledge for educators* (pp. 3–29). New York, NY: Routledge.

Koehler, M., & Mishra, P. (2009). *Technological pedagogical content knowledge (TPACK) [diagram]*. Retrieved April 13, 2018, from http://www.tpack.org/tpck/images/tpck/a/al/tpack-contexts.jpg

Lasica, J. (2002). Digital tools easier to grasp. *USC Annenberg Online Journalism Review.* Retrieved on October 27, 2018 from http://www.ojr.org/ojr/lasica/1034121182.php

Lathem, S. (2005). Digital storytelling and professional development: New media for ancient tradition. *Society for Information Technology and Teacher Education.* March 1-5, 2005, Phoenix, AZ. Retrieved on September 10, 2021, from http://www.uvm.edu/pt3/?Page=papers.html&SM=researchsub.html.

Lee, S. C. (2001). Development of instructional strategy of computer application software for group instruction. *Computers & Education, 37*(1), 1–9. https://doi.org/10.1016/S0360-1315(01)00020-3

Macquire, J. (1998). *The power of personal storytelling: Spinning tales to connect with others*. New York: Putnam.

Malita, L., & Martin, C. (2010). Digital Storytelling as web passport to success in the 21st Century. *Procedia - Social and Behavioral Sciences, 2*(2), 3060-3064. https://doi.org/10.1016/j.sbspro.2010.03.465

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Mouza, C., Karchmer-Klein, R., Nandakumar, R., Yilmaz-Ozden, S., & Hu, L. (2014). Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK). *Computers & Education, 71*, 206-221. https://doi.org/10.1016/j.compedu.2013.09.020

Mudzimiri, R. (2012). *A study of the development of Technological Pedagogical Content Knowledge (TPACK) in pre-service secondary mathematics teachers*. (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses. (Publication No. 3523442).

Nam, C. W. (2017). The effects of digital storytelling on student achievement, social presence, and attitude in online collaborative learning environments. *Interact Learning Environment, 25*(3), 412–427. https://doi.org/10.1080/10494820.2015.1135173

National Council for Accreditation of Teacher Education (2012). *CAEP announces commission on standards and performance reporting: Will raise the bar for educator preparation*. Washington, DC: NCATE.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*, 509–523. https://doi.org/10.1016/j.tate.2005.03.006

Niess, M.L., Ronau, R.N., Shafer, K.G., Driskell, S.O., Harper, S.R., Johnston, C., Browning, C., Özgün-Koca, S.A. & Kersaint, G. (2009). Mathematics Teacher TPACK Standards and Development Model. *Contemporary Issues in Technology and Teacher Education, 9*(1), 4-24.

Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research, 44*(3), 299-317. https://doi.org/10.2190/EC.44.3.c

Preiner, J. (2008). *Introducing dynamic Mathematics software to Mathematics teachers: the case of GeoGebra.* Unpublished doctoral dissertation. University of Salzburg, Austria Schumann.

Powell, J.V., Aeby, V.G. & Carpenter-Aebyc, T. (2003). A comparison of student outcomes with and without teacher facilitated computer-based instruction. *Computers & Education, 40*(2), 183–191. https://doi.org/10.1016/S0360-1315(02)00120-3

Rijnja G. & Van der Jagt R. (2004). *Storytelling: De kracht van verhalen in communicatie*. Alphen aan den Rijn The Netherlands: Kluwer.

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 2006,* 709-716. Chesapeake, VA: AACE.

Robin, B. R. (2008). Digital storytelling: A powerful technology tool for the 21st century classroom. *Theory into Practice, 47*, 220-228. https://doi.org/10.1080/00405840802153916

Rudnicki, A. (2009). *Coming full circle: Exploring story circles, dialogue, and story in a graduate level digital storytelling curriculum*. Unpublished doctoral dissertation. University of Houston, Houston, TX.

Sadik, A. (2008). Digital storytelling: A meaningful technology-integrated approach for engaged student learning. *Educational Technology Research and Development, 56*, 487-506. https://doi.org/10.1007/s11423-008-9091-8

Samaras, A. P., & Fox, R. K. (2013). Capturing the process of critical reflective teaching practices through e-portfolios. *Professional Development in Education, 39*(1), 23–41. https://doi.org/10.1080/19415257.2012.682318

Schiro, M. (2004). *Oral storytelling and mathematics*. *Pedagogical and multicultural perspectives*. Thousand Oaks, NJ: Sage Publications.

Schank, D. (1990). *Tell Me a Story: Narrative and Intelligence*. Evanston, IL: Northwestern University Press.

Stephan, M., Bowers, J., Cobb, P., & Gravemeijer, K. (2003). *Supporting one first-grade classroom's development of measuring conceptions: analyzing learning in social context*. Journal for Research in Mathematics Education Monograph, Reston, VA: NCTM.

Tally, B. & Goldenberg, L. B. (2005). Fostering historical thinking with digitized primary sources. *Journal of Research on Technology in Education, 38*(1), 1–21. https://doi.org/10.1080/15391523.2005.10782447

Tsai, C.C. & Chou, C. (2002). Diagnosing students' alternative conceptions in science. *Journal of Computer Assisted Learning, 18*, 157–165. https://doi.org/10.1046/j.0266-4909.2002.00223.x

Ugoretz, J., & Theilheimer, R. (2006). Making meaning from meaning making: Digital stories in teacher education and the liberal arts. In *Proceedings of Society for Information Technology and Teacher Education International Conference 2006*, ed. C. Crawford et al., 737–41. Chesapeake, VA: AACE.

Van Gils, F. (2005). *Potential applications of digital storytelling in education*. In 3rd Twente Student Conference on IT, University of Twente, Faculty of Electrical Engineering, Mathematics and Computer Science, Enschede, February 17–18.

Wheeldon, D. A. (2008). *Developing mathematical practices in a social context: An instructional sequence to support prospective elementary teachers' learning of fractions.* Unpublished doctoral thesis. University of Central Florida, Orlando.

Zazkis, R., Liljedahl, P., & Sinclair, N. (2009). Lesson plays: Planning teaching versus teaching planning. *For the Learning of Mathematics, 29*(1), 40-47.

Appendices

Content Knowledge Domain (CK)

The summary of a digital story with the title of "Levent's Pizza" as an example that can be examined under this heading as follows;

Teacher Seda taught about the volume of the cylinder in the classroom but Levent had difficulty understanding it. After the lesson was finished, Levent went to his teacher and said that he did not understand the subject. Teacher Seda suddenly asked if he liked pizza. Levent said that he liked the pizza very much and his teacher said that "let's talk again about this issue tomorrow" and left Levent. Levent didn't understand anything. When they came to the class the next day, Seda gave a pizza to everyone. Seda began to tell the volume of the cylinder by showing the pizzas. She stated that pizzas were actually cylinders and the volume of the cylinder could be found using the πr^2h formula. Seda wanted them to show the radius z and the height a. Then, when put in the formula, it became $\pi z^2a = \pi zza$ and indicated that it was read as *pizza*.

Technological Content Knowledge Domain (TCK)

The summary of the digital story having the title of "Country of Integers" is as follows:

Once upon a time, there was a country with the name of "Country of Integers". The inhabitants of this country live on a line called the number line. In addition, the inhabitants lived in two opposing groups in the form of positive integers and a group of negative integers. There was also a zero not feeling to be belonged to any of these groups. He lived at the middle of two groups, finding the middle way without interfering in any group. For this reason, he settled in the middle of the number line and lived in the middle of the positives and negatives. Negative integers were a group that never felt happiness, always felt unhappy and never smiled. On the other hand, positive integers were always smiling, loving living, liking nature and all living things and living with joy. All residents of this country wanted everyone to be happy. They began to do the necessary research. After many attempts, scientists discovered the "Great Bars". The number between these two bars was happy no matter what group it was and started to bear the characteristics of positive integers. As a result of the experiments, these bars only made sad people happy and helped the group of negatives to join the positive group. But for zero, the bars didn't work. Therefore, it was realized that the bars could not change the state of the zero's senseless state. From this day on, negative integers who were tired of being unhappy in this country became happy through entering these bars and had passed into the group of positives. There was no way for zero that could not change the state of insensitivity, and zero continued his life in this senseless way.

Technological Pedagogical Content Knowledge Domain (TPACK)

The summary of the digital story having the title of Ferhat and Şirin's digital story as follows:

Ferhat, who lives on the left hand side of the zero river in the land of integers and is a member of the tribe of negatives, falls in love with Şirin, a member of the tribe of positives who lives on the right hand side of the zero river. When these two lovers wants to meet up at the same time they would leave the house and at the same time they would come to the zero river because their house are in equal distance to the river, though in opposite directions of the zero river. Şirin and Ferhat, who meet each other on the opposite sides of the river many times, want to get together and be happy, but this is impossible. The tribe of the positives and the tribes of the negatives must remain on the opposite side of the river, and no one can cross the river. Şirin and Ferhat are now looking for ways to get together because they want to get together. According to them, love can eliminate the impossibilities. Saddened by this situation and trying to find a way, Ferhat consults a scholar from his own tribe. This scholar says that there is a way for Ferhat but this road is very difficult and nobody can afford it. However, he goes through the mountains of the high mountains and goes to the land of lovers and passes through the bars of the absolute value there. Ferhat, who hears these, begins to pierce the mountains for his love. Ferhat who hit mountains for days reaches the country of lovers. Finding absolute value bars, Ferhat learns that if he passes through these bars, he will not be able to get the minus again and will always have the added bonus of plus living in the tribe of positives. No one can prevent Ferhat, who learns this, and passes through these rods and obtains his feature of being positive. Afterwards, Ferhat goes to near Sirin in the tribe of positives. Thus, thanks to the absolute value bars, they live happily together in the tribe of positives forever on the right side of the river.

Technological Pedagogical Content Knowledge Domain (TPACK)

The summary of the digital story having the title of Peace Aerial Ropeway, for this type of knowledge level can be summarized as follows:

Once upon a time, there were two enemy cities. These two cities were positioned on two different mountains. The houses in the two towns were built along the road from the foot of the mountain to the top. People who lived in these cities known as the city of positives and negatives that hated those who lived in the other city. Because of the hostility of the two cities, there was no help and shopping between these cities. One day, the rivers of the city of positives were dried up and the city was left without water. In the city of negatives, so too many water was inefficient and the inhabitants could no longer grow wheat and the bread could not. The leaders of the two cities came together and decided to find a peaceful way to solve these problems between two cities. According to this decision, the positives would bring the bread to the city of negatives and the city of negatives would bring water to the other city. After discussing how to move bread and water, they decided to build an aerial ropeway connecting the cities. They placed this aerial ropeway at the junction point of two cities and called this point 0 (zero) point. They called the aerial ropeway as Peace Aerial ropeway because of combining two enemy cities. In the shopping between the two cities, the transport of water and bread to be taken from the houses would be done by a aerial ropeway. Only there were rules for this aerial ropeway to work. Water or bread wa taken from each house and these bread or water would be collected at the starting point of the lift and then distributed to the cities. So the aerial ropeway had to go back to zero every time. Ali Bey, who was very good at mathematical operations, especially in integers because of the machine running the aerial ropeway, was responsible, because the command and numbers related to which house the aerial ropeway would go to and the zero point would have to be mentioned in the machine. For example, when the aerial ropeway was going forward, plus the command plus and the minus command must be entered make the aerial ropeway move backward. Besides, what should be identified from which house? For example, for the water taken from the second-row house in the city of the negatives the command of -2, or for the bread from the third-row house in the city of positives, the +3 command must be defined on the machine to run the aerial ropeway. In his first job, Ali bought bread from the first house in the city of positives, and bought bread from the house next to the house in the first house. For this process, the machine specified the operation as 1 + 1. Then, he had to specify the result to bring the aerial ropeway back to zero. 1 + 1 = 2 as the process was completed and the aerial ropeway to zero point back to the storage of bread on the aerial ropeway.