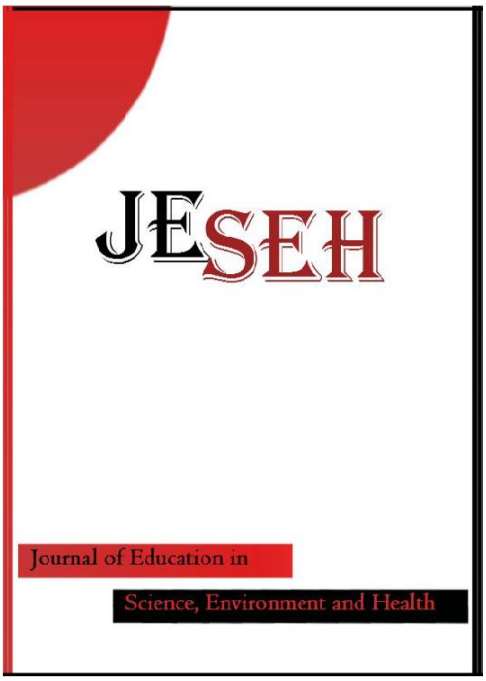

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Abstract

The purpose of the study is examination of the quality of digital stories developed by pre-service science teachers and deeply investigating pre-service teachers' experiences related to scientific concepts, the characteristics of scientific knowledge and the ways of reaching scientific knowledge in the stages of exploration, storytelling and digitalization. A case study design is used in the research. Criterion sampling was used from the purposeful sampling methods. The research was carried out with the 3th year 36 pre-service teachers who study at a public university in Turkey during the fall semester of 2018-2019. Rubric for Evaluation of Digital Stories, semi-structured reflection form and digital diaries form developed by researchers were used for data collection. Content analysis technique was applied to analyze the reflections and dairies, and the digital stories prepared by the participants were evaluated using the *Digital Storytelling in Educational Context Rubric (DSECR)* form. According to the findings, most of the digital stories prepared by pre-service science teachers were at high quality level. Participants stated that they used scientific concepts in their digital stories and transferred the characteristics of scientific knowledge to digital environment and scenarios. Additionally, science teachers' experience of preparing digital stories supported 21st century skills.

Introduction

It has been always critical helping students to understand the nature of science and it is a common goal of the scientists especially in the last century (Abd-El-Khalick, Bell, & Lederman, 1998; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). However, research suggests that pupils and teachers do not have a consistent understanding of science from preschool to the end of secondary school (Lederman, 2007; Lederman et al., 2002). In the programs and studies about understanding the nature of science, it is seen that besides teaching the content to the students, teaching the working principles of the scientists, the stages they experienced in the process of producing scientific knowledge and their contribution to understanding the nature of science are all critical (Akerson, Morrison, & McDuffie, 2006; Bati & Kaptan, 2017; Ministry of National Education [MEB], 2013; National Research Council [NRC], 1996). In addition, several studies indicate that teachers have a positive effect on the development of scientific thinking skills of the students if they correctly convey the characteristics of scientific knowledge and scientists, as well as the society-science and science-society relationship (Dogan, Cakiroglu, Cavus, Bilican, & Arslan, 2011; Khishfe, 2008; Zeidler, Walker, Ackett, & Simmons, 2002).

It has been a necessity for modern people to follow scientific and technological developments and use contemporary technology. Technological tools are entering our lives in almost every area and we have to take decisions and make choices as individuals and society (Kilic, Haymana, & Bozyilmaz, 2010). Scientific developments trigger technological developments, technological developments incite scientific developments, and therefore all these affect society and the environment. Therefore, the concepts of science, technology, society and environment closely interact with each other. It is also important to teach this dynamic interaction in science teaching (Kilic et al., 2010).

The new generation faces technological devices such as iPods, iPads, tablets, mobile phones and smartphones beginning from the moment they are born (Morgan, 2014). Some skills that are expected from today's generation and that became a necessity are called 21st century skills. These features, which are generally given under the headings of technology literacy, information literacy, communication skills, creativity, simulation, multitasking, collaborative working, problem-solving and social responsibility. These are some of the skills emphasized in today's educational settings and should be acquired by the learners (Leonard, Elizabeth, & Marta, 2010). The digital story approach appears to be a modern practice in developing the mentioned skills (Malita & Martin, 2010).

In addition, following and using the latest technologies play an important role in the academic success of the learners. New methods and techniques are widely used in education in order to increase the effectiveness of learning activities. Many studies on digital storytelling emphasized that this approach is a powerful and effective tool that can be used in educational environments (Clarke & Adam, 2011; Nilsson, 2008). Story and storytelling is an important strategy for teaching and learning, and stories help to express experiences (Lowenthal & Dunlap, 2010).

"Digital storytelling", which is built by bringing the video, picture, audio or written narrative or dialogues and music together in a story-building framework, has become a mean of expression. Use of digital stories has accelerated in different areas with the development of Web 2.0 technologies (Hartley & McWilliam, 2009; Robin, 2008). Digital storytelling was first introduced in California in the late 1980s by Dana Atchley and Joe Lambert (Hartley & McWilliam, 2009; Kocaman-Karaoglu, 2015; Robin, 2008). The Center for Digital Storytelling, founded by Lambert and Atchley in U.C. Berkley, in 1993, has been guiding and supporting the creation of digital stories and the studies conducted in this field (Robin, 2008). According to Robin (2008), with today's technologies creating a digital story is very easy and fast, which has been effective in the increase of the use of this method in schools.

In general, storytelling shapes the basis of digital story creation (Gocen, 2014). What distinguishes the digital story method from traditional storytelling is that it is supported by visual and audio materials in digital media. The use of digital story in teaching is an educational technology that includes many basic 21st century skills such as, technology literacy, creative thinking, effective communication and productivity (Jakes, 2006). Taking an active role in the digital story preparation process plays an important role in gaining mentioned skills (Jakes & Brennan, 2005). The process of digital story creation includes creative skills such as determining the topic, investigating this topic and creating scripts (Karatas, Bozkurt, & Hava, 2016). The different ideas available in the literature enrich the learning experiences by maximizing the interaction with the content they prepare. Digital storytelling practices can be used within a single lesson and subject; on the other hand, it is particularly a suitable approach to combine different disciplines (Benmayor, 2008; Robin, 2008). For example, according to Lederman and Niess (1997), the interdisciplinary approach signifies an undivided whole and they likened it to the formation of compounds in chemistry. The compounds show different properties than single elements that form them. When the disciplines are combined, a very different and clearer picture emerges (Lederman & Niess, 1997; MEB, 2016). In this study, the nature of science and the use of digital technology in science education were discussed together and digital stories were used as a teaching method.

Studies investigating the effect of digital storytelling on educational outcomes show that this activity has the potential to increase students' creative thinking skills, imagination, academic achievement and motivation (Duveskog, Tedre, Sedano, & Sutinen, 2012; Karatas et al., 2016; Wang, He, & Dou, 2014). In addition, digital storytelling also provides digital literacy skills (Karatas et al., 2016). Digital storytelling offers various opportunities such as diversity in classroom practices, personalization of the learning experience, supporting student-centered teaching, helping to explain complex issues, and creating easy and inexpensive learning environments (Xu, Park, & Baek, 2011; Yang & Wu, 2012). Thus, it is important to use digital storytelling in classroom practices.

Regarding the studies in science education area, there are not many studies related to the use of digital story (Hoban, Nielsen, & Shepherd, 2015; Robin, 2016; Valkanova & Watts, 2007). This study will contribute to the field about the use of digital story, which is a relatively new application for science education. In this study, it is planned that third grade pre-service science teachers will develop digital stories featuring the striking sections of scientists' lives, blending the knowledge and experience that they have gained in their fields and in the field of technology. The purpose of the study is examination of the quality of digital stories developed by pre-service science teachers and deeply investigating pre-service teachers' experiences related to scientific concepts, the characteristics of scientific knowledge and the ways of reaching scientific knowledge in the stages of exploration, storytelling and digitalization. For these purposes, the following questions will be addressed:

- What is the quality level of the digital stories developed by pre-service science teachers in terms of different dimensions?
- What are the experiences of pre-service teachers on scientific concepts, characteristics of scientific knowledge and the ways of reaching scientific knowledge in the stages of exploration, storytelling and digitalization?

Method

Research Model

This study was designed as a qualitative case study. According to Creswell (2007) case study is a research approach in which the researcher examines one or more of the situations delimited over time using multiple data sources, and describes the situations and contextual themes. In this study, the holistic single case design was used to investigate the experiences of pre-service science teachers while developing digital stories on life stories of scientists and to examine the quality of digital stories developed by pre-service teachers.

Study Group and Role of the Researchers

The study was carried out with 36 third year pre-service science teachers studying at a public university in Turkey during the fall semester of 2018-2019 academic years. Criterion sampling from purposeful sampling methods was employed to choose participants. The main criterion was taking Special Teaching Methods I course and have taken Computer II course. Thirty-three of the participants were female and three of them were male.

There are some important factors in choosing this group of students. Firstly, since the pre-service teachers study at the same department of the same higher education institution and at the same grade level, the content of the courses they take at the undergraduate level is considered to be appropriate for the purpose of the study and to comprehend the courses they will take during the study. Science pre-service teachers take various courses in general education, science education and technology and computers during their university education. However, they are not usually provided a supportive context in which they can apply these skills together for a common purpose. In this study, they were provided an opportunity for blending these different knowledge and skills gained in their teaching lives and also examining various aspects of scientific concepts and different aspects of scientific knowledge through concrete examples in this process.

Two researchers also participated in the data collection process of the research. In this process, the researchers informed the participants about the purpose, scope and duration of the study, avoided being intrusive and adopted a neutral role. The role of the researcher in qualitative research appears as an important factor affecting the study. Therefore, in this process, researchers tried to explain the whole research process in detail. The data collection process took place in a quiet environment, and the researcher became someone who observed the participants from the outside. Researchers have been empathic listeners throughout the process and have avoided behaviors that may affect the study negatively.

Research Process

The digital stories to be prepared should have been related to striking parts of life stories of scientists who had worked on the subjects covered in the secondary school science curriculum. At the beginning of the research, a four-hour training was given to pre-service teachers, on science, the characteristics of scientific knowledge, and the approaches to teach the nature of science. In addition, another four hours of training was provided on digital story content and digital story creation process. Pre-service teachers were provided help and feedback by two researchers throughout the process. The implementation period of the project was approximately three months. First participants did some research and prepared scenarios about striking parts of life stories of scientists who they have chosen. This process took around two weeks. Then they submitted draft scenarios and got feedback from the first researcher. Then they started to convert their scenarios to the digital form. They used templates and free images from PowToon, the Web 2.0 tool that they used to prepare their digital stories; and they also used other images as needed. They also made voice recordings for their scenes. Finally, they combined their video with voiceover and/or music.

Data Collection Tools

Digital story section of Digital Storytelling in Educational Context Rubric developed by Sarica and Usluel (2016) was used to determine the quality of digital stories developed by pre-service science teachers and Reflection Form for Digital Story Preparation Experiences was employed to determine pre-service science teachers' experience on scientific concepts, characteristics of scientific knowledge and the ways of reaching

scientific knowledge in the exploration, storytelling and digitization processes. In addition, digital logs were also used in order to deeply investigate digital story preparation experience of pre-service teachers. Different methods are used by researchers to ensure the validity and reliability of qualitative case studies. One of them is collecting data from multiple data sources to ensure internal validity and to synthesize and support each other with the triangulation method (Mills, Durepos, & Wiebe, 2010). In this study, triangulation method has been used by obtaining data at different stages of the application with multiple data collection tools.

Digital Storytelling in Educational Context Rubric

Digital Storytelling in Educational Context Rubric developed by Sarica and Usluel (2016) is comprised of three sections and 30 criteria related to the digital story-telling process in educational context. The sections are defined as "story", "storyboard" and "digital story", where the "story" section consists of eight criteria (purpose, use of language and grammar, authenticity, emotion, sincerity, conciseness and fluency), the "storyboard" section consists of four criteria (organization, content, integrity and fluency) and the "digital story" section consists of 18 criteria (purpose, use of language and grammar, clarity, length, authenticity, emotion, conciseness, suitability of visuals, effectiveness of visuals, suitability of sound, sound speed, sound quality, suitability of music, music speed, music-sound volume compatibility, integrity, fluency, copyright). The validation study of the developed rubric was conducted by experts in terms of content, structure and criteria dimensions. For the reliability of the rubric, Cohen`s Kappa index was calculated using interrater reliability coefficient = number of agreements / (total number of agreements + disagreements) (Miles & Huberman, 1994). A minimum of .60 value should be reached for reliability (Cohen, 1960). In this context, regarding the weighted Kappa coefficients of the criteria, it was determined that the majority of the criteria showed substantial or almost perfect agreement between two raters. According to these results, it can be stated that the developed rubric was valid and reliable (Sarica & Usluel, 2016).

Reflection Form for Digital Story Preparation Experiences

In the process of digital story preparation, pre-service teachers carried out exploration, storification and digitalization stages. A semi-structured reflection form has been prepared by the researchers to determine the experiences pre-service teachers had about scientific concepts, characteristics of scientific knowledge and the ways of reaching scientific knowledge. Reflection form aimed to elaborate the experiences of the pre-service teachers for each dimension of the digital story preparation process, and they were asked to express their thoughts in written form under the relevant heading with detailed explanations. The semi-structured nature of the form is intended to remind pre-service teachers their experiences in the process, but it is not as a short-answer questionnaire on which they can simply mark the answers, it is in a form allowing them to express their thoughts in their own words. The reflection form was applied to all pre-service teachers who participated in the study at the end of the research.

Digital Logs

In this study, digital logs were also used as a data collection tool. The digital log form was comprised of nine questions regarding the exploration of the scientist, the digitalization of the scenarios, the problems experienced in this process, the opinions and suggestions about the process of digital story preparation. Participants answered these questions electronically after their digital story preparation experience.

Data Analysis

Within the scope of the research, 19 digital stories produced by pre-service science teachers were evaluated using the Digital Storytelling Rubric developed by Sarıca and Usluel (2016). Digital stories were evaluated under 17 categories except the copyright category by two independent raters from 1 to 3. Weighted kappa coefficients were calculated, then the reliability of the two raters was checked. In Cohen's Kappa index, the reliability coefficient between raters was calculated by using the following formula: (K) = Agreement / (Agreement + Disagreement) (Miles & Huberman, 1994). If the raters gave the same score for an item, it was taken as "Agreement", if they gave different scores it was taken as "Disagreement". Regarding the values of Kappa coefficient, <.20 is interpreted as slight, .21–.40 as fair, .41–.60 as moderate, .61–.80 as substantial, and

.81–1.00 as almost perfect agreement (Cohen, 1960; Landis & Koch, 1977). Between the two raters, it was found that the majority of the criteria showed almost perfect and substantial agreement.

Content analysis was used to analyze the data obtained from digital logs and from the reflection form for digital story preparation experiences. There are two major types of content analysis: inductive and deductive (Armat, Assarroudi, Rad, Sharifi, & Heydari, 2018). Inductive content analysis is usually applied for the cases there are no studies/limited studies about the research topic (Elo & Kyngäs, 2008), then categories and themes emerge from the text. When the researcher adopts deductive content analysis, analysis starts with pre-existing categories that were adopted from a conceptual framework, theories, or earlier research findings (Armat et al., 2018). Then the researcher looks for whether predetermined categories exist or not in the text. For the analysis of this study, deductive method was applied for analysis of both digital logs and the reflection forms. For the digital logs, first, each researcher read the participants' answers separately and coded under predetermined themes. The opinions of the pre-service teachers included in the logs were reviewed in terms of 21st century skills, Partnership for 21st century learning (2015): Learning and innovation skills, knowledge, media and technology skills, and life and career skills. Then, at the end of the analysis process, the two researchers' separate analyzes were reviewed and the codes and themes were found to be coherent. Nvivo 12 pro software was utilized during these analyzes. For the reflection forms, the data obtained were grouped under the themes based on the study objectives. The identity of the participants was kept confidential in the direct quotations taken from the opinions in the reporting process. At the end of the analysis period, the analyses of the two researchers were reviewed and the codes and themes were adapted.

In order to ensure internal validity in this research, pre-service teachers' experiences on the digital story-building process were first defined from the direct quotations and then interpreted. For the reliability of the study, multiple data collection tools (rubrics, reflection form and digital logs) were utilized and both researchers analyzed the data independently and the results they obtained were compared.

Findings

Findings about the Quality of Digital Stories Developed by Pre-Service Science Teachers

Nineteen digital stories developed by pre-service science teachers individually and in groups were reviewed independently by two raters. The qualities of digital stories were evaluated (weak, medium, good) using Digital Storytelling Rubric, consisting of 17 items in three categories. It has been found that pre-service teachers achieved at least 50% points from the majority of 18 scale items for 19 digital stories. As seen in Table 1; For 16 rubric categories, at least 11 of 19 stories were rated as “good”. The number of stories rated as "medium" ranges from 1-8. For another rubric category (purpose), all of the stories were rated as “medium”. There is no story with a "weak" score in any category, which is also seen in the Table 1. As a result, it was concluded that on average 58% of the prepared stories were at high quality level and 42% of them were at "medium" quality level.

Table 1. Frequencies of mean of ratings for digital story quality (N=19)

Rubric categories	Weak	Medium	Good
Purpose	0	19	0
Language	0	0	19
Clarity	0	2	17
Length	0	2	17
Originality	0	1	18
Affect	0	0	19
Plainness	0	1	18
Proper visuals	0	5	14
Effective visuals	0	6	13
Proper audio	0	1	18
Audio speed	0	3	16
Audio quality	0	1	18
Proper music	0	7	12
Music speed	0	7	12
Music level	0	8	11
Integrity	0	2	17
Fluency	0	5	14

Pre-Service Teachers' Experiences related to Scientific Concepts, the Characteristics of Scientific Knowledge and the Ways of Reaching Scientific Knowledge in the Stages of Exploration, Storytelling and Digitalization

As a result of the analysis performed on the data obtained from the reflection forms: the scientific concepts, the characteristics of scientific knowledge, and the ways of reaching scientific knowledge themes emerged. The categories included under the theme of scientific concepts are: concepts and taking part in the story (Table 2).

Table 2. Frequencies related to categories and codes in the theme of scientific concepts

Themes	Categories	Codes
Scientific Concepts	Concepts	scientific knowledge DNA electricity the earth is round solar system-space gene audio atmospheric pressure solenoid bacteria natural selection buoyancy microscopic organisms penicillin radioactivity telephone
	Taking part in the story	content of the scene study of scientists basic concepts visualization getting attention dubbing

The opinions that are mostly mentioned by pre-service science teachers under the *concepts* category were the concepts related to the characteristics of scientific knowledge. One of the participants (P) expressed his/her idea as:

> Scientific knowledge is based on observations and inferences. He observed the piece of mushroom left in his pocket and made inferences by examining this piece (P24),

whereas another opinion supporting this one was:

> Imagination and creativity occupy an important place at every stage of the development of scientific knowledge. This concept can be associated with seeing porous structure of the mushroom and likening it to the cells in the monastery where the monks stay (P35).

Another code that was frequently repeated by the participants under the *concepts* category was DNA. A participant stated his/her opinion about DNA as:

> I have encountered scientific concepts related to the structure of DNA (P5),

another participant stated that he/she had chosen Aziz Sancar as the scientist of his/her digital story and said the following about the concepts he/she encountered:

> My digital story was about the DNA repair work that he had found; the scientific concepts in this study were: DNA, nucleotide, gene, cancer cell, enzyme, ultraviolet rays, and DNA damage (P16).

Pre-service teachers often included scientists working on electricity in their digital stories. One of the participants who went through the concept of electricity in his/her digital stories mentioned the concepts that he/she encountered as:

> In the digital story about Nikola Tesla we faced with scientific concepts of electricity (P11).

whereas another participant stated the concepts that he/she faced as:

> Electricity is the concept that Franklin works on. Positive charge, negative charge, neutral took place as the particles forming materials. Electrical attraction force and push-pull concepts were also included (P10).

Pre-service teachers stated that they mostly included concepts as scene content in their digital stories. As seen in Table 2, the findings under the category of *taking part in the story* are grouped under six separate codes. A participant stated his opinion on this issue as:

> The concepts in our digital story are based on Torricelli's experiment. We tried to story and explain Torricelli experiment in which he made open air pressure measurable using mercury (P2).

A screenshot from the digital story describing Torricelli's experiment is shown in Figure 1.

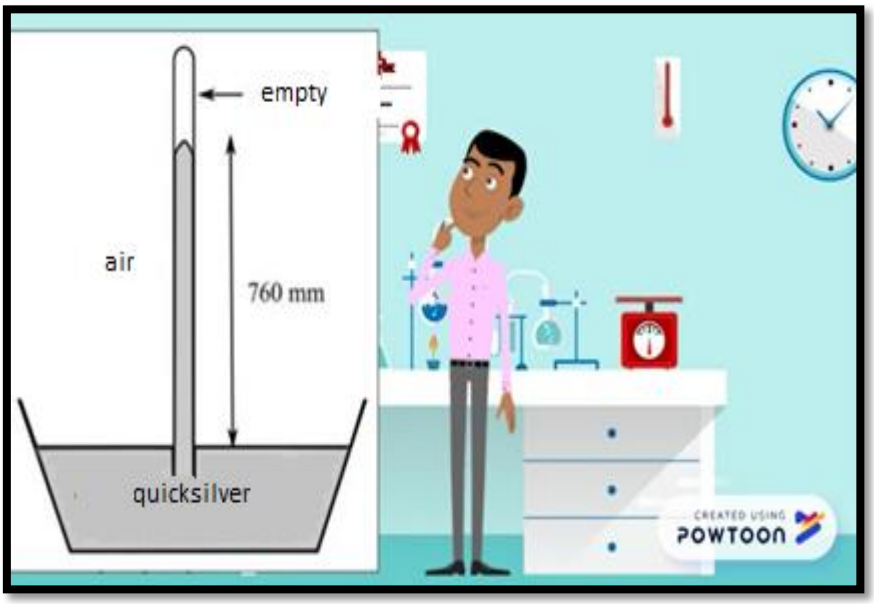

Figure 1. A digital story example describing the experiment by Torricelli

Another participant said that:

> Earth, diameter, trigonometry, tangent, cotangent, measurement, etc. Biruni has measured the diameter of the earth using a formula. We covered these concepts in this part (P31).

The other recurring view under this category is that the concepts mentioned in digital stories were the ones included in the work of scientists. An opinion mentioned under this code was as follow:

> The subject of my story was the life of a person who was engaged in science, and this person was the inventor of telephone, one of the technological devices. Developmental characteristics of science were mentioned. As an example, Graham Bell developed his invention and then proceeded to open up a long-distance phone line. In doing so, naturally he used technology and this product emerged as an accumulation of his work with his friend Watson (P13).

The categories under the characteristics of the scientific knowledge theme were perception of scientific knowledge process, scripting process and digitalization process. The characteristics of scientific knowledge have been included in the perception of scientific knowledge process (see Table 3).

Table 3. Frequencies related to categories and codes in the theme of the characteristics of scientific knowledge

Themes	Categories	Codes
Characteristics of Scientific Knowledge	Perception of scientific knowledge	*SK2 *SK4 *SK6 *SK5 *SK3 *SK7 *SK1
	Scripting process	utilize the features of scientific knowledge stages of research process utilization of visuals simplification work of the scientist determining important parts
	Digitizing digital stories	use of visual media preparing scenes visualization of scientific knowledge using characters appropriate for student level research

*SK1: These aspects include teaching students that scientific knowledge, its "facts," "theories," and "laws" are both reliable and tentative.
*SK2: Empirically based (based on and/or derived from observations of the natural world).
*SK3: Subjective and/or theory-laden.
*SK4: Partly the product of human imagination and creativity.
*SK5: Subject to a distinction between observations and inferences.
*SK6: Influenced by social and cultural factors.
*SK7: That theories and laws are different kinds of knowledge.

Scientific knowledge (SK) includes logical, mathematical or empirical inferences, which is one of the characteristics of nature of science, is frequently emphasized by pre-service teachers under this category. An opinion stated under this code is:

> Biruni mathematically formulated the diameter of the earth with trigonometry and proved it via experiment (P23).,

whereas another opinion supporting this was:

> Hook made reasoning about the thing that he saw in his pocked but cannot make sense of as it might be the mushroom he eats before. He made experimental inferences by conducting an examination in the microscope to obtain a clearer result (P24).

In this category, another prominent characteristic of nature of science, which was frequently repeated by the pre-service teachers, was imagination and creativity have an important role in the acquisition of scientific knowledge. A participant expressed his opinion related to this topic as:

> Galileo looked at Saturn constantly, making observations, he used his own creativity to name Saturn Rings as the Saturn Ears (P27).

Whereas another opinion supporting this was:

> I have seen this characteristic of scientific knowledge in the part where Robert Hook and his wife examined the mushroom tissue, likened it to the cells of the priests in the monastery and named them as the cell (P33).

Another nature of science characteristic mentioned by pre-service teacher under this category was:

> The scientific knowledge is influenced by the social and cultural surrounding at the stage of development and practice.

An opinion stated under this code was:

> Mendel's father engagement in agriculture and Mendel's interest in plants were influential in this study (P20).

another opinion supporting this was:

> The church opposed the books published by Galileo and he was accused of influencing the people. He was eventually put under house arrest (P27).

Another nature of science characteristic expressed by pre-service teacher under this category was:

> Observation and inference are different things.

One of the opinions mentioned under this code was:

> Franklin has taken many pictures of DNA and has observed these pictures abundantly. However, he could not connect his observations to an idea. The people who interpreted these pictures and made inferences were Watson and Crick (P34).

Another nature of science characteristic stated by pre-service teachers under this category was: Scientific knowledge is subjective. An opinion mentioned under this code was as follow:

> The best example of it is Watson and Crick believed that DNA has a double spiral structure when Pauling was thinking that it has a triple helical structure (P34).

The nature of science characteristic less frequently mentioned by pre-service teachers under this category was: Scientific theories and laws are different types of knowledge. An opinion stated under this code was:

> Theory is the information without a definitive conviction, which may be changed in some cases. However, the law is the information accepted by everyone, which cannot be changed. Mendel has enacted his hypotheses. They are still accepted today (P36).

The nature of science characteristic that was least mentioned by pre-service teachers under this category was:

> Scientific knowledge is changeable.

The participant explained his/her opinion related to this code as:

> As time progresses, technology is evolving. Science is progressing by this means. Aziz Sancar has now achieved DNA repair with today's technology. But in the future, new solutions will be found with the technology that is continuing to develop (P22).

The following codes were achieved in the *scripting process* category: utilizing the characteristics of scientific knowledge, stages of research process, utilization of visuals, simplification, works of the scientists and determining important parts. Pre-service teachers emphasized that scientific knowledge includes logical, mathematical or experimental inferences. A participant expressed his/her opinion as:

> Fleming used experiments and calculations while working on penicillin and in other studies. We talked about these works in detail in the scenario (P29).

Pre-service teachers stated that they used the stages of the research process while preparing a scenario. Regarding the stages of the research process, a participant stated that:

> Scientific knowledge is systematic and methodical. Such as measuring the diameter of the world through certain stages and methods (P23),

whereas another said:

> Rachel Carson's narration of her life took place in the scenario as describing the stages in the process of conducting her research (P1).

Pre-service teachers stated that they mostly used visual media when *digitizing digital stories*. A participant expressed his/her opinion on this code as:

> Since we covered it in the script, it wasn't too hard. We've included it by adding in the event and supporting it with pictures and sounds (P10).

whereas another stated:

> For the information that I transferred to the script, I created scenes via the Powtoon application in digital format. I prepared the scene related to the topic and used visuals. Then I transferred this information to the digital media with voiceover (P21).

Another opinion supporting these was:

> We put into the screen a short summary about Galileo and the scenario we prepared from it via Powtoon. We transferred the pictures of the observations that he had made to the scenes with the characters (P27).

Pre-service teachers declared that while digitizing their digital stories they prepared the scenes first. A participant expressed his/her opinion as:

> I took scientific information into consideration when preparing the scenes and arranging the objects in the scene (P14),

and another said:

> We created the script and then we started to create the scenes. In most cases we had problems in reflecting the background and the basic parts of the invention, we had to change the scenes we made constantly, but we didn't remove any scene from the scenario or added a scene contrary to the scenario (P19).

The ways of reaching scientific knowledge theme was comprised of scientists' ways of reaching knowledge, pre-service teacher's ways of reaching knowledge, the contribution of creating digital stories, and the contribution of digitalizing. Observation, experiment, research and inference were the most mentioned codes by the pre-service teachers under the category of *scientist's ways of reaching knowledge* (Table 4).

Pre-service teachers stated that scientists often made observations to reach scientific knowledge. A participant expressed his/her opinion about observation as:

> Leeuwenhoek has first identified the issue that attracted his attention, in other words the problem: Why do spectacle lenses show objects larger (P9)?

He then went to the optician's shop and worked with the craftsmen, in other words he made observations about the problem and collected data. The opinion of a participant suggesting that the scientist reaches scientific knowledge through experiment was:

> He was a scientist who makes experiments and observations, who is able to observe different situations directly, we also mentioned in our story, he was someone constantly making experiments in his laboratory, who was working dispersed, and penicillin was found because of this (P29).

Participants also emphasized that scientists make inferences when reaching scientific knowledge. A participant stated that:

> He studied previous studies conducted on cancer cells and proceeded with deductions (P22).

whereas another expressed his/her opinion as:

Watson and Crick have reached scientific knowledge by reviewing previous studies and making logical inferences (P34).

Table 4. Frequencies related to categories and codes involved in the ways of reaching scientific knowledge

Themes	Categories	Codes
The Ways of Reaching Scientific Knowledge	Scientist's ways of reaching knowledge	observation experiment research inference curiosity imagination mathematical calculations disciplined work collaboration trial reasoning produce theory method daily life hypothesis testing law cause and effect relationship training systematic study socio-cultural environment changeable
	Pre-service teacher's ways of reaching scientific knowledge	research collaboration reviewing the work of scientists
	Contribution of creating digital stories	research skills review of the process of acquiring knowledge understanding the properties of scientific knowledge learn about scientists questioning skills feeling like a scientist gaining technical skills gaining a scientific perspective inference material development no contribution
	Contribution of digitalizing category	technical skills understanding the properties of scientific knowledge collaboration learning systematic study ensure the reliability of scientific knowledge contribution of the prepared material to students understand the ways of reaching scientific knowledge experience entertainment visualization comprehending concretization of scientific knowledge decision-making professional development questioning no contribution

Pre-service teacher's ways of reaching scientific knowledge category is consisted of conducting research, collaborating and reviewing the work of the scientists. While pre-service teachers offered a variety of ways through which scientists reach scientific knowledge, they did not mention this diversity for themselves. Pre-service teachers stated that they mostly do exploration to reach scientific knowledge. A participant expressed his/her opinion on this issue as:

> We explored Kepler's life and inventions (P12).

whereas another stated that:

> We have reached this information by reading Fleming's life story (P29).

Another opinion supporting these was:

> While I was exploring the life story of the scientist I made a systematic source search. I took care to conduct my work in a plan (P28).

Regarding the *contribution of creating digital stories*, pre-service teachers mostly stated that it contributed to their exploration skills. A participant expressed his/her opinion on this issue as:

> Creating a story about a scientist has contributed a lot to me on the ways of reaching scientific knowledge. In order to create this story, I explored scientific knowledge by conducting a detailed search (P11).

whereas another participant said that:

> Yes, I think it contributed on me. Because before we decided to the scientist, we explored and worked on many scientists. As we read the lives of many scientists until we reached the decision-making stage, we had a lot of information at hand (P35).

Under *the contribution of digitalizing category*, pre-service teachers often stated that digital stories strengthen their technical skills. An opinion on this issue is as follows:

> As we know, recording scientific information is a necessity for the performance of the science process. Any data that I transfer to digital media paves the way for potential scientific methods that I will use in the future. The data that I transfer to the digital media will always be there, and maybe one day they may even directly influence my life. I now understand how important technology is in accessing information. I think we have to catch the new age in these days that we call Industry 4.0 (P13).

Findings Obtained from Digital Logs

Findings obtained from digital logs were reviewed in terms of 21st century skills. The logs were grouped under the themes of information, media and technology skills, learning and innovation skills, and life and career skills. Information literacy, information and communication technology literacy, and media literacy categories were the items under the theme of information, media and technology skills. The frequencies related to the themes, categories and codes of 21st century skills are listed in Table 5.

Under the *information literacy* category, the most mentioned opinion was analyzing the learning objectives. Pre-service science teachers said that they were examining the objectives covered in the 2018 Science Course Curriculum while preparing the life stories of scientists in the digital story preparation process. A participant said that:

> Regarding the scientist, we decided to choose Johannes Kepler considering the objectives in the science curriculum (P30).

Another opinion mostly mentioned under *information literacy* category was research skills. Pre-service science teachers stated that in the digital story preparation process, they investigated the life stories of scientists in detail. A participant expressed his/her opinion as:

> Firstly, I started to work by exploring Nikola Tesla's childhood. It was not difficult to create my script after exploring the interesting events he has experienced during his childhood and his business life and the beautiful inventions that he has made (P12).

whereas another participants stated his/her opinion as:

> First, we explored the life of Marie Curie in detail and thoroughly internalized it, we insisted on her works and designed a scenario (P19).

However, pre-service science teachers stated that they wanted to choose a different scientist during the digital story preparation process.

Table 5. Frequencies related to themes, categories and codes in twenty-first century skills

Themes	Categories	Codes
Information, Media and Technology Skills	Information literacy	review of learning objectives research being different and native
	Information and communication technology literacy	digitization recording recording process experiences during digitization affordances of the program
	Media literacy	visual media audio recording software audio
Learning and Innovation Skills	Critical thinking & Problem solving	problems experiences
	Collaboration	support support type
	Flexibility & Adaptability	making choice
Life and Career Skills	Productivity & Responsibility	opinions about the process professional development use of technology productivity use different materials imagination & creativity

Under *information and communication technology literacy* category, the opinions mostly mentioned by the participants were about transferring to digital media. Regarding transferring the script that they prepared to the digital media a participant stated his/her opinion as:

> First of all, we wrote our script and prepared in Powtoon using the characters suitable for the subject, tools, backgrounds, visuals and the appropriate vocalization options (P16).

Whereas another participant said that:

> In this process, we first created our scenes. Then we made the character selection and determined the character movements. After this stage, we carried out voice recording and transferred it to the program (P20).

Another opinion mostly mentioned under *information and communication technology literacy* category was related to the recording process. It is seen that pre-service science teachers performed their recording in different ways. A participant said that:

> I used YouTube to save the story. I shared my story with Powtoon and uploaded it to YouTube and recorded it by downloading to my computer using mp4 converters on internet sites (P14),

whereas another one explained it as:

> After all the scenes, pictures and sound recordings were completed and our mistakes were corrected, I started the video on Powtoon. At the same time I started to record the video on the Bandicam program that I downloaded on my computer. Bandicam recorded the video screen while Powtoon video was playing (P26).

Another participant said:

> After completing our story, we recorded it via Active Presenter program (screen capture program) (P27).

Another opinion mentioned by the participants was what happened during the digitalization. It is seen that pre-service science teachers experienced different problems related to this subject. A participant expressed his/her opinion on this issue as:

> It did not take much time to write our script in this process, however it took quite a while for us to find the visuals and to create audio recordings and to insert them in the program while transferring the script to digital media (P8).

The facilities of the program that pre-service science teachers used while utilizing information and communication technologies have also affected their work. A participant reflected his/her opinion as:

> I wanted to animate an eagle's chasing a rabbit in that scene, but Powtoon didn't allow it, I couldn't find the necessary characters and movements. Again, I wanted to create this scene in a cloud of thought, but the visual could not be placed on the speech cloud. In short, I couldn't do what I imagined in a scene (P1).

Under *Media Literacy* category, pre-service science teachers stated that they mostly used visual media while digitalizing the scenarios they prepared. The opinion of a participant on this issue is as follows:

> Some characters and pictures in the Powtoon application were not sufficient, so we used pictures of Nikola Tesla found from external sources. We found the pictures that fit our script. We paid attention the scenarios and the pictures being compatible (P12).

Another opinion mostly mentioned under *media literacy* category, was audio recording software. Pre-service science teachers explained that they performed the audio records of their digital stories by the Powtoon. A participant stated his/her opinion on this issue as:

> We added it directly, using the voice recording feature the Powtoon program. We took some sounds via WhatsApp sound recording, we converted them by a program and added it to the Powtoon program (P27).

However, there are also participants who recorded audio using WhatsApp (P24) and the phone's voice recorder feature (P32). They preferred a quiet environment while performing audio recording and managed the process. A participant expressed his/her opinion as:

> We made sound recordings in a quiet environment, because when we insert it to the program, sometimes it sounds like there are other sounds in the background and we didn't let it happen (P16).

Learning and innovation skills theme consisted of *critical thinking and problem-solving* and *collaboration* categories. The problems and the experiences in the process were put under *critical thinking and problem solving* category. Pre-service science teachers experienced a number of problems while preparing the digital stories and they were able to solve these problems. Regarding the problems of pre-service science teachers, it is seen that they mostly stemmed from the program they use. The opinion of a participant on this issue is as follows:

> The biggest problem we experienced in this process was the character and visual elements. In Powtoon, we didn't find the appropriate visual and character for our script, so we had to export pictures and videos. In addition, both character types and the properties of the character we selected were limited, for example we could only use a single sitting character on a scene showing that he was doing a microscope examination and his hands were on the keyboard. Therefore, we couldn't create most of the scenes we dreamed for our script in Powtoon (P40).

Another participant expressed his/her opinion as:

> It was a very tiring and instructive process (P15).

Support and support types codes were under *collaboration* category. Pre-service science teachers received help from friends in this process. A participant stated his/her opinion on this issue as:

> Usually we took care of everything together with my friends from the group, we consulted with other close friends in only a few points (P33).

They stated that they got support from the teachers along with the friends from the group as follows:

> We got support from our lecturer and computer teacher in cooperation with our group friends (P21).

Regarding the type of support that pre-service science teachers needed, it is seen that it was technical. A participant stated his/her opinion on this issue as:

> We got help from our computer teacher on adding sound. The sounds we inserted were present in all the scenes. We couldn't add sound to each scene separately. We got help on how to add the sounds we recorded to the relevant scene (P34).

Life and career skills theme consisted of *flexibility and adaptation* and *productivity and responsibility* categories. Making choice was a code included under *flexibility and adaptation* category. In the process of digital story preparation, pre-service science teachers have decided about the scientist to work on in a flexible way. A participant explained his/her choice as:

> While reviewing various scientists, we've seen Edmund Halley. We wondered and decided to explore his life. Later, the life story of scientist attracted our attention. We said "we should make the digital story of this scientist" (P20).

whereas another one explained it as:

> I've been curious about Nicola Tesla since I was a kid. I chose Nikola Tesla for this homework because I thought it would be both fun and useful for me (P12).

Under the category of *productivity and responsibility*, opinions about the process were mentioned. A participant stated his/her opinion as:

> The process was quite disciplined. We tried to do our best. We laughed at some point, but we never left our seriousness and made an educational, interesting video (P38).

Another opinion mentioned under *productivity and responsibility* category was that this process contributed to their professional development. A participant expressed his/her opinion on this issue as:

> We both got the experience of writing stories in digital media, and we learned a lot of new and innovative programs that can be used in our teaching life in the future. We implemented many activities in the programs and I think it contributed to our development in this respect (P7).

A participant explained his/her opinion that the digital story preparation process supported the use of technology in their courses as follows:

> Because of our field, we have to know the technology and use it in the most effective way. We used the technology efficiently by preparing a digital story (P5).

Pre-service science teachers stated that digital story preparation process provided productivity. A participant stated his/her opinion on this issue as:

> Most importantly, I think it is one of the first steps in creating something for another age group, not for ourselves (P14).

whereas another participant expressed his/her idea as:

> Powtoon is an application very enjoyable to use. I have both learned and created a very instructive story (P12).

Under the category of *productivity and responsibility*, pre-service science teachers emphasized that digital stories can be used as a different material in the classroom. A participant said on this issue:

> Their contribution to me is, it may be a material that can be used in the courses (P31).

Pre-service science teachers also pointed that digital story preparation process provided them the opportunity to use their imagination and creativity. The opinion of a participant on this issue was:

> Narrating the process of the invention of our scientist allowed us to use our imagination (P27).

Discussion and Conclusion

With this research, it was intended that pre-service science teachers prepare digital stories about scientists' lives, bringing their field knowledge and technology skills together. Investigation of the experiences gained and the quality of the final product in terms of different variables were conducted at the end of the process. For this purpose, Digital Storytelling Rubric in Educational Context, Reflection Form and Digital Logs were used as data collection tools. This section contains the discussions and suggestions developed based on the findings.

Nineteen digital stories, which have been developed by pre-service science teachers individually and in groups, were reviewed independently by two raters. The features required in digital stories were evaluated according to the Digital Storytelling Rubric in Educational Context (weak, medium, and good) that consists of 17 items, in three categories. Weighted Kappa coefficients of the categories developed by Sarica and Usluel (2016) showed a substantial or almost perfect agreement between the two raters in most of the criteria. According to this result, it can be said that product evaluation results were valid and reliable. More than half of the digital stories prepared by pre-service science teachers were found to be at high quality level.

The analysis of the data obtained from the reflection forms revealed that pre-service science teachers used the characteristics of scientific knowledge in their digital stories and they included DNA, electricity, round form of the world, solar system-space and gene concepts most. In addition, pre-service teachers stated that they used these concepts in their digital stories mostly as the scene content. In the literature, it was also reported that digital storytelling is effective in increasing students' knowledge about the topics they investigate (Gakhar, 2007; Koltuk & Kocakaya, 2015). *Scientific knowledge includes logical, mathematical or experimental inferences* theme, which is one of the nature of science themes in the perception of scientific knowledge process, has been frequently emphasized by pre-service teachers. The nature of science theme that was least mentioned by pre-service teachers was *Scientific knowledge is changeable*. The review of the literature revealed that students cannot understand that scientific knowledge can change (Griffiths & Barman, 1995; Griffiths & Barry, 1993; Ryan & Aikenhead, 1992). Moreover, there are many studies in the literature indicating that science teachers and pre-service science teachers has naïve views about the nature of science (Abd-El-Khalick, 2005; Abd-El-Khalick & Lederman, 2000; Dogan-Bora, 2005; Yakmaci, 1998). Teachers' understanding of the nature of science is parallel to the students' understanding of the nature of science. There are also studies that show that the changeability of scientific knowledge is a characteristic that can be developed rapidly (Abd-El-Khalick & Akerson, 2004; Morrison, Raab, & Ingram, 2009).

Pre-service science teachers mostly stated that they used the characteristics of scientific knowledge and visual media when transferring their stories to digital media. Studies indicating that digital stories improve students' media skills are available in literature (Ohler, 2006; Robin, 2008). This finding of the research seems to support the literature. Participants emphasized that scientists often made observations, experiments, research and draw inferences to reach scientific knowledge. While pre-service teachers presented a variety of ways through which scientists reach scientific knowledge, they did not reflect this diversity for themselves. Pre-service teachers stated that they mostly do research to reach scientific knowledge. Regarding the contribution of creating digital stories, pre-service teachers mostly stated that it contributed to their research skills.

Pre-service teachers also stated that digital stories provided them technical skills. According to the results of the study conducted by Koltuk and Kocakaya, (2015), students stated that they were doing research about the

subjects in modern physics and the scientists who were dealing with physics, using computer, making audio-visual-music-graphics search from the internet, sharing videos in YouTube and using technology effectively. In a study by Dogan (2012), it was reported that digital stories improve students' technology skills. The findings of the study by Dogan (2012) and Koltuk and Kocakaya (2015) are consistent with the findings of this study.

Findings obtained from digital logs were reviewed in terms of 21st century skills. The logs were grouped under the themes of *information, media and technology skills*, *learning and innovation skills*, and *life and career skills*. *Information literacy, information and communication technology literacy, and media literacy* categories were under the theme of *information, media and technology skills*. Pre-service science teachers stated that in the preparation of digital story, they reviewed science course curriculum in terms of learning objectives and they researched life stories of scientists in detail. The participants explained that in the process of digitizing their scenarios, they first created scenes, then they looked for appropriate visuals and they performed a voiceover in the final stage. Regarding the products prepared by pre-service teachers, it is observed that the used media items (text, sound, visual) were directly related to the content and supported the content. The studies in the literature also support that the images, sounds and texts unrelated to the scenario should not be used in the digital story; if used, it would decrease the effectiveness of the prepared content (Kilinc & Yuzer, 2015; Uslu-Pehlivan, Erden, & Cebesoy, 2017).

Another finding from digital logs is that pre-service science teachers performed their voice recording in different ways. They stated that they used visual and audio media to digitalize the scenarios they prepared about scientists. Participants explained that their digital stories were recorded using Powtoon program. They preferred a quiet environment while making sound recordings. They had some problems while preparing the digital story and they were able to solve these problems. In a study conducted with the high school students by Koltuk and Kocakaya (2015), it was found that they had some difficulties while creating the digital stories, developed suggestions to solve these problems. This shows that digital stories contribute to the development of problem-solving and critical thinking skills of 21st century skills.

The literature review also showed that digital stories contribute to critical thinking skills (Robin, 2008; Yang & Wu, 2012) and problem solving ability (Yuksel, Robin, & Mcneil, 2011). Regarding the problems of pre-service science teachers, they stated that some of the problems they faced stemmed from the features of the program they used. In a study conducted by Uslu-Pehlivan et al. (2017), pre-service teachers experienced some difficulties in the process of creating digital stories. These problems were grouped as technical difficulties, problems experienced in the story-building process and the difficulties experienced in terms of time. In addition, in a study conducted by Kobayashi (2012) most of the pre-service teachers reported that they have experienced technical difficulties. The findings of this study support the literature (Kobayashi, 2012; Uslu-Pehlivan et al., 2017). In this process, pre-service science teachers received help from their friends and technical support from the researchers. These findings of the study are in line with the findings of the studies by Koltuk and Kocakaya (2015) and Sadik (2008).

Analysis of the data from digital logs also suggest that, in the process of digital story preparation, pre-service science teachers have decided about the scientist to work on in a flexible way. Pre-service science teachers stated that the digital story preparation process contributed to their professional development, provided support for the development of their technological competences, provided productivity, and provided different materials preparation experience. In a study by Bullock (2013), it was reported that experiences that are clearly positioned around digital technologies can greatly reinforce a positive bias towards the use of technology for teaching. In the literature, there are several studies emphasizing that the development of digital story improves the productivity skills (Jakes, 2006; Koltuk & Kocakaya, 2015; Robin, 2008). In addition, pre-service science teachers also stated that the digital story preparation process provided them the opportunity to use their imagination and creativity. In a study by Uslu-Pehlivan et al. (2017), pre-service teachers stated that preparing digital stories was educative, fun and creative. The findings of the study by Uslu-Pehlivan et al. (2017) support the findings of this study.

In conclusion, from the data, it was found that the digital stories prepared by science pre-service teachers were at "high" or "medium" quality level. This finding coincides with the finding obtained from the reflection form that digital story preparation provides research and technical skills. In addition, the findings obtained from diaries that digital story preparation help participants gaining 21st century skills support this result. In the reflection form findings, the participants stated that they used scientific concepts in their digital stories and transferred the features of scientific knowledge to digital media and scenarios. When the scenarios and products prepared by the participants were examined, it was seen that they confirmed this finding.

Recommendations

Findings from digital logs are in line with the existing literature in terms of supporting the development of 21st century skills (Karatas et al., 2016; Koltuk & Kocakaya, 2015; Robin, 2006; Tunc & Karadag, 2013). Similar studies can be conducted with different working groups and compared with this study. Studies can be carried out by using rubric which is one of the alternative measurement and evaluation tools. In addition, experimental studies can be carried out in which the digital stories prepared by pre-service science teachers are applied in the science courses in the related units at different grade levels and the effects of these applications in terms of various variables can be analyzed. Further studies on the use of digital stories produced by pre-service teachers in real classroom settings can be conducted and student outcomes might be analyzed.

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References

Abd-El-Khalick, F. (2005). Developing deeper understandings of nature of science: The impact of a philosophy of science course on preservice science teachers' views and instructional planning. *International Journal of Science Education*, *27*(1), 15–42.

Abd-El-Khalick, F., & Akerson, V. (2004). Learning as conceptual change: Factors mediating the development of preservice elementary teachers' views of nature of science. *Science Education*, *88*(5), 785–810.

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of the nature of science: A critical review of the literature. *International Journal of Science Education*, *22*(7), 665–701.

Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education*, *82*(4), 417–437.

Akerson, V. L., Morrison, J. A., & McDuffie, A. R. (2006). One course is not enough: Preservice elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching*, *43*(2), 194–213.

Armat, M., Assarroudi, A., Rad, M., Sharifi, H., & Heydari, A. (2018). Inductive and Deductive: Ambiguous Labels in Qualitative Content Analysis. *The Qualitative Report*, *23*(1), 219-221. Retrieved from https://nsuworks.nova.edu/tqr/vol23/iss1/16

Bati, K., & Kaptan, F. (2017). Model tabanlı sorgulama yaklaşımının, öğrencilerin bilimin doğası görüşlerine etkisi [The effect of model based inquiry towards students' views of nature of science]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 32*(2), 427–450.

Benmayor, R. (2008). Digital storytelling as a signature pedagogy for the new humanities. *Arts and Humanities in Higher Education*, *7*(2), 188–204.

Bullock, S. M. (2013). Using digital technologies to support self-directed learning for preservice teacher education. *Curriculum Journal*, *24*(1), 103–120.

Clarke, R., & Adam, A. (2011). Digital storytelling in Australia: Academic perspectives and reflections. *Arts and Humanities in Higher Education*, *11*(1-2), 157–176.

Cohen, J. A. (1960). A coefficient of agreement for nominal scales. *Educational and psychological measurement*, *20*(1), 37–46.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five traditions* (2nd ed.). London: Sage.

Dogan, B. (2012). Educational uses of digital storytelling in K-12: Research results of digital storytelling contest (DISTCO) 2012. In P. Resta (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2012* (pp. 1353-1362). Chesapeake, VA: AACE.

Dogan, N., Cakiroglu, J., Cavus, S., Bilican, K., & Arslan, O. (2011). Öğretmenlerin bilimin doğası hakkındaki görüşlerinin geliştirilmesi: Hizmetiçi eğitim programının etkisi. [Developing science teachers' nature of science views: The effect of in-service teacher education program]. *Hacettepe University Journal of Education*, *40*, 127–139.

Dogan-Bora, N. (2005). *Türkiye genelinde ortaöğretim fen branşı öğretmen ve öğrencilerinin bilimin doğası üzerine görüşlerinin araştırılması [Views on Turkey to investigate the nature of science in general high school science teacher and student branch]* (Unpublished doctoral dissertation). Gazi University, Ankara.

Duveskog, M., Tedre, M., Sedano, C. I., & Sutinen, E. (2012). Life planning by digital storytelling in a primary school in rural Tanzania. *Educational Technology & Society*, *15*(4), 225–237.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of advanced nursing*, *62*(1), 107-115.

Gakhar, S. (2007). The influence of digital storytelling experience on pre-service teacher education students' attitudes and intentions. Masters thesis, Iowa State University, USA.

Gocen, G. (2014). *Dijital öyküleme yönteminin öğrencilerin akademik başarı ile öğrenme ve ders çalışma stratejilerine etkisi* (Unpublished Master's Thesis). Mugla Sıtkı Kocman University, Mugla.

Griffiths, A. K., & Barman, C. (1995). High school students' views about the nature of science: Results from three countries. *School Science and Mathematics, 95*, 248–255.

Griffiths, A. K., & Barry, M. (1993). High school students' views about the NOS. *School Science and Mathematics*, *93*(1), 35–37.

Hartley, J., & McWilliam, K. (2009). *Story Circle: Digital Storytelling around the World*. Wiley-Blackwell, Hoboken, NJ.

Hoban, G., Nielsen, W., & Shepherd, A. (2015). *Student-generated digital media in science education: Learning, explaining and communicating content*. New York, NY: Routledge.

Jakes, D. (2006, March). Standards-proof your digital storytelling efforts. *TechLearning* Retrieved May 3, 2019, from http://www.techlearning.com/news/0002/standardsproof-your-digital-storytelling-efforts/57983

Jakes, D. S., & Brennan, J. (2005). Capturing stories, capturing lives: An introduction to digital storytelling. Retrieved May 3, 2019, from http://www.jakesonline.org/dstory_ice.pdf

Karatas, S., Bozkurt, S. B., & Hava, K. (2016). Tarih öğretmeni adaylarının öğretim ortamlarında dijital hikâye anlatımı etkinliğinin kullanımına yönelik görüşleri. [The perspective of history pre-service teachers' towards the use of digital storytelling in educational environments]. *International Journal of Human Sciences*, *13*(1), 500–509.

Khishfe, R. (2008). The development of seventh graders' views of nature of science. *Journal of Research in Science Teaching*, *45*(4), 470–496.

Kilic, G. B., Haymana, F., & Bozyilmaz, B. (2010). İlköğretim fen ve teknoloji dersi öğretim programının bilim okuryazarlığı ve bilimsel süreç becerileri açısından analizi. [Analysis of the elementary science and technology curriculum of Turkey with respect to different aspects of scientific literacy and scientific process]. *Eğitim ve Bilim*, *33*(150), 52–63.

Kilinc, A. G. H., & Yuzer, T. V. (2015). Açık öğrenme sistemlerinde dijital öykülemeden faydalanmak [Benefit from the digital storytelling in the open learning system]. *Eğitim ve Öğretim Araştırmaları Dergisi, 4(1),* 243–250.

Kobayashi, M. (2012). A digital storytelling project in a multicultural education class for pre-service teachers. *Journal of Education for Teaching*, *38*(2), 215–219.

Kocaman-Karoglu, 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]. *Eğitim Teknolojisi Kuram ve Uygulama*, *5*(2), 89–106.

Koltuk, N., & Kocakaya, S. (2015). 21. yüzyıl becerilerinin gelişiminde dijital öykülemeler: Ortaöğretim öğrencilerinin görüşlerinin incelenmesi. [Digital storytelling for developing 21st century skills: From high school students' point of view]. *Eğitim ve Öğretim Araştırmaları Dergisi*, *4*(2), 354–363.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*, 159–174.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In Abell, S. K., & Lederman, N. G. (Eds.), *Handbook of research on science education* (pp. 831-879). London: Lawrence Erlbaum Associates.

Lederman, N. G., Abd- El- Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, *39*(6), 497–521.

Lederman, N., & Niess, M. (1997). Less is more? More or less. *School Science and Mathematics*, *97*(7), 341–343.

Leonard, A. A., Elizabeth, F., & Marta, K. (2010). *V-Learning: Distance education in the 21st century through 3D virtual learning environments*. New York: Springer Science & Business Media.

Lowenthal, P. R., & Dunlap, J. C. (2010). From pixel on a screen to real person in your students' lives: Establishing social presence using digital storytelling. *The Internet and Higher Education*, *13*(1-2), 70–72.

Malita, L., & Martin, C. (2010). Digital storytelling as web passport to success in the 21st century. *Procedia Social Behavioral Sciences 2*, 3060–3064.

Miles, M. B., & Huberman, M. A. (1994). *An expanded sourcebook qualitative data analysis.* London: Sage.

Mills, A. J., Durepos, G., & Wiebe, E. (2010). *Thematic analysis. Encyclopedia of case study research*. Thousand Oaks: SAGE Publications.

Ministry of National Education [MEB] (2013). *İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı [Primary education institutions (primary and secondary schools) science courses (3, 4, 5, 6, 7 and 8 grades) curriculum]*. Ankara: Talim Terbiye Kurulu Başkanlığı.

Ministry of National Education [MEB] (2016). STEM Eğitimi Raporu [STEM Education Report]. Ankara: YEGİTEK.

Morgan, H. (2014). Using digital story projects to help students improve in reading and writing. *Reading Improvement, 51*(1), 20–26.

Morrison, J. A., Raab, F., & Ingram, D. (2009). Factors influencing elementary and secondary teachers' views on the nature of science. *Journal of Research in Science Teaching, 46*(4), 384–403.

National Research Council [NRC] (1996). *National science education standards.* Washington, DC: National Academy Press.

Nilsson, M. E. (2008). Digital storytelling as a tool in education. In T. Hansson (Ed.), *Handbook of research on digital information technologies: Innovations, methods, and ethical issues* (pp. 131–145). Hershey: IGI Global.

Ohler, J. (2006). The world of digital storytelling. *Educational Leadership, 63*(4), 44–47.

P21 (2015). Partnership for 21st century learning 2015. Retrieved April, 18, 2019, from http://www.p21.org/storage/documents/ P21_framework_0515.pdf

Robin, B. (2006, March). The educational uses of digital storytelling. In Society for Information Technology & Teacher Education International Conference (pp. 709–716). Association for the Advancement of Computing in Education (AACE).

Robin, B. (2008). Digital storytelling: A powerful technology tool for the 21st century classroom. *Theory into practice, 47*(3), 220–228.

Robin, B. R. (2016). The power of digital storytelling to support teaching and learning. *Digital Education Review, 30*, 17–29. Retrieved from http://revistes.ub.edu/index.php/der/article/view/16104

Ryan, A. G., & Aikenhead, G. S. (1992). Students' preconceptions about the epistemology of science. *Science Education, 76*, 559–580.

Sadik, A. (2008). Digital storytelling: A meaningful technology-integrated approach for engaged student learning. *Educational Technology Research and Development, 56*(4), 487–506.

Sarica, H. Ç., & Usluel, Y. K. (2016). Eğitsel bağlamda dijital hikâye anlatımı: Bir rubrik geliştirme çalışması [Digital storytelling in the educational context: A rubric development study]. *Eğitim Teknolojisi Kuram ve Uygulama, 6*(2), 65–84.

Tunc, Ö. A., & Karadag, E. (2013). Postmodernden oluşturmacılığa dijital öyküleme. [Digital storytelling to the postmodern constructivism]. *Eğitim ve Öğretim Araştırmaları Dergisi, 2*(4), 310–315.

Uslu-Pehlivan, E., Erden, M. K., & Cebesoy, Ü. B. (2017). Öğretmen adaylarının dijital öykü oluşturma deneyimleri. [Digital story creation experiences of pre-service teachers]. *Usak University Journal of Social Sciences, 10*, 1–22.

Valkanova, Y., & Watts, M. (2007). Digital story telling in a science classroom: Reflective self-learning (RSL) in action. *Early Child Development and Care, 177*(6-7), 793–807.

Wang, D., He, L., & Dou, K. (2014). StoryCube: Supporting children's storytelling with a tangible tool. *The Journal of Supercomputing, 70*(1), 269–283.

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 & Society, 14*(4), 181–191.

Yakmaci, B. (1998). *Science (biology, chemistry and physics) teachers' views on the nature of science as a dimension of scientific literacy* (Unpublished Master's Thesis). Bogazici University, Istanbul.

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

Yuksel, P., Robin, B., & McNeil, S. (2011, March). Educational uses of digital storytelling all around the world. In *Society for Information Technology & Teacher Education International Conference* (pp. 1264–1271). Association for the Advancement of Computing in Education (AACE).

Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science education*, *86*(3), 343–367.

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