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Digital Storytelling: Developing 21st Century Skills in Science Education

Gülden Gürsoy *

Adiyaman University, TURKEY

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Abstract: The present study aimed to provide a digital story development experience for pre-service science teachers in the “instructional technologies and material development” course and to determine the impact of these experiences on their views on digital storytelling. Simultaneous parallel design, one of the mixed methods in which both quantitative and qualitative data were collected, was used in the study. Quantitative and qualitative findings are presented in different sections and both were interpreted in the discussion section. The quantitative study data were collected from 50 pre-service teachers, while the qualitative data were collected from 16 pre-service teachers. Quantitative data were collected by a survey and the qualitative data were collected in interviews. Descriptive/inferential statistics were employed in the analysis of the survey data. The steps of the analysis, coding, and categorization were adopted in the study for qualitative data. The positive effect of digital storytelling on the 21st-century skills of pre-service teachers was revealed by both quantitative and qualitative data. Furthermore, it was determined that pre-service teachers considered digital storytelling as advantageous since it provided meaningful and permanent learning, was fun and motivational; however, it also had disadvantages since it was time-consuming and required technological knowledge. It was revealed that they experienced certain difficulties in scriptwriting, finding the related images/videos and photographs, and finalizing the recording, and they considered that most, if not all, topics in the science course were suitable for digital storytelling. For pre-service teachers to acquire 21st-century skills, digital storytelling should be employed in several courses including the teaching practice course, and pre-service teachers should gain experience in preparing the students for digital storytelling.

Keywords: *Digital storytelling, science education, 21st-century skills, instructional technologies.*

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Introduction

Storytelling is the art of narration of the experiences, traditions, or the culture of ancestors using language, vocalization, and gestures to simulate the scenes of an event (Chung, 2006). During storytelling, various characters, actions, interactions, and reactions (e.g., emotions), thoughts, desires, and intentions are portrayed based on different perspectives (Yürük, 2015). Storytelling is an inherent human attribute and is one of the oldest practices in social life, communication, and learning (Bratitsis & Ziannas, 2015). Storytelling is an educational method due to its capacity to prevent racial, religious, and lingual discrimination (Barret, 2005). The educational nature of storytelling allows the distribution of knowledge and understanding among individuals of different cultures (Wang & Zhan, 2010). Schank (1990) reported that storytelling is an effective instructional strategy that improves the learning performance and motivation of the students (Hung et al., 2012). Although storytelling was introduced as an instructional methodology and learning tool in early childhood education, it is also effective in all fields of higher education (Heo, 2009; Wang & Zhan, 2010). It has been used in the instruction of geometric shapes in the preschool period, and various educational topics such as dental clinic applications in higher education.

Due to technological advances, the art of storytelling has changed and acquired various forms (Castañeda, 2013) including digital. In late 1980, the digital format employed by community theater staff to record, produce and broadcast their stories was conceptualized as “digital storytelling (DS)” (Lambert, 2009) and has been used to facilitate learning and instruction in education (Xu et al., 2011). In the early 1990s, Dana Atchley was a pioneer who employed digital multimedia tools such as Apple QuickTime (Apple, 1991), Adobe Premiere (Adobe, 2003), and Macromedia Director (Adobe, 1988) to develop the idea of DS. Atchley also used photos, videos, music, etc. to create a more professional

* Correspondence:

Gülden Gürsoy, Adiyaman University, Mathematics and Science Education Department, Adiyaman, Turkey. ✉ gakdag@adiyaman.edu.tr



narrative. Dana Atchley employed multimedia devices with this software and founded the Center for DS in Berkeley, California (McLellan, 2007).

DS is based on the employment of computer-based tools to tell a story. Although it has been described by other definitions such as digital essays, digital documentaries, computer-based narrative, electronic memories, interactive storytelling, it is generally described based on the idea of combining the art of storytelling and a variety of multimedia elements, including graphics, sound, video, and web publishing (Daniels, 2013 Doğan & Robin, 2008). The multimodal nature of the DST educational technology thus has the potential to be used to create an authentic learning context for all students, regardless of their background (Chubko, 2020). Smeda et al. (2014) described DS as an innovative pedagogical approach that leads to deep and meaningful learning among students.

The fact that DS does not require a special environment for students to acquire 21st-century skills, its low cost and high instructional capacity increase the value of DS. The short learning curve and fast production of digital stories add value to the employment of DS as a gateway to multimedia-based education technologies that allow pre-service teachers to develop other personal technological attributes (Heo, 2009). Furthermore, DS could serve as a mirror that allows students to reflect on their characteristics, perspectives, imagination, and developmental processes. Barrett (2006) reported that there was a correlation between DS and e-portfolios (e-development files). According to Kearney (2009), digital stories could help strengthen the link between students' product experiences and reflection activities within the portfolio medium. DS helps students develop their identity, multitasking skills such as collaboration, peer feedback, and 21st-century skills, contributing to education by offering the students an opportunity to acquire these skills (Foley, 2013).

After the employment of DS in education, several studies have been conducted on learning or the contribution of DS to students and teachers of different education levels (Balaman, 2018; Baki & Feyzioğlu, 2017; Demirer & Baki, 2018; ; Göçen Kabaran et al., 2019; Haşlamam, 2017; Renda & Sprouse, 2010; Robin, 2008; Yang & Wu, 2012; Yoon, 2013).

Previous studies demonstrated that digital story development provided a strong foundation for the development of 21st-century literacy, or 21st-century skills. It was evidenced in previous studies that DS contributed to the development of digital, global, technological, visual, and knowledge literacy (Brown et al., 2005; Çetin, 2021), critical thinking and problem-solving skills (Chen & Chuang, 2020; Yang & Wu, 2012; McLellan & Wyatt, 2006), reflective thinking skills (Kim & Silver, 2016; Pieterse, 2018; Saritepeci, 2017), communication skills (Karakoyun & Kuzu, 2017; Mnisi, 2015; Al-Amri, 2020; Öztürk & Tunç Ayvaz, 2017), creativity and critical thinking (Anggeraini, 2020; Tabieh et al., 2021), research skills (Çiçek, 2018), and integration skills (Göçen Kabaran et al., 2019). DS has been globally popular as studies demonstrated that it contributed to the development of advanced skills. Countries such as Canada, the USA, New Zealand, the United Kingdom, Australia, and Austria employed DS for different purposes such as caring for community members, sharing experiences, and providing therapy, in addition to the inclusion of an entertaining factor in education (Yüksel, 2011).

It was determined that in addition to technological facilities, understanding the cognitive processes, communication, and interaction expectations of digital natives who were born and grew in a technological environment or 21st-century learners and providing the relevant instruction are required in education planning (Göksün Orhan & Kurt, 2017). The changes in learner roles and skills and the design of learning environments suitable for learner attributes have shaped teacher skills in the 21st-century. As learner skills would determine teacher skills, teacher skills would also improve learner skills. High teacher performance, in other words, the efforts of the teacher to design effective instruction processes, would motivate student learning and improve performance (Sanders & Rivers, 1996).

Pre-service teachers should learn DS for both the acquisition and instruction of 21st-century skills which in turn would improve their teaching performance. Development of DS by pre-service teachers would allow them to use technological tools, improve their content knowledge, and learn how to balance their use in pedagogy, and to meet the expectations of technological pedagogical content knowledge competence expected from future teachers. Development of DS in undergraduate courses in teacher training programs and recognition of its effects by the pre-service teachers will make it easier to train students with 21st-century skills in the future. Simsek (2020) reported that the use of digital stories should not be limited to one-off courses in teacher training programs, and efforts should be spent to ensure that all stakeholders adopt a technological approach throughout the program.

DS is an effective technological instruction tool, especially in science education. Enhanced classroom environments are required for students to acquire science literacy. Science teachers require higher communication technology skills and competencies such as using computers and related devices, software and hardware effectively and efficiently and conducting classroom management using technological tools to develop a rich course content (Sancar-Tokmak et al., 2014). In the present study, digital stories were developed by pre-service science teachers, and the study aimed to determine their views on this experience and the contributions of digital story development.

Methodology

Research Goal

The mixed-method where both quantitative and qualitative data were collected was used in the study. In the study, quantitative data were collected by a survey and qualitative data were collected in interviews. Since it was considered that the determination of the impact of digital storytelling on 21st-century skills of pre-service teachers only based on their responses to the questionnaire would not be sufficient for the validity and reliability of the study, interview data were utilized to deepen the findings on the impact of digital storytelling on the 21st century skills of the pre-service teachers.

Thus, the study aimed to achieve valid and reliable findings by combining qualitative and quantitative data (Creswell & Plano Clark, 2015) and to provide a larger view by providing a deep understanding of a phenomenon (Chen, cited by Johnson et al., 2007).

Based on the stages suggested by Creswell and Plano Clark (2015) in design selection, the simultaneous parallel design was preferred in the study since the correlation between quantitative and qualitative stages was independent, both quantitative and qualitative data were employed equally, the qualitative and quantitative stages were not successive, and the data were collected simultaneously and combined in the interpretation stage. Quantitative and qualitative findings are presented in different sections and both were interpreted in the discussion section. Simultaneous parallel design is presented in Figure 1

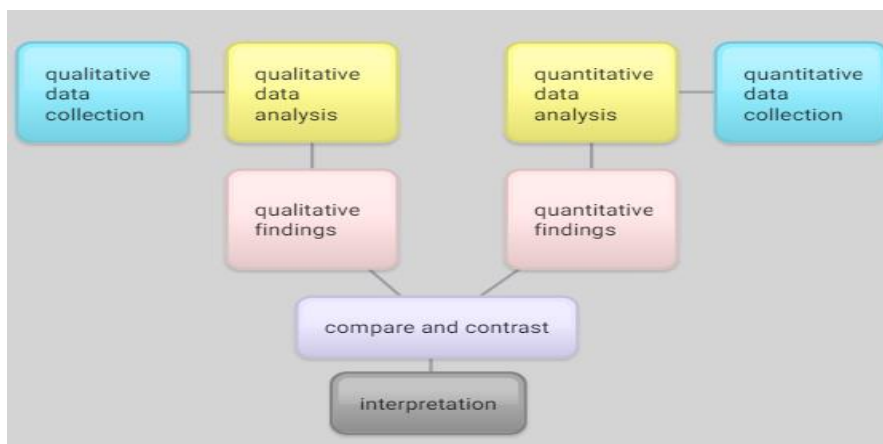


Figure 1. Simultaneous parallel design (Creswell & Plano Clark, 2015)

Sample and Data Collection

The study participants included 50 junior pre-service teachers (41 female and 9 male), attending Adiyaman University, Faculty of Education during the 2018-2019 academic year fall semester. The quantitative study data were collected from 50 pre-service teachers, while the qualitative data were collected from 16 pre-service teachers. Participants were assigned with the criterion sampling technique, a purposive sampling method. Selection criteria included attendance in information technologies I and II courses, the DS prep course, and commitment to developing at least two digital stories for the science course. Qualitative data were collected from 16 pre-service teachers (12 females and 4 males), whose achievement levels were different in DS to ensure diversity. Participants did not attend any training on instructional technologies previously. It was the first time that they encountered DS in the instructional technologies and material development course. Before they developed the digital stories, computer ownership among the pre-service teachers was determined. Pre-service teachers, who did not own a computer or did not have the opportunity to use a computer for an adequate time, were allowed to use the workstations available at the computer laboratory.

Data Collection Instruments

Since the study was conducted with the simultaneous parallel design mixed method, the sample was the same in quantitative and qualitative data collection, and to compare or interpret both quantitative and qualitative data, questions about the quantitative data collection tool dimensions were also included in the qualitative data collection tool. The quantitative data were collected with the "21st Century Skills Scale for Digital Storytelling" that was developed by Karakoyun (2014). The 90-item survey was reduced to 60 items based on the views of two field experts at the first stage. In the second stage, 15 faculty members analyzed the scale, and similar and overlapping items were removed and the survey form was reduced to 41 items. The 41-item, 5-point Likert type scale included the three sub-dimensions of learning and innovation skills, information, media and technology skills, and life and professional skills.

The qualitative study data were collected with the interview technique. The interview technique is the most powerful method to understand the perceptions, feelings, and thoughts of individuals, and it is the basic tool for qualitative data collection (Punch, 2014). An interview form that allowed comparison or interpretation of qualitative and quantitative data was developed by the author. The draft interview form included eight questions, and finalized as a 6-question form after the review by two expert educational instructors; one question was removed since it was not adequate for the aim of the study, and another question was excluded since the response overlapped with that of another question. The finalized interview form was applied to the pre-service teachers after their digital stories were presented.

Data Collection

The present study was conducted in the "Instructional Technologies and Material Design" course in the sixth semester of the Science Instruction Undergraduate Program. Based on the course outcomes, instructional technologies were introduced, examples of instructional technology techniques were demonstrated and applied. One of these techniques was "digital storytelling". The impact of DS on student or pre-service teacher achievements was reported in several studies in the literature. Thus, the time allocated for the instruction of DS was longer when compared to other techniques. The data collection process and period are presented in Table 1.

Table. 1 Data collection process and period

Period	Data collection process
The first week	The definition, components, elements, advantages, and disadvantages of DS and its pedagogical benefits were introduced to pre-service teachers within a discussion environment to ensure active participation of the students
The second week	The steps of DS were introduced and the content of the software that could be used in each step was discussed. Pre-service teachers were assigned to research the DS software. Then, good and bad digital story examples and their advantages and disadvantages were discussed by the author.
The third week	A DS topic was determined, a script was written, and the storyboard was developed with pre-service teachers. During the applied DS process, the experience and motivation of the pre-service teachers improved. After the instruction and implementation of the digital story, pre-service teachers were asked to develop two digital stories. The topic of one digital story developed by the pre-service teachers (among the science course outcomes) was assigned by the author, the topic of the second was determined by the students. The pre-service teachers were asked to write the script and design the storyboard within a week. The pre-service teachers were allowed one month to finalize the digital stories.
The fourth week	The pre-service teachers who selected the topic, written the script and the storyboard discussed their products with the author, and the latter provided ideas for improvement. During the remaining weeks, the DS software was instructed.
The Last Week	The pre-service teachers who completed digital stories presented these in the class. The reasons for the use of particular music, software, photographs, characters, etc. in digital stories were discussed. The pre-service teachers, who also received feedback from their peers, noted the sections they needed to revise before submitting their assignments. On the assignment deadline, they posted their stories on EDMODO and YOUTUBE. After the submission of the assignments, the pre-service teachers were interviewed and participated in the survey.

Data Analysis

In simultaneous parallel design mixed method, quantitative and qualitative data are collected simultaneously; however, data analysis is conducted separately. The qualitative data analysis reveals inferences for qualitative questions, while quantitative data analysis reveals inferences for quantitative questions. The inferences are then combined and quantitative and qualitative data could be synthesized to reach holistic inferences (Teddlie & Tashakkori, 2015). In the present study, descriptive/inferential statistics were employed in the analysis of the survey data. Items associated with the survey sub-dimensions were described separately and significant findings were interpreted.

Analysis of qualitative data is an important step in a study. The analysis, classification, and interpretation of the qualitative data may affect the study findings. The steps of the analysis, coding, and categorization were adopted in the study for qualitative data (Strauss & Corbin, 1990). The interview records were transcribed and read by the author several times to familiarize herself with the data. Then, the data were coded to determine repeated or important word-groups or concepts. Categories were determined by grouping similar codes and the study data were finalized.

Validity and Reliability

Data and methodological diversity were prioritized in the study to improve data validity. The shortcomings of one method were compensated with the other method. The internal validity of the study was improved by collecting the data with different data collection instruments. The study method was explained in detail. The detailed explanation of the rationale of the method, the application process, participants, and analysis techniques improved the transferability of the study findings and external validity. To improve the credibility of the study, data were diversified, reliability was calculated and comparisons with previous studies were conducted. Furthermore, the transferability of the study was improved with several examples of direct participant quotes. To ensure the confirmability of the study, questions serving the same purpose were conveyed to pre-service teachers both quantitatively and qualitatively, and the responses were collected separately but simultaneously and interpreted. Attention was paid to collect and record the data without prejudice, and expert opinions were obtained during data analysis for confirmability.

To improve the reliability of the study data, the interviews conducted with the pre-service teachers were recorded with a tape recorder and transcribed. The interview data were analyzed simultaneously by the author and an instructional technologies expert faculty member. After the codes and categories determined by the two coders were discussed, the agreement rate was calculated. The agreement rate was calculated with the formula developed by Miles and Huberman (2015) ($\text{Reliability} = \text{Agreement} / (\text{Agreement} + \text{Disagreement})$). The calculated agreement rate was 81%. Since it was above the lower limit determined by Miles and Huberman (2015), the scale was considered reliable.

Findings / Results

The quantitative and qualitative study findings based on the simultaneous parallel mixed design are presented under different sections. The quantitative findings are presented under sub-sections that reflected the survey sub-dimensions, and qualitative findings are presented based on the research questions.

*Qualitative Findings**Learning and Innovation Skills Findings*

Descriptive statistics for each "learning and innovation skills" sub-dimension item in the survey are presented in Table 2. The mean student scores for the survey items are listed in descending order.

Table 2. Descriptive statistics for each item in each "learning and innovation skills" sub-dimension

ITEM NO.	LEARNING AND INNOVATION SKILLS	\bar{X}	SD
LI6	It enabled me to consider the subject I chose as a whole.	4,38	0,78
LI2	It helped me form my thoughts using the information on the topic I chose (for example, when writing a script, creating a digital story).	4,28	0,57
LI7	It made me realize the details of the subject I chose.	4,28	0,67
LI5	It enabled me to learn new information on many subjects.	4,24	0,74
LI8	It enabled me to establish a relationship between the information I obtained from different sources (such as books, magazines, pictures, music, internet resources, etc.) on the subject I chose.	4,22	0,79
LI9	It enabled me to develop different perspectives on the subject I chose.	4,16	0,77
LI18	It helped me cooperate with my friends.	4,16	1,11
LI13	It allowed me to use new communication tools (computer, internet, smartphone, etc.).	4,12	1,22
LI19	It allowed me to use new communication tools (computer, internet, smartphone, etc.).	4,10	1,15
LI1	It enabled me to use my previous knowledge in creating new products (such as script, picture, video, digital story, etc.) related to the subject I chose.	4,06	0,87
LI3	It allowed me to follow current issues and innovations.	4,06	1,02
LI17	It helped me to improve my writing skills (for example writing scripts, creating storyboards).	4,06	0,93
LI10	It enabled me to come up with solutions for the problems I encountered (for example; when creating a scenario, using technological tools, while dubbing).	4,04	1,14
LI12	It enabled me to exchange ideas on the subject I researched with my friends.	4,02	1,13
LI4	It increased my desire to research new topics.	3,98	1,10
LI11	It enabled me to evaluate my friends' thoughts (for example, when giving feedback to scripts).	3,98	0,98
LI15	It allowed me to express my thoughts clearly on the topic I chose (for example; when writing a script).	3,94	0,93
LI16	It helped me to improve my reading skills (for example; reading information sources, reading scripts).	3,94	1,00
LI20	It helped me use my voice more accurately (eg voice acting).	3,88	1,04
LI14	It allowed me to get to know different cultures (for example; stories introducing different lives and cultures).	3,44	1,18

As seen in Table 2, the mean score for each item associated with learning and innovation skills was above 3. It was determined that most pre-service teachers stated that DS contributed to learning and innovation skills.

The pre-service teachers mostly agreed with the statement, "it allowed me to approach the topic from a holistic perspective." This statement was followed by the "it assisted me to form my views using the knowledge on the selected topic," and "it made me realize the details of the selected topic" statements with similar frequencies. The efforts of the pre-service teachers to find various materials such as images, videos, or cartoons associated with their topic when writing the script and drawing the storyboard may have contributed to their holistic approach to the topic. Furthermore, the efforts of pre-service teachers to produce an original script and story allowed them to reflect their ideas. The requirement of in-depth research about the topic when writing a script may have contributed to the topical knowledge levels and awareness of the pre-service teachers.

Few pre-service teachers agreed with the statement, "it allowed me to learn about different cultures (e.g., stories that introduced different lives and cultures)." Since the pre-service teachers developed digital stories for the science course, they might not have reflected events associated with their culture or lives.

Information, Media and Technology Skills Findings

Descriptive statistics for each item in the "information, media, and technology skills" sub-dimension of the survey are presented in Table 3. The mean student scores for the survey items are listed in descending order in Table 3.

Table 3. Descriptive statistics for each item in the "information, media and technology skills" sub-dimension

Item No.	Information, Media, and Technology Skills	\bar{x}	SD
IMT5	It allowed me to associate different multimedia elements (such as pictures, photographs, graphics, videos, voiceovers, music, written text, etc.) with each other.	4,38	0,78
IMT6	It helped me organize my new knowledge using technological resources (such as WeVideo, Microsoft word, storyboard, etc.).	4,30	0,81
IMT1	It enabled me to gather information from more than one source (such as books, magazines, pictures, video internet resources, etc.) on the subject I chose.	4,26	0,96
ITM8	It enabled me to use technological tools (such as a computer, voice recorder, camera, smartphone, etc.) effectively.	4,20	1,12
IMT4	It enabled me to use information resources (such as books, magazines, pictures, videos, internet resources, etc.) related to the subject I chose.	4,18	0,80
IMT2	It enabled me to decide whether it was correct by comparing the information I collected on the subject I chose.	4,10	0,84
IMT3	It enabled me to decide which sources of information I should use while creating products (scenarios, pictures, videos, digital stories, etc.) related to the subject I chose.	4,10	0,76
ITM9	It helped me present better.	3,88	0,98
ITM7	It allowed me to share my information or thoughts on social networks (such as youtube, Facebook, Twitter, Flickr, etc.).	3,80	1,05
ITM10	It allowed me to use Internet resources and programs (such as WeVideo, youtube, etc.) for free.	3,64	1,29

As seen in Table 3, the mean score for each item associated with information, media, and technology skills was above 3. It was determined that most pre-service teachers stated that DS contributed to information, media, and technology skills.

The majority of the pre-service teachers agreed with the statement "it allowed me to associate various multimedia elements (e.g., images, photographs, graphics, videos, voiceover, music, manuscripts, etc.). Pre-service teachers presented several demos to improve their stories and presented the final product to an audience of their classmates. After the pre-service teachers found the cartoons and photographs adequate for their script, they spent significant efforts and created demos until they found the right sound and music that complemented the desired emotion with the cartoons and photographs. They continued to shoot demos until they achieved unity among the multimedia elements. Pre-service teachers realized the requirement of the association of various multimedia elements during the development of digital stories.

Only a few pre-service teachers agreed with the statement "it allowed me to use free Internet resources and software (e.g., WeVideo, YouTube, etc.)." Pre-service teachers either did not prefer to use these resources when they developed digital stories or they already used these programs in their daily lives.

Life and Professional Skills Findings

Descriptive statistics for each item in the "life and professional skills" sub-dimension of the survey are presented in Table 4. The mean student scores for the survey items are listed in descending order in Table 4.

Table 4. Descriptive statistics for each item in the "life and professional skills" sub-dimension

ITEM NO.	LIFE AND PROFESSIONAL SKILLS	\bar{X}	SD
LP1	Helped me adapt to different tasks (e.g. writing scripts, voiceovers, storyboards)	4,32	0,94
LP5	It enabled me to be active in the activities (for example, while researching a topic, creating a scenario).	4,28	0,81
LP8	It helped me decide which of the tasks I should do first and which next.	4,24	0,80
LP9	It enabled me to take responsibility while doing a task (for example, when doing research, creating a script).	4,24	0,89
LP10	It helped me connect with real-life (for example; the contents of digital stories).	4,22	0,91
LP7	It allowed me to make plans.	4,16	0,79
LP2	It made me respect the opinions of others (for example, when giving feedback about the script).	4,12	0,98
LP6	It helped me clearly articulate my goals (for example; when creating a script).	4,02	1,02
LP3	It helped me plan the time.	4,02	1,00

As seen in Table 4, the mean score for each item associated with life and professional skills was above 4. It was determined that most pre-service teachers stated that DS contributed to the life and professional skills.

The majority of the pre-service teachers agreed with the statement "it helped me adapt to various tasks (e.g., writing scripts, voiceovers, storyboards)." Pre-service teachers who developed personal digital stories took this responsibility alone throughout the process and they did not share any task. They wrote the study script, selected music, or vocalized the text, and edited the sequences to create the final product when necessary. They learned to complete all the tasks along the way.

Only a few pre-service teachers agreed with the statement "it helped me plan my time," when compared to other statements. This could be due to the distant due date assigned by the author.

Qualitative Findings

The data collected with the interviews conducted with pre-service teachers were grouped into six themes. These themes included the problems that pre-service teachers experienced in the DS process, the contributions of DS, its advantages and disadvantages, its suitability for science learning areas, and the software they employed in storytelling. The themes are presented in Figure 2.

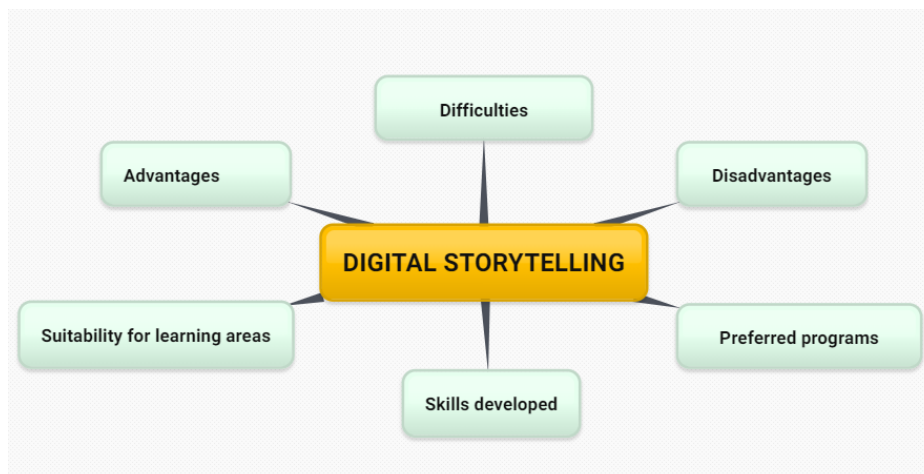


Figure 2. The themes determined by pre-service teacher views on DS

Findings on the Problems Experienced in DS Process

The problems experienced by pre-service teachers during the development of digital stories were scrutinized under three categories. The related categories, codes, and direct quotes are presented in Table 5.

Table 5. The Problems Experienced in DS Development

Category	Code	f	Sample Sentences
Scriptwriting	Insufficient field knowledge	6	"I had difficulties in the scriptwriting stage because my field knowledge was not sufficient."
	Inability to plan text content	4	"I could not list the beginning, middle, and end of the story."
	Inability to narrate text	3	"I couldn't tell the subject in story language."
	Inability to maintain fluency	3	"I could not achieve fluency between dialogs while converting the text into the script."
Finding the related images-videos	Writing a script but not being able to find a picture	10	"First I wrote the script, but I couldn't find any pictures that fit my mind. I searched for a lot. I shaped the things in my mind by adding cartoons. "
	Finding a picture but not being able to write a script	6	"I said it would be easier if I write a script on the pictures I have, but it didn't work as I wanted."
Finalizing the recording	Inability to adjust sound-photo transition	7	"My voiceovers in photo transitions sometimes ended early, sometimes didn't catch up. Adjusting it forced me. "
	Inability to adjust the tone of voice according to the character	5	"I had a hard time in the proper tone of voice. Sometimes I had to turn my voice into four different people's voices. "
	Pricy software	4	"Some programs were priced, which prevented my creativity."

As seen in Table 5, it was determined that pre-service teachers experienced three types of difficulties during the DS process. The pre-service teachers experienced problems when writing the script, finding an image or a video, and finalizing the recording.

When writing the script, the fact that pre-service teachers did not have in-depth knowledge of the science course content prevented them to write the script easily. The pre-service teachers also experienced problems in planning the script content, storifying the text, and fluency. The pre-service teacher T1 stated, "I experienced difficulties in writing the script because my content knowledge was not adequate."

When finding the related images-videos, the pre-service teachers experienced difficulties to find an image-photo to enhance the script or to write a script based on the image-photo they could find during the development of digital stories. Pre-service teachers conducted significant research to find the visuals they imagined for the script. Pre-service teacher T3 stated, "First, I wrote the script, but I could not find images that I imagined. I searched for a lot. I had to add cartoons to the images." The pre-service teachers, who could not find the images they needed, tried to create the visuals with Web 2.0 tools.

When finalizing the recording, the pre-service teachers experienced difficulties in sound-image transitions. They also could not find an adequate voice for their characters and could not record the story since the free versions of the software did not allow recording. Pre-service teacher T5 stated, "The voiceover sometimes started early or late during transitions. It was difficult to adjust it." Pre-service teacher T7 stressed, "I experienced difficulty to find a suitable intonation for the character. Sometimes I had to transform my voice into those of four people." Adjusting the timeline, the moment the voiceover starts, the tone, or the timing of the transition between the stories are important factors that affect the story quality.

Findings on the Skills that DS Developed

The views of the pre-service teachers on the skills they acquired during the development of preparing digital stories were grouped under three categories. The categories, codes, and direct quotes associated with these codes are presented in Table 6.

Table 6. The Views on the Skills Developed by DS

Category	Code	f	Sample Sentences
Learning and Innovation Skills	Writing skill	14	"I wrote and deleted a lot while writing scripts for my demos. Then I noticed that my deletion count decreased. "
	Research skill	12	"Painting-video, music, preparing cartoons, etc. I did a lot of research, now I know better how to find what I'm looking for. "
	Problem Solving Skills	7	"I found how to solve problems while using programs, writing scripts, using technology, and I was able to create a product."
	Creative thinking skills	4	"As I had problems in using the program, in the scenario, in technology, I figured out how to solve it, and I was able to create a product."
Information, Media, and Technology Skills	Technology use skill	16	"I listened and learned even the programs I did not know on Youtube to do different things. I loved the technology. "
	Ability to integrate	8	"I cut the videos. I added dialogue to the pictures. I did the characters. I realized the transitions, the sounds, the color-ground relationship, how they should all be completed. "
Life and Professional Skills	Take responsibility	10	"I was able to do my demos and homework alone without a group. When I was alone, I had to do everything myself. "
	Critical thinking skills	4	"We shared our stories with our friends. Everyone gave each other feedback. We started to look at the products with a critical look. "
	Planning skills	3	"We had a month. We had to plan very well. I did that too. "

As seen in Table 6, the views of the pre-service teachers on the skills acquired during the development of digital stories were grouped into three categories: learning and innovation skills, information, media and technology skills, and life and professional skills.

In the category of learning and innovation skills, pre-service teachers stated that the most significant skill they acquired during the development of digital stories was the writing skill. This was followed by research skills, problem-solving skills, and creative-thinking skills, respectively. Pre-service teacher T5 stated, "When I was preparing images-video, music, and cartoons, etc., I did a lot of research, now I know better how to find what I am looking for." As seen in the other direct quotes presented in Table 5, pre-service teachers had to write scripts for their demos several times, and in the process, they conducted significant research to find adequate images and videos for their scripts, learned how to solve problems, and produced new things to add original elements when necessary.

In the category of information, media, and technology skills, pre-service teachers stated that the most significant skill they acquired during the development of digital stories was technology use skill. This was followed by the skill to take responsibility. Pre-service teacher T12 stated, "I cut the videos. I added dialogue to the images. I created characters. I organized the transitions, the sounds, the color-background relationship, and realized how to complete these," representing all related codes. Pre-service teachers' use of completely different technological products in all tasks such as cutting videos, adding dialogue, adjusting sound, adding music, and integrating these tasks may have contributed to their development of technology use and integration skills.

In the life and professional skills category, pre-service teachers stated that the most significant skill they acquired during the development of digital stories was to take responsibility. This was followed by critical thinking skills and planning skills, respectively. Pre-service teacher T8 stated, "I could develop my demos and assignments alone without a group. Since I was alone, I had to do everything myself." The fact that the students developed both digital story demos and the final product for the assignment personally improved their ability to take responsibility. Furthermore, everyone provided feedback on everyone else's story, allowing the acquisition of a critical perspective. In particular, the fact that they had to plan for accurate management of the process may have improved their planning skills as well.

Findings on the Advantages and Disadvantages of DS

The views of the pre-service teachers on the advantages and disadvantages of DS proves were grouped under several codes. The codes and direct quotes associated with these codes are presented in Table 7.

Table 7. Advantages and Disadvantages of DS

Category	Code	f	Sample Sentences
Advantages	Permanent learning	14	"It will make it easier for students to learn and it will be more permanent because they learn meaningfully."
	Meaningful learning	10	"I think students will learn the subjects better thanks to many different elements such as music, painting, and expression."
	Entertaining	9	"The more tired I was while making my story, the more fun I had. It is very nice both to prepare and to be used for training purposes."
	Significant	7	"It drew my attention from the first moment our teacher explained it. Even my brothers at home started to wonder."
	Motivational	7	"I was happy as the pieces of the stories fit into place. Even if I finished, I was striving for the better. Even my interest in the lecture increased."
	Facilitating the transfer to daily life	6	"While both the friends in the class and I were determining our story topics, we wrote scripts by considering the reflection of that subject in daily life."
	Providing opportunities for learners of various learning styles	5	"I think the best part of DS is that it appeals to our five senses and can attract everyone's attention and teach something."
Disadvantages	Time-consuming	16	"Digital story demos took a lot of time when we considered our main homework. When I become a teacher I can only prepare a few each year; because it takes a lot of time."
	Technological requirements	14	"In this process, I used a lot of technology tools, cut videos, prepared cartoons, created dialogue, played on pictures. Learning all of these scares you, it makes you feel like you can't do it."

As seen in Table 7, the codes associated with the advantages of DS were more than the codes associated with the disadvantages. The fact that its advantages were more when compared to the disadvantages demonstrated that it should be employed in instruction. Furthermore, both cognitive and affective contributions of the advantages of DS contribute to the significance of DS.

In the advantages category, pre-service teachers stated that the most significant contribution of the employment of digital stories in the classroom or development of digital stories was permanent learning. They stated that also, it contributed to meaningful learning among students. In the affective dimension, pre-service teachers emphasized that DS was fun, significant, and motivating, respectively. Pre-service teacher T4 stated, "I had as much fun as I was tired while writing my story. It was very nice both to develop and use it in education." The fact that the pre-service teachers considered DS fun would also contribute to their attitudes towards DS during their service in the future.

The pre-service teachers stated that DS contributed to the transfer of scientific topics to daily life and facilitated the learning of students with various learning styles. Pre-service teacher T12 stated, "I think the best part of DS was that it appealed to five senses and it could be interesting for all and teach something." The fact that the DS method contributed to the learning of all students with different learning styles could increase the significance and value of DS.

In the disadvantages category, the majority of pre-service teachers stated that DS was both time-consuming and it required significant technical knowledge. Pre-service teacher T16 stated, "I used several technology tools in this process, cut videos, drew cartoons, wrote dialogues, played with images. Learning all these made you worry that you could not." The requirement of significant knowledge of DS technologies could be perceived as a significant disadvantage. It would be difficult to motivate teachers without interest, knowledge, and a positive attitude towards technology to employ DS.

Findings on DS Development Applications

The most preferred applications by pre-service teachers during the development of DS were grouped under two categories. The categories, codes, and direct quotes associated with these codes are presented in Table 8.

Table 8. DS Applications

Category	Code	f	Sample Sentences
Third-party software	Photostory 3	10	"We all used this program because it is the easiest to download and use."
	Microsoft iMovie	7	"I used it to shorten videos. I preferred it because it's easy."
	Tondoo	16	"It was a program we learned in class to create cartoons; we've all used it."
Web 2.0	Pixton	6	"I used it to create funny cartoons."
	Powtoon	6	"We made great use of Powtoon to make a difference."
	Comic Life	3	"I loved comic life. It was fun to use."

As seen in Table 8, the pre-service teachers employed both third-party software and Web 2.0 tools. In the third-party software category, it was determined that pre-service teachers mostly employed Microsoft Photostory 3 software, which was instructed in the course. The reasons for this preference were stated by the pre-service teacher T1 as, "We all used this software because it was the easiest to download and use.". In the Web 2.0 category, it was determined that pre-service teachers mostly employed Toondoo software. Pre-service teacher T6 stated the following reasons for using Toondoo: "It was a cartoon software we learned in the course and we all used it." The pre-service teachers also employed other Web 2.0 applications presented in Table 8 besides the software they learned in the course.

Findings on the Adequacy of DS for Science Course Topics

The views of the pre-service teachers on the adequacy of DS for science course topics were grouped into three categories. The categories, codes, and direct quotes associated with these codes are presented in Table 9.

Table 9. The Views on the Adequacy of DS for Science Course Topics

Category	Code	f	Sample Sentences
Earth and Universe	Our planets	12	"There was a lot of DS about planets on the internet. Since it is an abstract subject, its preparation can be much more remarkable. "
	Natural disasters	8	
	Seasonal events	4	
Living Creatures and Life	Humans and Environment	14	"I think biology topics are very suitable for digital narration. Because it is the area with the most transfer to daily life. These topics can be handled very well in the stories. "
	Systems in Our Body and Health	7	
	Energy Conversions and Environmental Science	4	
	Matter and its Nature	3	
	Matter and Industry	3	"Substance and industry issue, factories, etc. I think it can be told with storytelling to raise awareness. "

As seen in Table 9, the pre-service teachers stated that DS was only suitable for three learning areas in the science course. They did not claim that every topic in the learning areas was suitable for DS. When asked to develop a digital story on a topic of their choice, pre-service teachers researched which topic would better suit them. This research may have provided an idea about suitable topics for DS.

In the Earth and Universe category, the pre-service teachers stated that the "our planets" unit was most adequate for DS. This topic was followed by "natural disasters" and "seasonal events" topics. Pre-service teacher T9 stated, "there were several digital stories about the planets on the internet. Since these are abstract topics, the development of digital stories could be more significant."

In the living creatures and life category, the pre-service teachers stated that the "humans and environment" unit was most suitable for DS. This was followed by "Systems in Our Body and Health," "Energy Conversion and Environmental Science" topics, respectively. Pre-service teacher T1 stated, "I think biology topics are very suitable for DS. Because it is an area that could be easily adapted to daily life. These topics could be addressed very well in stories."

In the category of matter and its nature, the pre-service teachers stated that only one topic would be suitable for DS. Pre-service teacher T17 stated, "the topic of matter and industry, factories, etc., I think, could be instructed with storytelling to raise awareness."

Discussion

Based on the views of the pre-service teachers, the impact of digital story development on the instruction of 21st-century skills was determined in the study. The views of the pre-service teachers were collected with quantitative and qualitative methods using the "21st Century Skills Scale for DS" and an interview form developed by the author. The

analysis of the scale data demonstrated that the mean “learning and innovation skills” score was above 3, indicating that developing digital stories improved the pre-service teachers’ learning and innovation skills. Similar findings were obtained in the interviews conducted with pre-service teachers. It was determined that the writing skills of pre-service teachers improved due to writing scripts for digital stories, research, and creative thinking skills were improved due to the research they conducted to discover various things, and problem-solving skills were improved due to solving the problems during the digital story development stages. In an empirical study conducted with interviews, Chen and Chuang (2020) revealed that the digital story game encouraged students to improve their critical and problem-solving skills, and media literacy.

Doğan and Robin (2008), in one of the studies with similar findings, aimed to determine whether primary and high school teachers integrated DS in their classes after the digital narration seminars and the difficulties they encountered in the process. The study findings demonstrated that certain teachers did not implement it in the classroom due to lack of time, and those who implemented DS stated that it improved the technical, presentation, research, organization, and writing skills of the students. In a study conducted by Demirer and Baki (2018) to determine the views and perceptions of Turkish language teachers on DS, it was reported that DS contributed to the development of writing and technical skills based on their views. In an empirical study, Baki and Feyzioğlu (2017) concluded that DS improved the story writing skills of the students better than the current curriculum. Balaman (2018) reported that DS improved students’ writing skills; however, the application should not be product-oriented but should focus on writing skills.

The fact that the mean “information, media, and technology skills” score was above 3 indicated that the development of digital stories improved the information, media, and innovation skills of the pre-service teachers. The interview data were also consistent with this finding. Since they had to use and learn several technological tools when they developed digital stories, it was determined that the pre-service teachers’ technology use skills improved, and their integration skills improved since they had to plan the picture-video-sound-music components with a holistic approach. Previous studies reported similar conclusions (Michalski, Hodges & Banister, 2005; Renda & Sprouse, 2010; Robin, 2008). Renda and Sprouse (2010), in a study that aimed to improve the technical skills of primary school teachers with the DS approach, asked 17 pre-service science teachers to develop digital stories and concluded that the technical skills of the teachers improved. Göçen Kabaran et al. (2019) reported similar findings in a study that aimed to develop integration skills. The study revealed that according to the teachers, the DS approach was most beneficial in planning the stories, creating images, and integrating material associated with the story.

The fact that the mean “life and professional skills” score was above 4 indicated that according to the pre-service teachers, digital story development improved their life and professional skills the most when compared to other skills. The analysis of the qualitative data revealed that the life and professional skills of the pre-service teachers improved. It was determined that pre-service teachers’ ability to take responsibility improved since they developed the digital stories individually, allowing them to tackle all problems alone. Furthermore, it was determined that according to the pre-service teachers, their critical thinking skills improved due to the peer analysis and evaluation of the stories. It was also found in the study that planning skills, one of the life and professional skills, of the pre-service teachers improved in DS. Haşlamam (2017) reported similar findings. In a study on the potential of DS to support self-regulation, it was determined that pre-service teachers’ self-regulation, goal setting, planning, task strategy, self-observation, strategy change, self-assessment, satisfaction, and future inferencing skills were improved. Yang and Wu (2012) revealed in an empirical study that DS improved the academic achievements, critical thinking skills, and learning motivation of senior high school students.

The fact that the mean pre-service teacher score in the survey was above 3 revealed that according to the views of the pre-service teachers, DS developed the 21st-century skills. The advocates of DS argue that the DS leads to the acquisition of 18 out of 20 21st century skills (Dalim et al., 2019; Ekmekçi, 2016; Kocaman Karoğlu, 2015; Jakes, 2006; Niemi et al., 2014; Seçkin Kapucu & Yurtseven Avci, 2020).

It was determined in the study that the pre-service teachers experienced three types of difficulties during the development of digital stories (scriptwriting, image-video development, and finalizing the recording). During the scriptwriting stage, pre-service teachers experienced difficulties such as lack of content knowledge, inability to plan the manuscript, lack of fluent writing skills, and storifying the text, and they could not find images suitable for their scripts, or could not write an adequate script for the images they found in the image-video stage. It was determined that pre-service teachers experienced difficulties in sound-image transitions, findings adequate voiceover tone for the characters, and due to the software prices in the recording finalization stage. Previous studies reported that pre-service teachers had difficulties during the scriptwriting phase (Anılan et al., 2018; Çetin, 2021; Mirza, 2020; Sancar-Tokmak et al., 2014). A pre-service teacher with adequate content knowledge would know how to write an introduction, how to draw attention, how to deepen the subject, and how to end the story. Furthermore, pre-service teachers with content knowledge know which sections the students would like more, know how to narrate a story, and how to focus student interest in the story. It could be suggested that the lack of content knowledge also indirectly affected the ability of the pre-service teachers to plan the script content, to narrate the story, and to ensure the fluency of the text in the introduction-development-conclusion sections. It could be suggested that the lack of content knowledge was one of the factors that prevented the originality, creativity, and attractiveness of the scripts of the pre-service teachers. Dreyer

(2017) argued that pedagogical knowledge alone was not sufficient to prepare teachers to offer meaningful learning. In the digital age, pre-service teachers should include the DS method in their pedagogical technology repertoire.

The views of the pre-service teachers on the advantages and disadvantages of DS after they developed a digital story were determined in the study. The pre-service teachers mostly considered the advantages of DS since it led to meaningful and permanent cognitive learning and allowed students with different learning styles to learn, it was fun, motivating and attractive in the affective dimension, and facilitated the adoption to daily life in the psychomotor skills dimension. Anılan et al. (2018) reported that according to the pre-service teachers, adding components such as sound, music, animations, and images to their stories, provided more impressive and permanent learning, unlike conventional stories. Özüdoğru and Çakır (2020) stated in their study that DS was perceived as entertaining by pre-service teachers. In an experimental study, Ahmad & Yamat (2020) reported that the learning attitudes of the students changed since they considered Ds fun and interesting.

Furthermore, it was determined in the study that according to the pre-service teachers, the disadvantages of DS included the time required to develop digital stories and the technological knowledge requirements. Yiğit (2020) stated that social studies pre-service teachers encountered various challenges like copyright issues, time constraints, teamwork problems, and technological incompetence, etc. In the post-industrial information society, students who live in a technology-driven information age are expected to easily adopt DS; however, the limitations they would experience include mainly the lack of technological facilities (Dreyer, 2017).

The review of the applications employed by the pre-service teachers during the development of digital stories demonstrated that the pre-service teachers employed both third-party software (Photostory 3, Microsoft I-move) and Web 2.0 tools (Toondoo, Pixton, Comic Life, Pawtoon). The facts that the interfaces of the software used by the pre-service teachers in DS were clear, easy and the software were free were the reasons for preference. Chung (2006) reported similar findings in a study conducted with teachers and pre-service teachers. In the study, digital stories were developed in the visual arts course, and it was determined that pre-service teachers and teachers preferred Photostory 3 software, which was suitable and free for beginners. Robin and Mcneil (2012) attributed the widespread use of the Photostory 3 software by the students despite several limitations to its ease of use and the fact that it was free. Other preference factors included content copying, transfer, and association capacities of the Web 2.0 tools, which offer an ideal platform for DS and are free of charge (Alexander, 2008). It is expected that students, teachers, or pre-service teachers who would develop a digital story for the first time to work with applications with easy interfaces. In cases where multi-component media are required, the difficulty of the software could cause negative attitudes and experiences for individuals. This would make it difficult to achieve the goal and education. Experienced individuals could be guided to work with more difficult software.

It was determined that certain topics in humans and environment, world and universe learning areas, and only matter and industry topic in the learning matter and its nature learning area were suitable for DS. It was not determined in the study that why teachers considered these topics more suitable for DS. Yılmaz and Sigirtmaç (2020) evaluated DS as a material that can be integrated into different science content areas such as Earth and space science, physics, the science of life, history, and the nature of science.

Conclusion

The present study aimed the pre-service science teachers to acquire digital story development experiences in the “instructional technologies and material development” course and to determine the impact of these experiences on their views on DS. After the instruction of the DS content in detail to the pre-service teachers, they were individually asked to develop two digital stories. In the first task, all pre-service teachers were asked to develop a digital story on the same topic, while in the second task, pre-service teachers were asked to develop a digital story on a science course topic of their choice. The first task aimed to determine the creativity of pre-service teachers, and the second task aimed to determine the science course topics that were suitable for DS. Pre-service teachers independently selected the topic and software.

The effect of DS on 21st-century skills of pre-service teachers was revealed by both quantitative and qualitative data. DS developed the 21st-century skills (Learning and innovation skills, information, media and technology skills, life, and professional skills). Furthermore, it was determined in the study that pre-service teachers see DS as advantageous because DS provides meaningful and permanent learning, fun, and motivation, but disadvantaged because it takes a lot of time and requires multiple technological information. It was revealed that they had some difficulties in scriptwriting, finding the related images-videos and photographs, and finalizing the recording. The review of the applications employed by the pre-service teachers during the development of digital stories demonstrated that the pre-service teachers employed both third-party software and Web 2.0 tools. When the pre-service teachers were asked which science course topics were suitable for DS, it was determined that according to the pre-service teachers, every science topic was not suitable for DS.

Recommendations

The fact that DS alone could lead to the acquisition of the majority of 21st-century skills increase the significance and indispensability of DS. The theoretical and practical training of pre-service teachers in these learning and instruction tools would help them gain experience and adopt a more positive attitude since they could experience the effects individually. The positive views of the pre-service teachers on the effects and advantages of DS gave hope that they would employ DS in the future as teachers. DS is an adequate method to develop in all undergraduate program courses. Thus, developing digital stories in various courses would allow pre-service teachers to reinforce their knowledge and make it easier for them to implement the parts that seem difficult at first. Acquisition of the required technical skills to develop digital stories in the information technologies course, which is mandatory in all undergraduate programs, and improvement of the pedagogical content knowledge of pre-service teachers on DS in further educational courses, allowing them to employ DS in applications such as PowerPoint presentations in applied courses, would ensure their employment of DS in the future.

The effects of digital storytelling have been and are studied for a long time. There still could be certain effects of digital storytelling that have not been determined in the literature. The other effects of digital storytelling on users could be investigated in future studies. Also, the factors that could reduce the impact of digital storytelling and possible prevention methods could be determined in future studies.

Limitations

In the present study, the effects of DS on 21st-century skills were limited to the responses of the pre-service teachers to the questionnaire and interview forms. The effects of DS on 21st-century skills could be more clearly demonstrated with the observation technique.

References

- Ahmad, W. I. W., & Yamat, H. (2020). Students' perception on learning English language through conventional and digital storytelling. *International Journal of Academic Research in Business and Social Sciences*, 10(2), 484–504. <https://doi.org/10.6007/IJARBS/v10-i2/6945>
- Al-Amri, H. M. (2020). Digital storytelling as a communicative language teaching based method in EFL classrooms. *Arab World English Journal*, 11(1), 270-281. <https://doi.org/10.24093/awej/vol11no1.20>
- Alexander, B. (2011). *The new digital storytelling: Creating narratives with new media*. Praeger.
- Anggeraini, Y. (2020). An Investigation of the students' opinion on the use of digital storytelling in learning English. *ELT-Lectura*, 7(1), 47-51. <https://doi.org/10.31849/elt-lectura.v7i1.3645>
- Anılan, B., Berber, A., & Anılan, H. (2018). The digital storytelling adventures of the teacher candidates. *Turkish Online Journal of Qualitative Inquiry*, 9(3), 262-287. <https://doi.org/10.17569/tojqi.426308>
- Baki, Y., & Feyzioğlu, N. (2017). Dijital öykülerin 6. sınıf öğrencilerinin öykü yazma becerilerine etkisi [The effects of digital stories on the writing skills of 6th grade students]. *International Online Journal of Educational Sciences*, 9(3), 686-704. <https://doi.org/10.15345/iojes.2017.03.009>
- Balaman, S. (2018). Digital storytelling: A multimodal narrative writing genre. *Journal of Language and Linguistic Studies*, 14(3), 202-212.
- Barrett, H. (2005). Storytelling in higher education: A theory of reflection on practice to support deep learning. In C. Crawford, R. Carlsen, I. Gibson, K. McFerrin, J. Price, R. Weber & D. Willis (Eds.), *Proceedings of SITE 2005-Society for Information Technology & Teacher Education International Conference* (pp. 1878-1883). Association for the Advancement of Computing in Education (AACE).
- Barrett, H. (2006). *Digital stories in ePortfolios: Multiple purposes and tools*. Digital Storytelling. <http://electronicportfolios.com/digistory/index.html>
- Bratitsis, T., & Ziannas, P. (2015). From early childhood to special education: Interactive digital storytelling as a coaching approach for fostering social empathy. *Procedia Computer Science*, 67, 231–240. <https://doi.org/10.1016/j.procs.2015.09.267>
- Brown, J., Bryan, J., & Brown, T. (2005). Twenty-first century literacy and technology in k-8 classrooms. *Innovate: Journal of Online Education*, 1(3), 1-5.
- Castaneda, M. E. (2013). Digital storytelling: Building 21st century literacy in the foreign language classroom. *The Northeast conference on the teaching of foreign languages review (NECTFL Review)*, 71, 55–65. Salisbury University
- Çetin, E. (2021). Digital storytelling in teacher education and its effect on the digital literacy of pre-service teachers. *Thinking Skills and Creativity*. Advance online publication. <https://doi.org/10.1016/j.tsc.2020.100760>

- Chen, H. L., & Chuang, Y. C. (2020). The effects of digital storytelling games on high school students' critical thinking skills. *Journal of Computer Assisted Learning*. Advance online publication. <https://doi.org/10.1111/jcal.12487>
- Chubko, N. (2020). *Digital storytelling as an astronomy disciplinary literacy enhancement approach for adolescent Kyrgyzstani EFL students* [Unpublished doctoral dissertation]. Edith Cowan University.
- Chung, S. K. (2006). Digital storytelling in integrated arts education. *The International Journal of Arts Education*, 4(1), 33-63.
- Çiçek, M. (2018). *Investigating the effects of digital storytelling use in sixth grade science course: A mixed method research study* [Unpublished doctoral dissertation]. Middle East Technical University.
- Creswell, J. W., & Plano Clark, V. L. (2015). *Karma yöntem araştırmaları: Tasarımı ve yürütülmesi* [Designing and conducting mixed methods research]. (Y. Dede & S. B. Demir, Trans. Eds.). Anı. (Original work published 2011)
- Dalim, S. F., Azliza, N. Z. M., Ibrahim, N., Zulkipli, Z. A., & Yusof, M. M. M. (2019). Digital storytelling for 21st century learning: A study on pre-service teachers' perception. *Asian Journal of University Education*, 15(3), 226-234.
- Daniels, K. (2013). Exploring the impact of critical reflection through the use of service-learning and digital storytelling. *Journal on School Educational Technology*, 9(1), 1-10.
- Demirer, V., & Baki, Y. (2018). Türkçe öğretmeni adaylarının dijital öyküleme sürecine ilişkin görüşleri ve algıları [Opinions and perceptions of prospective Turkish teachers related to the digital storytelling process]. *Journal of Theoretical Educational Science/ Kuramsal Eğitimbilim Dergisi*, 11(4), 718-747. <https://doi.org/10.30831/akukeg.392654>
- Dogan, B., & Robin, B. R. (2008). Implementation of digital storytelling in the classroom by teachers trained in a digital storytelling workshop. In K. McFerrin et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2008* (pp. 902-907). AACE.
- Dreyer, L. M. (2017). Digital storytelling to engage postgraduates in reflective practice in an emerging economy. *South African Journal of Education*, 37(4), 1-10. <https://doi.org/10.15700/saje.v37n4a1475>
- Ekmekçi, E. (2016). Improving English as a foreign language (EFL) learners' ICT literacy skill through digital storytelling. *Participatory Educational Research (PER), Special Issue*, 1-9.
- Foley, L. M. (2013). *Digital storytelling in primary-grade classrooms* [Unpublished doctoral dissertation]. Arizona State University.
- Göçen Kabaran, G., Karalar, H., Aslan Altan, B., & Altıntaş, S. (2019). Sınıf öğretmeni ve sınıf öğretmeni adayları dijital öykü atölyesinde [In-service and Preservice Classroom Teachers in Digital Story Workshop]. *Cumhuriyet International Journal of Education/ Cumhuriyet Uluslararası Eğitim Dergisi*, 8(1), 235-257. <https://doi.org/10.30703/cije.469461>
- Göksün Orhan, D., & Kurt, A. A. (2017). Öğretmen adaylarının 21. yüzyıl öğrenen becerileri kullanımları ve 21. yüzyıl öğrenen becerileri kullanımları arasındaki ilişki [The relationship between pre-service teachers' use of 21st century learner skills and 21st century teacher skills]. *Education and Science/ Eğitim ve Bilim*, 42(190), 107-130. <https://doi.org/10.15390/EB.2017.7089>
- Haşlamam, T. (2017). Özdüzenleyici öğrenmenin desteklenmesi: Bir dijital öyküleme uygulaması [Supporting self-regulated learning: a digital storytelling implementation]. *Elementary Education Online/ İlköğretim Online*, 16(4), 1407-1424. [10.17051/ilkonline.2017.342964](https://doi.org/10.17051/ilkonline.2017.342964)
- Heo, M. (2009). Digital Storytelling: An empirical study of the impact of digital storytelling on pre-service teachers' self-efficacy and dispositions towards educational technology. *Journal of Educational Multimedia and Hypermedia* 18(4), 405-428.
- Hung, C. M., Hwang, G. J., & Huang, I. (2012). A project-based digital storytelling approach for improving students' learning motivation, problem-solving competence and learning achievement. *Educational Technology & Society*, 15(4), 368-379.
- Jakes, D. (2006, March 01). *Standards-proof your digital storytelling efforts*. Tech & Learning. <http://shorturl.at/am569>
- Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, 1(2), 112-133. <https://doi.org/10.1177/1558689806298224>
- Karakoyun, F. (2014). *Çevrimiçi ortamlarda oluşturulan dijital öyküleme etkinliklerine ilişkin öğretmen adayları ve ilköğretim öğrencilerinin görüşlerinin incelenmesi* [Examining the views of elementary school students and preservice teachers about digital storytelling activities in online environment]. [Unpublished doctoral dissertation]. Anadolu University.

- Karakoyun, F., & Kuzu, A. (2016). The investigation of preservice teachers' and primary school students' views about online digital storytelling. *European Journal of Contemporary Education*, 15(1), 51-64. <https://doi.org/10.13187/ejced.2016.15.51>
- Kearney, M. (2009). Investigating digital storytelling and portfolios in teacher education. In G. Siemens & C. Fulford (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2009* (pp. 1987-1996). AACE
- Kim, Y., & Silver, R. E. (2016). Provoking reflective thinking in post observation conversations. *Journal of Teacher Education*, 67(3), 203-219. <https://doi.org/10.1177/0022487116637120>
- Kocakaya, S., Kotluk, N., & Karakoyun, F. (2016). Pre-service physics teachers views on designing and developing physics digital stories. *Digital Education Review*, 30-December 2019
- Kocaman-Karoğlu, A. (2015). Öğretim sürecinde hikâye anlatmanın teknolojiyle değişen doğası: Dijital hikâye anlatımı [The changing nature of storytelling by means of technology in the instructional process: Digital storytelling]. *Educational Technology Theory and Practice/ Eğitim Teknolojisi Kuram ve Uygulama*, 5(2), 89-106. <https://doi.org/10.17943/etku.29277>
- Lambert, J. (2009). *Digital storytelling cookbook*. Digital Diner Press.
- McLellan, H. (2007). Digital storytelling in higher education. *Journal of Computing in Higher Education*, 19(1), 65-79. <https://doi.org/10.1007/BF03033420>
- McLellan, H., & Wyatt, M. (2006). Digital storytelling in higher education. *Journal of Computing in Higher Education*, 19(1), 65- 79.
- Michalski, P., Hodges D., & Banister S. (2005). Digital storytelling in the middle childhood special education classroom: A teacher's story of adaptations. *Teaching Exceptional Children Plus*, 1(4).
- Miles, M. B., & Huberman, A. M. (2015). *Nitel veri analizi: Genişletilmiş bir kaynak kitap* [Qualitative data analysis: An expanded sourcebook]. (S. Akbaba Altun & A. Ersoy, Trans. Eds). Pegem. (Original work published 1994)
- Mirza, H. S. (2020). Improving university students' English proficiency with Digital storytelling. *International Online Journal of Education and Teaching*, 7(1), 84-94.
- Mnisi, T. (2015). Digital storytelling: Creating participatory space, addressing stigma, and enabling agency. *Perspectives in Education*, 33(4), 92-107.
- Niemi, H., Harju, V., Vivitsou, M., Viitanen, K., Multisilta, J., & Kuokkanen, A. (2014). Digital storytelling for 21st century skills in virtual learning environments. *Creative Education*, 5, 657-671. <https://doi.org/10.4236/ce.2014.59078>
- Öztürk, A., & Tunç Ayvaz Ö. (2017). The effect of digital storytelling project on fine arts high school students' teamwork skills. *Journal of Educational and Instructional Studies in the World*, 7(4), 58-68.
- Özüdoğru, G., & Çakır, H. (2020). An investigation into the opinions of pre-service teachers toward uses of digital storytelling in literacy education. *Participatory Educational Research*, 7(1), 242- 256. <https://doi.org/10.29329/epasr.2019.208.10>
- Pieterse, G. (2018). To see someone else's perspective: A case for digital stories in schools. *Independent Journal of Teaching and Learning*, 13(1), 41-56.
- Punch, K. F. (2014). *Sosyal araştırmalara giriş: Nicel ve nitel yaklaşımlar* [Introduction to social research: Quantitative and qualitative approaches] (Z. Akyüz, D. Bayrak & H. Bader Aslan, Trans.). Siyasal. (Original work published 2014)
- Renda, C., & Sprouse, D. (2010, January 6-10). *Giving experiential learning a digital makeover: A case study in using digital storytelling and web 2.0 applications to promote greater technological competency in k-12 teachers*. [Paper presentation]. International Conference on Education 2010, Honolulu, Hawaii.
- Robin, B. (2008). Digital storytelling: A powerful technology tool for the 21st century classroom. *Theory into Practice*, 47(3), 220-228. <https://doi.org/10.1080/00405840802153916>
- Robin, B. R., & Mcneil, S. G. (2012). What educators should know about teaching digital storytelling. *Digital Education Review*, 22, 37-51.
- Sancar-Tokmak, H., Sürmeli, H., & Özgelen, 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. <https://doi.org/10.12973/ijese.2014.214a>
- Sanders, W. L., & Rivers, J. C. (1996). *Cumulative and residual effects of teachers on future student academic achievement* (Research Progress Report). <http://shorturl.at/kCQTO>

- Sarıtepeci, M. (2017). Ortaokul düzeyinde dijital hikâye anlatımının yansıtıcı düşünme becerisi üzerindeki etkisinin incelenmesine yönelik deneysel bir çalışma [An Experimental Study on the Investigation of the Effect of Digital Storytelling on Reflective Thinking Ability at Middle School Level]. *Bartın University Journal of Faculty of Education/ Bartın Üniversitesi Eğitim Fakültesi Dergisi*, 6(3), 1367-1384. <https://doi.org/10.14686/buefad.337772>
- Schank, R. (1990). *Tell me a story: Narrative and intelligence*. Northwestern University Press.
- Seckin Kapucu, M., & Yurtseven Avci, Z. (2020). The digital story of science: Experiences of pre-service science teachers. *Journal of Education in Science, Environment and Health*, 6(2), 148-168. <https://doi.org/jeseh.689444>
- Simsek, M. R. (2020). Towards emancipatory L2 instruction: Exploring significant learning outcomes from collaborative digital storytelling. *International Journal of Educational Methodology*, 6(3), 555-569. <https://doi.org/10.12973/ijem.6.3.555>
- Smeda, N., Dakich, E., & Sharda, N. (2014). The effectiveness of digital storytelling in the classrooms: a comparative study. *Smart Learning Environemnts*, 1(6), 1-21. <https://doi.org/10.1186/s40561-014-0006-3>
- Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedure and techniques*. Sage.
- Tabieh, A. A., Al-Hileh, M. M., Afifa, H. M. J. A., & Abuzagha, H. Y. (2021). The effect of using digital storytelling on developing active listening and creative thinking skills. *European Journal of Educational Research*, 10(1), 13-21. <https://doi.org/10.12973/eu-jer.10.1.13>
- Teddle, C. B., & Tashakkori, A. M. (2015). *Karma yöntem araştırmalarının temelleri* [Foundations of mixed methods research] (Y. Dede & S. B. Demir, Trans, Eds.). An. (Original work published 2009)
- Wang, S., & Zhan, H. (2010). Enhancing teaching and learning with digital storytelling. *International Journal of Information and Communication Technology Education (IJICTE)*, 6(2), 76-87.
- Xu, Y., Park, H., & Baek, Y. (2011). A new approach toward digital storytelling: An activity focused on writing self-efficacy in a virtual learning environment. *Educational Technology and Society*, 14(4), 181-191.
- 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.
- Yigit, E. O. (2020). Digital storytelling experiences of social studies pre-service teachers. *International Journal of Technology in Education*, 3(2), 70-81. <https://doi.org/10.46328/ijte.v3i2.25>
- Yılmaz, M. M., & Siğirtmaç, A. (2020). A material for education process and the Teacher: The use of digital storytelling in preschool science education. *Research in Science & Technological Education*. Advance online publication. <https://doi.org/10.1080/02635143.2020.1841148>
- Yoon, T. (2013). Are you digitized? Ways to provide motivation for ells using digital storytelling. *International Journal of Research Studies in Educational Technology*, 2(1), 25-34.
- Yüksel, P. (2011). *Using digital storytelling in early childhood education a phenomenological study of teachers' experiences* [Unpublished doctoral dissertation]. Middle East Technical University.
- Yürük, S. E. (2015). *Dijital öykülemeye dayalı değerler eğitiminin öğrencilerin değer kazanımı ve tutumlarına etkisi* [The effect of digital storybased values education on students' attitudes and value acquisiton] [Unpublished master's thesis]. Fırat University.