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The opinions of prospective teachers on the design and use of digital educational comics as a technological teaching material in science education

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Abstract

In this study, it is aimed to examine the opinions of prospective teachers about the design of digital educational comics designed within the scope of science education and their use in educational environments. This study, conducted with 129 prospective teachers determined by purposeful sampling method, is suitable for a case study. After the prospective teachers received a four-hour training on digital educational comics, they designed their digital educational comics for two weeks. After the design process, their views on design and applicability of these designs were determined with structured survey forms. The collected data were analyzed in four stages with the MAXQDA-20 program in accordance with content analysis. In the study, it was determined that the prospective teachers had difficulties at the point of designing visual and graphical elements in digital environment during the digital educational comic design process and that they were negatively affected by technological insufficiencies. In addition to this, the prospective teachers expressed the views on the need to pay attention to the digital educational comic's subject-acquisition relationship, scientific knowledge and the relationship of this knowledge with daily life. It is recommended to increase the use of technology-oriented alternative teaching materials such as digital educational comics in science education from preschool to undergraduate level instead of traditional teaching materials.

Keywords: Digital educational comics; science education; prospective teachers

1. Introduction

In the 21st century, the century we live in, technology shows itself in the field of education as in every field. Today, it is aimed to create modern learning environments with technological learning tools designed to enrich the teaching process. Teachers benefiting from technological learning tools enables more students to participate in the lesson (Tekmen, 2016), and ensures that what is learned becomes permanent (Akkaya, 2013; Aşçı, 2020) by increasing the efficiency of learning-teaching activities (Yılmaz, Üredi & Akbaşlı, 2015). At this point, it gains importance for teachers to have the

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competence to use technological fields and to be open to new developments and experiences in this field.

1.1. Digital Educational Comics

Digital educational comics basically started out from bringing an educational side to digital comics. Digital comics, on the other hand, were created by moving comics to digital media through pulling them away from the printed form we are familiar with (Sömen & Akcanca, 2020). When the development in the historical process is examined, it is possible to say that the fact that comics with a fluctuating past can appear as digital comics is actually the result of the interest in comics. At this point, it is thought that discussing the development of comics in the historical process will be useful in relating and interpreting the educational and digital transformation of them.

Although it is based on the first cave paintings according to some sources (McCloud, 1993; McCloud & Manning, 1998), Swiss Rudolphe Töpffer published the first example of the real comic in history in 1840 (Gündüz, 2004). Afterwards, comics began to spread in many European countries such as France and Germany, as well as in America, and attracted attention all over the world and created a fan base for itself (Çetin, 2010; Gündüz, 2004; Olson, 1993; Türkal, 2018). When it was arrived to the 1950s, it became the target of criticism due to its sexuality and violence content, and the interest in comics decreased. After the restrictions placed on the publishing and distribution rules of comic books, the comics gaining an artistic side in the 1970s attracted the filmmakers in the following years, and the stories of the comic book heroes were turned into movies (Çetin, 2010; Türkal, 2018).

The idea that comics might have an educational side emerged from W. W. D. Sones (1944) and many educators making a series of studies on the use of comics on education (Berkowitz & Packer, 2001; Marianthi, Boulodakis & Retalis, 2016; Parsons & Smith, 1993). Nowadays, educational comics are published as an alternative learning tool for different subjects in various disciplines, as they have the ability to increase children's desire to read thanks to their pictures, short narratives, excitement and entertainment elements instead of long narratives that reduce students' motivation (Lazarinis, Mazaraki, Verykios & Panagiotakopoulos, 2015; Lesmono, Bachtiar, Maryani & Muzdalifah, 2018; Topkaya, 2016). One of these disciplines that enable the use of new educational resources to encourage students' learning is science education (Morel, Peruzzo, Juele & Amarelle, 2019).

The preference of digital educational comics as alternative tools in science education (Koutníková, 2017), it is thought to be useful in providing a potential environment especially for children (Tatalovic, 2009). Digital educational comics help explain a world consisting of abstract science concepts that students describe as complex (Akcanca, 2020; Morel et al., 2019). Educational comics help especially children to improve their science

literacy by increasing their ability to interpret science subjects at an early age (Olson, 2008; Tilley, 2008). With the comics used in the educational process, students' interest in the lesson increases, it becomes easier to focus their attention on the message to be given, and their creativity development is positively affected (Jampel et al., 2018; McCloud, 1993; Phoon, Roslan, Shahrill & Said, 2020). When it is considered these contributions of comics, it has become inevitable to use digital comics (McCloud, 2006), which are more advantageous because they can be arranged in the desired way compared to printed ones, in education process. In this way, teachers can create comic book stories suitable for their outcomes or topics, thanks to the existing web tools (Pixton, Canva, Storyboardthat, etc.).

It is thought that it is important for teachers to be introduced with digital educational comics before starting their profession and during their undergraduate education and to have more extensive knowledge and experience about this teaching tool. In this context, it seems important to determine the opinions of prospective teachers about the design of digital educational comics and their use in educational environments.

1.2. Purpose of the Study

The purpose of this study is determined as to examine the opinions of teachers about the design of digital educational comics which they designed within the scope of science education and their use in educational environments. Within the scope of this purpose, answers to the following questions are sought;

- What are the opinions of the prospective teachers about the difficulties they face while designing digital educational comics?
- What are the factors to be considered when designing digital educational comics according to the opinions of the prospective teachers?
- What are the opinions of the prospective teachers on the benefits of using digital comics in educational environments?
- What are the opinions of the prospective teachers on the use of digital comics in early childhood science education?
- What are the prospective teachers' notional structures about digital educational comics in their cognitive structures?

2. Method

2.1. Research Model

The method of this study conducted within the framework of qualitative research is a case study. Case studies, one of the descriptive research models, aim to provide researchers with comprehensive and detailed information (Lichtman, 2006). Well-

structured case studies are thought to have contextual sensitivity (Patton, 2014). The subject dealt with in case studies is researched with a holistic approach by being examined closely and the focus is on the roles and relationships in the process (Yin, 2003; Yıldırım & Şimşek, 2016). Since there is only one unit of analysis in the research, it is thought that the research is in conformity with the holistic single case pattern (Yıldırım & Şimşek, 2016). For this reason, a case study was preferred in this study, which aims to reveal the experiences and opinions, by deeply scrutinizing them, of the prospective teachers about digital educational comics.

In the study, it can be seen as a limitation to work with pre-school prospective teachers who continue their education at the second-grade level in the Faculty of Education.

2.2. Workgroup

The research was conducted with a total of 129 second grade prospective teachers who were attending pre-school education in the primary education department of the education faculty of a state university. The study group consists of 99 female and 30 male prospective teachers. Keeping the study group large for a qualitative research can be explained with the necessity of setting the study group as large as possible in order to ensure data saturation and to obtain different opinions from the answers given (Guba & Lincoln, 1982).

Purposeful sampling approach was used in the selection of prospective teachers. It is based on the principle of determining the purposeful sample participants according to their characteristics suitable for the study (Patton, 2014). Basic science education concepts and teaching methods and techniques that will be used to gain these concepts are discussed in the early childhood science education course. In this context, the study group was purposefully chosen from the 2nd graders taking this course.

2.3. Data Collection Tool

In the study, a structured survey form was used with the aim of determining the opinions of prospective teachers about the design of digital educational comics which they designed within the scope of science education and their use in educational environments. With these forms, the questions to be asked within the framework of the purpose were asked in the same way to the entire research group, thus systematic and comparable data were obtained (Yıldırım & Şimşek, 2016). Educational comics and studies on their digital versions were examined in detail in the preparation of the survey form. The determined questions were presented to two academics, one specialized in science education and the other in pre-school education, in order to get expert opinions about ensuring construct and internal validity. The form was finalized after necessary corrections such as reducing the number of questions, changing the expressions and

combining similar questions in a single question were made within the framework of the experts' opinions. The prepared form consists of five questions. Four questions in the form were prepared in regard to the design and use of digital educational comics. The content includes questions about determining the factors to be considered in the design and implementation of digital educational comics, the benefits of their use in educational environments and their use in preschool science education. In the last question, though, "digital educational comics" was chosen as the keyword and the prospective teachers were asked to produce different words that they thought were related to it.

2.4. Data Collection Procedure

Prospective teachers' volunteerism to participate in the research was taken as a basis, and the process was initiated by informing that the research results would only be used for scientific purposes. Prospective teachers received a four-hour training before proceeding to the digital educational comic design process. Within the scope of this training, it was aimed for them to get information about what comics are, their use in educational environments, their digital use in the transformational process, and their handling as an alternative teaching material in science education. After the training, the prospective teachers were asked to design a short digital educational comic book that could be used in science education by choosing one of the concepts or topics in Table 1.

Table 1. Topics to be dealt with in digital educational comics

Topics to be dealt with in digital educational comics	
Wind	Air Pollution
Fire	Erosion
Spring	Forest
Rainbow	Renewable Energy
Lightning/Thunder	Traffic Problem
Global Warming	Weather Events
Volcanos	Recycling
Our Body	Environmental Pollution

When looked at Table 1, it is seen that the topics to be dealt with are determined from the environment and environmental issues. The reason for this is that it is considered important to include information about the environment and environmental problems in lectures or researches. In this study, with the thought that educational comics have a very important place for individuals to gain awareness and take responsibility for environmental issues, it is aimed to increase the awareness of the prospective teachers about environmental problems in the educational comics they will design and to actively use the information they have acquired during the preparation process in their daily lives. The design process of comics took two weeks within the scope of the determined

concepts and topics. An example of a digital educational comic book designed for "Environmental pollution" by one of the prospective teachers is included in Figure 1.

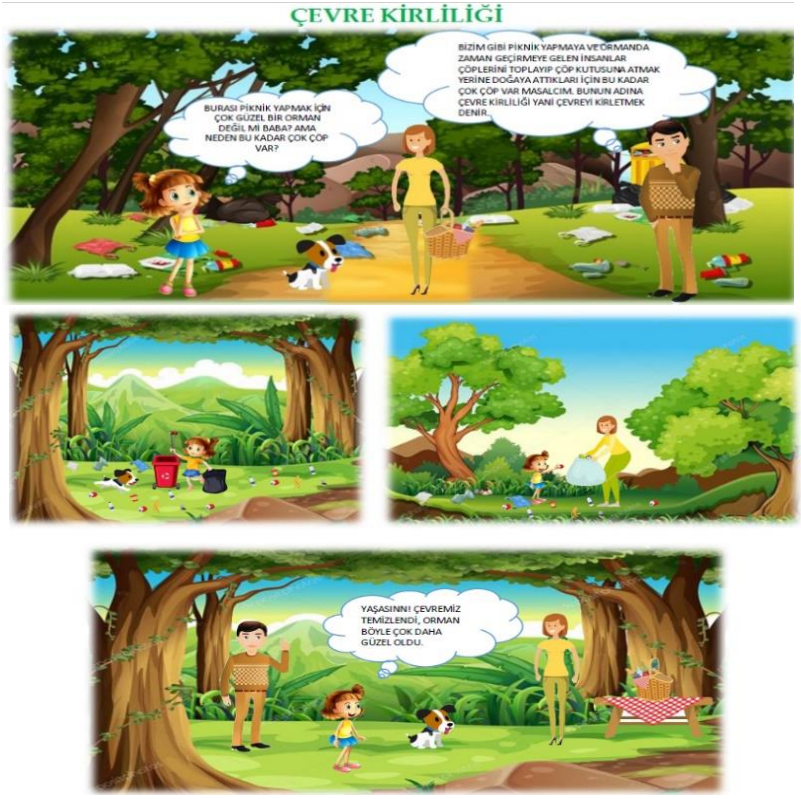


Figure 1. Example of a digital educational comic designed by prospective teachers

After the design process, structured survey forms were delivered to prospective teachers. The prospective teachers were given a time frame of approximately 40 minutes to fill in the forms.

2.5. Data Analysis

The data obtained by the prospective teachers filling out the structured survey form were analyzed in accordance with the content analysis with the MAXQDA-20 program. While trying to reach meaningful explanatory concepts and relationships from the data collected within the scope of the purpose of the study, a four-stage content analysis process was followed (Yıldırım & Şimşek, 2016). First of all, all data were reviewed in detail and similar expressions were coded. Later, the themes representing the codes were found, and finally, the emerged codes and themes were organized, the findings were defined, and interpreted with graphical displays. Instead of the names of the prospective teachers, it was named as P1, P2 ... (Participant 1). Besides, the findings were

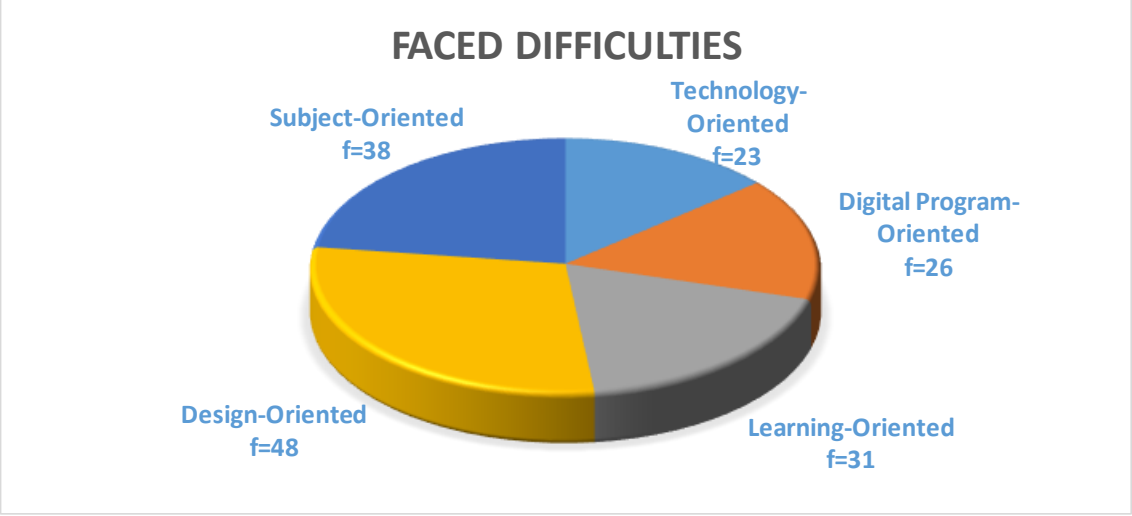
interpreted by placing direct quotes from different prospective teachers under the graphics.

2.6. Validity and Reliability

Since the research is a qualitative research, validity-reliability is considered differently from quantitative studies (Yıldırım & Şimşek, 2016); the reliability, the accuracy of the results and the competence of the researcher should be mentioned (Krefting, 1991; Patton, 2014). In the study, in order to ensure its verification, the results of the collected data were tried to be systematically expressed in a clear, simple and understandable language. The transferability criterion, on the other hand, was tried to be met by including direct quotations from prospective teachers. In addition, Miles and Huberman's (2016) Consensus / (Consensus + Disagreement) x 100 formula was used at the point of ensuring the reliability among the coders of the data obtained in the study, and this concordance rate was determined as 84%.

3. Results

The themes obtained from the opinions of the prospective teachers regarding the difficulties they faced in the design of digital educational comics within the scope of the research are given in Graphic 1.



Graphic 1. Difficulties prospective teachers faced in the design of digital educational comics

When Graphic 1 was examined, it was found that prospective teachers mostly (f=48) had design-oriented difficulties while designing digital educational comics. Most of the prospective teachers who expressed that they had design-oriented difficulties stated the difficulties they experienced during drawing and background design. Subject-oriented difficulties (f=38) are also common difficulties experienced by prospective teachers.

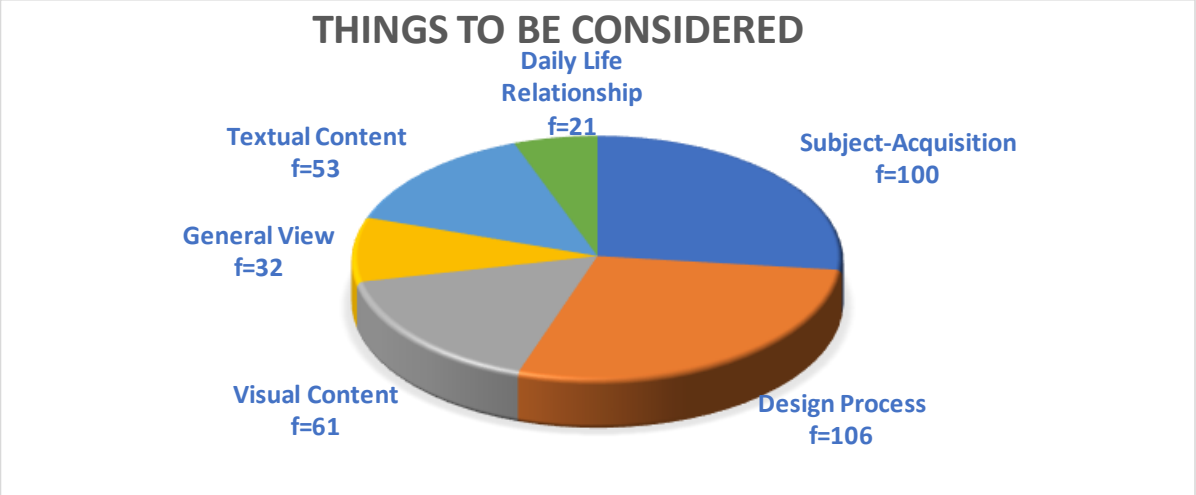
Among these difficulties; there are identifying original subject and characters and creating dialogue and fiction. In addition to this, having problems in establishing the subject-acquisition relationship based on the age level from the difficulties experienced in learning-oriented (f=31) is among the difficulties faced by the prospective teachers. Most of the prospective teachers who stated that they experienced digital program-oriented difficulties (f=26) showed digital programs being paid and being insufficient in themselves as reasons. In addition, technology-oriented difficulty (f=23) was found to be the least difficulty faced by prospective teachers. It is among the findings that the source of these difficulties of prospective teachers is the preparation of the programs in digital environment and the insufficiency of technological facilities. In this context, the opinions of the prospective teachers are as follows:

P12: "*Creating the text part because it was challenging to create a text that the age group could understand.*"

P76: "*The part that I had the most difficulty while preparing the comic book was how I would explain the subject according to the age group of the children. I needed to explain the concept of lightning in a way that children can understand, and this was the most challenging part for me. Almost all children are afraid of lightning, and while I was preparing my story, I told the children that lightning was actually not a bad event, but a natural event, and for children to learn this concept I needed to tell a story that they would understand. Creating the story was the hardest part.*"

P91: "*I had a hard time as I had never prepared a comic book before. Along with this, adjusting different facial expressions and gestures of all the scenes one by one challenged me a bit. Also, since everything I wanted was not included in the program where I prepared the comic book, I had to liken it to different objects even though I wanted something else.*"

Within the scope of the research, the themes obtained from the opinions of the prospective teachers about the elements that should be considered in the preparation of digital educational comics are given in Graphic 2.



Graphic 2. Prospective teachers' opinions regarding the things to be considered while preparing digital educational comics

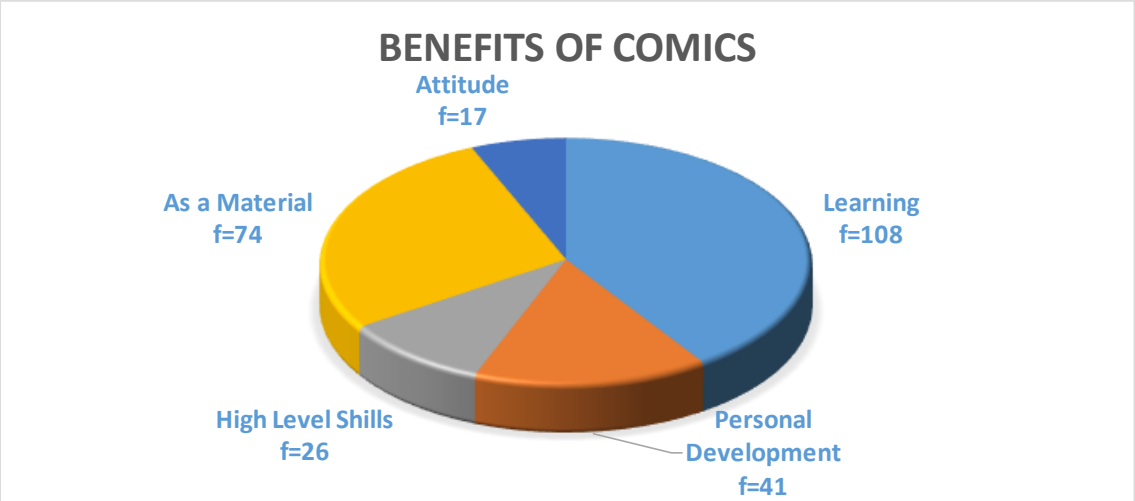
When Graphic 2 was examined, prospective teachers stated that while preparing their digital educational comics, attention should be paid mainly to the design process (f=106) and subject-acquisition (f=100) dimension. During the design process, opinions were expressed about paying attention to the age range and development levels of the educational comic addresses. In addition, it was stated that the characters and fiction in the comics prepared have an important place among the elements that need to be considered. The prospective teachers expressed that their comics' outcome-subject relationship, subject integrity, scientific knowledge and plot are important and need to be paid attention to. Visual content (f=61) depends on the relationship between visual content and acquisition, visual text relationship and visuals. In addition, the textual content (f=53) is related to the simplicity and comprehensibility of the text and dialogues. Besides, it was determined that the prospective teachers mentioned the importance of attracting attention and flow in the general view (f=32). Moreover, it was stated that daily life relationship (f=21) which has the least ratio among the things need to be considered while designing educational comics of prospective teachers was related to the message desired to be given in the theme content. In this context, the opinions of the prospective teachers are as follows:

P21; "*First of all, it is necessary to consider the developmental state of the children, then to pay attention to acquisition and content compatibility, the harmony of the visuals and characters, and the harmony with subject desired to convey*."

P98; "*The concepts wanted to be gained should be gained correctly without creating any misconceptions. It should be simplified in a way that children can understand the subject. It should be visually rich, capable of attracting the attention of children*."

P3; "*It is necessary to pay attention to the comic books being educational, the drawings and dialogues constituting a whole and making them more qualified*."

Within the scope of the research, the themes obtained from the opinions of the prospective teachers about the benefits of using digital educational comics in educational environments are given in Graphic 3.



Graphic 3. Prospective teachers' opinions on the benefits of using digital educational comics in educational environments

When Graphic 3 was examined, the opinions of prospective teachers about the benefits of using digital educational comics in educational environments were predominantly at the learning level (f=108). The prospective teachers stated that comics are beneficial in terms of permanent learning, facilitating learning and achieving acquisition by having fun. The benefits of educational comics as a material (f=74) include the sub-components of drawing students' attention to the lesson, their use as an educational tool, and concretizing abstract concepts. In addition to these, the benefits of educational comics in personal development (f=41) dimension are among the findings. It was determined that prospective teachers mentioned that visual memory could be improved and awareness about different subjects could be increased by means of educational comics. It has also been stated that comics are beneficial in terms of modeling. In addition to these, in terms of high-level skills (f=26), prospective teachers stated that their comics appeal to different senses and that creativity skills and imaginations can be developed through these materials. In the attitude dimension (f=17), prospective teachers mentioned that educational comics can be effective in developing a positive attitude towards science lesson and reading books. In this context, the opinions of the prospective teachers are as follows:

P7; "*Today, visuality has a dominance that covers our entire life. As comics are visually powerful tools, they will be very useful for children to learn easily and permanently.*"

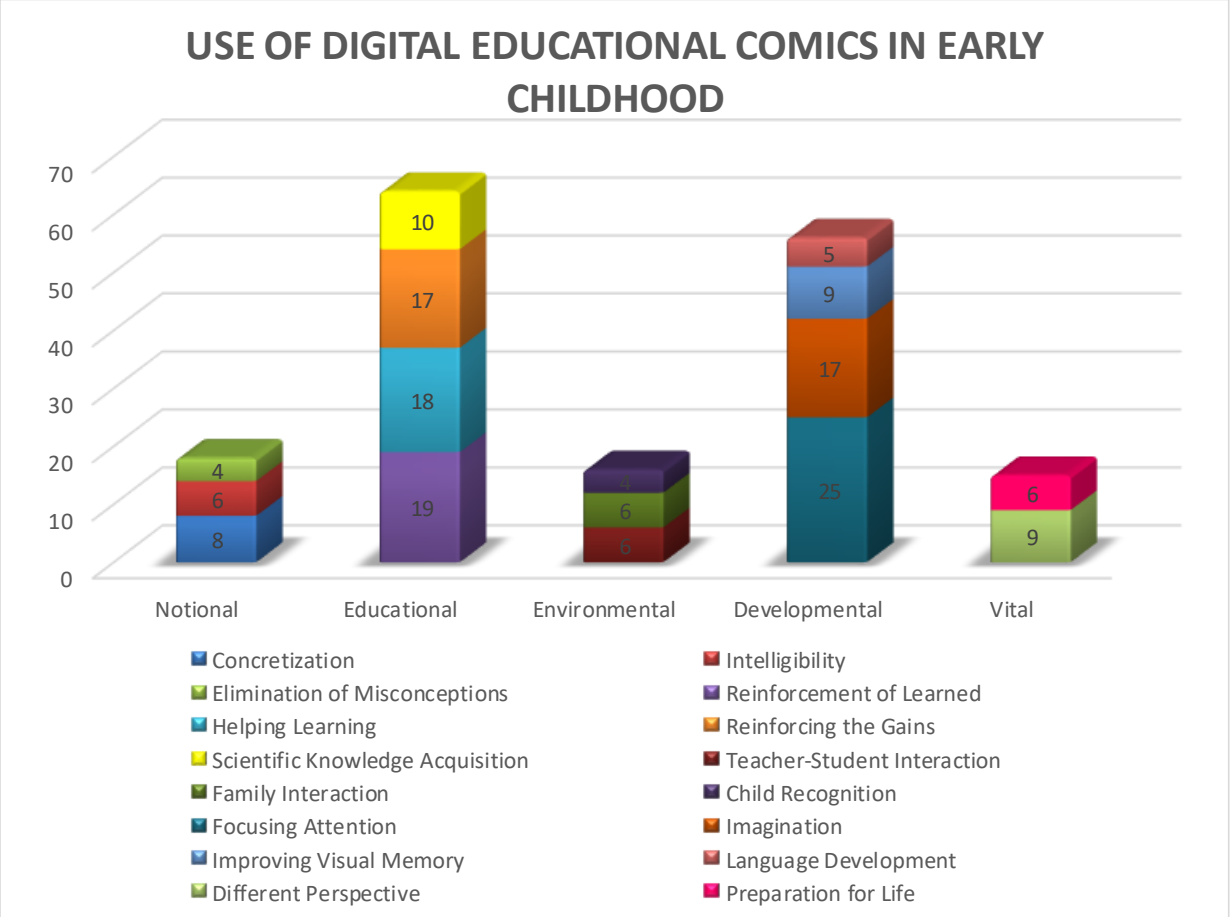
P27; "*I think it can provide economy in terms of time, I think it will appeal to both visual and cognitive mental areas of children at the same time, and I can say that*

children's empathy skills will improve and their creative thinking will develop thanks to comics."

P31; "*We can teach children various behaviors such as being able to interpret, argue and guess without realizing it through visual reading. At the same time, by using comics as a tool, we can easily present the gains that we think to bring the child with a colorful expression.*"

P120; "*The characters in educational comics become models for the child. It allows the child to comprehend the gains and take behaviors easily and willingly.*"

Within the scope of the research, the opinions of prospective teachers about the use of digital educational comics in early childhood are given in Graphic 4.



Graphic 4. Opinions of prospective teachers on the use of digital educational comics in early childhood

When Graphic 4 was examined prospective teachers' opinions about the use of digital educational comics in early childhood stated that they are beneficial mainly in terms of educational (f=64) and developmental (f=56) themes. Under the educational theme, it is thought that it will be useful in helping learning, reinforcing the learned-gains and in scientific knowledge acquisition codes. The prospective teachers emphasized the developmental aspects of the educational comics and focused on the codes of focusing attention, imagination and visual memory. Besides, in the views on the notional (f=18) theme in the use of educational comics, prospective teachers mentioned the codes of concretizing and understanding the concepts and eliminating possible misconceptions. Furthermore, under the environmental theme (f=16), teacher-student interaction, family interaction and child recognition codes are among the findings. Finally, opinions of prospective teachers who focus on vital (f=15) theme about gaining different perspective and preparing for life in early childhood thanks to educational comics were determined. In this context, the opinions of the prospective teachers are as follows:

> P50, "*In early childhood, we cannot directly teach some of the topics and concepts we want to teach. In order for children to grasp, we should achieve the gains we want to bring in different techniques and creative ways in a way that attracts their attention and they can easily grasp. Educational comics is a creative and fun way to teach especially the concepts that are abstract and unfamiliar to children*."

> P52, "*In the early childhood period, children's imaginations enable them to keep the linear world within themselves more alive; likewise, by using it as a method, children are provided with a more understandable and age-appropriate education*."

> P67, "*Children can think with extremely clear perceptions and creatively in early childhood. Whichever issue is dealt with, it is a fact that they will achieve the gains. Explaining children through comics is very effective in preparing them for life. Because they will be conscious children*."

The codes obtained from the last question of the survey form based on the opinions of the prospective teachers were presented by being modeled with the MAXQDA program. The word cloud was used to reveal the conceptual structures of digital educational comics in the cognitive structures of the prospective teachers, and it was designed as a "speech bubble" as it is thought to be related to comics within the scope of the subject. The conceptual structures frequently emphasized by the prospective teachers about digital educational comics are given in Figure 2.

Figure 2. The conceptual structures frequently emphasized by prospective teachers about digital educational comics

In Figure 2, it is seen that the concepts frequently emphasized by prospective teachers are picture, story, fun, gain, character. On the other hand, concept, nature, science, awareness, animation, curiosity appear as concepts that prospective teachers emphasize less frequently.

4. Conclusion and Discussion

The findings obtained from the research were handled within the framework of sub-problems, the results of the research were discussed within the context of the relevant literature.

For the first sub-problem, the opinions of the prospective teachers about the difficulties they encountered while designing digital educational comics were revealed. It was also determined that prospective teachers had design-oriented difficulties in drawing and background design. These concepts that the prospective teachers mentioned point to the graphic elements, which are another element of the comics. Visual elements in comics have an important function in gaining the readers' appreciation, maintaining the existence of comics and keeping the story alive (Sömen & Akcanca, 2020). With this study, it is thought that prospective teachers became aware of the delicate balance between picture and text. Also, the prospective teachers received help from digital programs while designing their comics. It is thought that their new acquaintance with these digital programs caused them to have difficulties in drawing.

Furthermore, it was determined that the prospective teachers had difficulty in finding an original subject and determining the characters while designing digital educational comics. Characters are the most important element of the comic and the story is processed through characters (Cantek, 2014). For this reason, it is very important to determine the characters correctly. In the study, it is thought that prospective teachers realized the importance of this element in the process of designing a comic book. In addition, the subject of the educational comics has a special importance in terms of using to support teaching (Gülersoy & Türkal, 2020). The originality of the subject in comics has a great role in attracting prospective teachers' attention. In the research, the prospective teachers were given some topics related to the environment and environmental problems, and they were asked to design their educational comics based on the topic or concept they chose. This situation may have caused prospective teachers to have difficulties in finding an original topic by sticking to the determined subject or concept.

Another factor that prospective teachers had difficulty with was determined as forming the fiction. Educational comics should be prepared within a fiction, and should have some features such as space-time, character, relationships, movements, emotions and thoughts, cause-effect relationships (Cantek, 2014; Uslu Üstten, 2014). The prospective teachers' attempts to deal with the subject briefly and concisely may have forced them to fit the fiction into the story. Along with this, it was determined that the prospective teachers thought they had difficulty in establishing the subject-outcome relationship. In her study, Şentürk (2020) suggested to the teachers that they should pay attention to the point of preparing their stories in a way that does not distract from the outcome while designing educational comics. In their research, Gülersoy and Türkal (2020) emphasize that creating educational comics requires a serious accumulation of knowledge and that the elements in comics should be handled in terms of teaching. It is thought that because of the illiteracy of children that are in their early childhood period, the prospective teachers participating in this study may have had difficulties in designing educational comics that are appropriate for their age level and for the relevant outcomes.

It was determined that prospective teachers also experienced technology-oriented difficulties. The prospective teachers referring to the difficulty of preparing comics in a digital environment stated that their technological facilities were insufficient. Archambault and Crippen (2009) found in their study that teachers do not perceive themselves as sufficient in technology knowledge. Tatlı and Akbulut (2017) emphasized that the technological knowledge and skills of prospective teachers can be increased with the trainings to be given in their research results. The fact that prospective teachers tried to design educational comics for the first time in digital environment, and some prospective teachers tried to do this over the phone because they do not have a computer can be seen as the reason for this situation. Additionally, the prospective teachers stated that they experienced some problems due to the inadequacies of the programs such as

limited character and background selection in digital comic design programs, and access to different characters and backgrounds is paid. In their research on educational comics, Zaibon, Azman and Shiratuddin (2019) mentioned, in their study, the difficulty of providing enough content and action in order to creat the content of speech bubbles in the preparation of digital comics, to blend them with pictures that will facilitate the flow of the story, and to keep the reader moving through the story.

For the second sub-problem of the study, the opinions of the prospective teachers about the elements that should be considered in the preparation of digital educational comics were determined. The prospective teachers referred to the need to pay attention to the scientific information contained in digital educational comics. Arroio (2011) defines educational comics as an effective teaching tool that is a dialogue using symbols, signs or images is maintained and that is used to convey information. From this view put forward by the prospective teachers, it is understood that they did research within the scope of the subject they determined in the process of designing their educational comics, and meticulously determined the scientific information they wanted to have in their comics. At this point, it would not be wrong to say that the prospective teachers are also knowledgeable about the relevant subject. Gavaldon and McGarr (2019) also supports this result of the research by commenting that the use of digital educational comics has a great potential in teacher education.

It was determined that the prospective teachers expressed their opinions about the need to pay attention to the visual content included in the comic book design. The visuals in the comic book are effective in creating a perception of spatial relationships in the context on the readers (Pratt, 2009). However, the prospective teachers also touched on the importance of text and dialogues, and emphasized that the language used in comics should be simple and understandable. In her research, Sömen (2020) emphasizes that although the severity in comics seems to be in the picture, the texts are also complementary to the pictures. A harmony must be achieved between text and picture in comics (Sarıbıyık, 2018). Otherwise, it makes it difficult to keep track of the continuity between pictures (Cantek, 2014). In order to reveal the details of the information that is intended to be given to readers in comics, it is thought that it would be beneficial to present the determined subject in a short and concise manner (Topkaya, 2014). It is thought that prospective teachers participating in the research may have noticed how important visuals and text are for comics during the process of designing comics.

The opinions of the prospective teachers regarding the importance of the message to be given in the comics were determined. It is known that comics has a great power, which is provided by stories consisting of words and pictures, as conveying a message (Rota & Izquierdo, 2003). In another definition, it was mentioned that comics convey important messages in transferring realistic or imaginary ideas through using visual images (Toh, Cheng, Jiang & Lim, 2016). From this point of view, it can be thought that the education

provided within the scope of the research enables the prospective teachers to correctly understand the purpose of using comics in education.

Within the framework of the third sub-problem of the study, the opinions of the prospective teachers about the benefits of using digital comics in educational environments were determined. The opinions of the prospective teachers were stated that comics are beneficial in terms of facilitating learning. This obtained result is supported by studies which show that educational comics facilitate students' learning (Hosler & Boomer, 2011; Rozkosz & Wiorogórska, 2016). prospective teachers' own pleasure in the design process may have eased their learning.

The prospective teachers 'opinions were detected that digital comics could be used as an effective educational tool to attract students' attention to the lesson. Many unique features of comics attract students' attention (Lin et al., 2015; Lin & Lin, 2016). In the study, the opinions of the prospective teachers regarding the improvement of visual memory through comics were learned. Silva et al. (2017) revealed that the use of comics as a teaching strategy can increase the development of different skills in their students. Farther, the opinions of the prospective teachers participating in the research were that comics would have positive effects on learning by having fun and realizing permanent learning. It is also supported by research that educational comics are effective in learning by having fun (Assad, 2017; Lo et al., 2019) and permanent learning (Hoosler & Boomer, 2011; Marianthi et al., 2016). Weber et al. (2013), in their research on the use of comics as an alternative scientific narrative, revealed that undergraduate students see comics as both teaching and entertaining material. The prospective teachers actively participated in the design process of the comics, and they continued the process carefully because they actualized this for the first time. It is thought that they may have used their imaginations in the stages of creating the story, thinking for the background and creating relationships between panels during the design process.

Within the framework of the fourth sub-problem, the opinions of the prospective teachers about the use of digital comics in early childhood science education were determined. The opinions of the prospective teachers that educational comics would be effective on children's learning were stated. Besides, it was determined that prospective teachers' views were that children would learn about daily life with the use of digital educational comics in early childhood, and that comics would be effective in terms of preparing for life. Although they are illiterate, comics are interesting and arousing curiosity for young children (Afrilyasanti & Basthomi, 2011). With this material that attracts their attention, children witness the expression of the subjects out of the ordinary and learn from their own experiences (Topkaya & Şimşek, 2015). In this way, they carry the information they have acquired into their daily lives spontaneously in the process. Educational comics are known for allowing educators to combine scientific knowledge with real situations from students' lives (Affeldt, Meinhart & Eilks, 2018).

During this period, when the prospective teachers participating in the study were introduced to digital educational comics, they thought that these effective tools would be beneficial for children in many ways, and it was associated with the prospective teachers gaining this awareness.

In addition, prospective teachers' opinions were determined as children's imagination and creativity can develop and they can gain different perspectives by using digital educational comics in early childhood. Conducted studies have revealed that educational comics support the development of imagination and creativity skills (Weber et al., 2013; Yang, 2003). The prospective teachers may have thought that the different characters and stories in digital educational comics would be effective in helping children develop their imaginations and gain different perspectives.

In the framework of the last sub-problem, the conceptual structures of the prospective teachers related to digital educational comics were determined in their cognitive structures, and it was detected that these structures were related to the results obtained from other sub-problems of the research. However, herein it should be noted that the prospective teachers touched on nature and science in their conceptual structures. According to Tatalovic (2009), the main purpose of educational comics is to educate the reader about the nonfiction scientific concept or theme. At this point, the emphasis of the prospective teachers on nature and science was found to be related to the latent purpose of the research, which is "to raise awareness about environment and environmental problems", and it was accepted as a pleasing result.

5. Recommendations

Within the scope of the results obtained from the research, the following recommendations were made;

- It is recommended that prospective teachers at the undergraduate level should be encountered more frequently with technology-oriented alternative teaching materials such as digital educational comics rather than traditional teaching materials.
- It is recommended that the programs used in the design of digital educational comics should be free for students and teachers.
- It is recommended to increase the use of digital educational comics in science education from preschool to undergraduate level.
- By addressing universal issues that are wanted to attract attention in digital educational comics, students' awareness of this point can be increased.
- The illiteracy of children in early childhood period opens the door to an interaction between their teachers or their families who read comics to them. For this reason, it is recommended that teachers and families encounter children with such materials more often.

- In future studies, the effect of digital educational comics, which will be prepared on different subjects or concepts determined in science education, on different skills of students can be examined.

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References

Affeldt, F., Meinhart, D., & Eilks, I. (2018). The use of comics in experimental instructions in a non-formal chemistry learning context. *International Journal of Education in Mathematics Science and Technology, 6*(1), 93-104. https://doi.org/10.18404/Ijemst.380620.

Afrilyasanti, R., & Basthomi, Y. (2011). Adapting comics and cartoons to develop 21st century learners. Language in India, *11*(11), 552-568.

Akcanca, N. (2020). An alternative teaching tool in science education: Educational comics. *International Online Journal of Education and Teaching, 7*(4), 1550-1570. https://files.eric.ed.gov/fulltext/EJ1271026.pdf

Akkaya, A. (2013). A different activity in grammar learning in Turkish course: Educational comic strips. *International Journal of Academic Research Part B, 5*(5), 118-123. https://doi.org/10.7813/2075-4124.2013/5-5/B.18

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education, 9*(1), 71-88. https://www.learntechlib.org/primary/p/29332/.

Arroio, A. (2011). Comics as a narrative in natural science education. [Special issue]. *Western Anatolia Journal of Educational Sciences*, 93-98. http://hdl.handle.net/20.500.12397/5157

Assad, M. K. (2017). How a comic book assignment can help students learn the value of research evidence. *CEA Forum, 46*(2), 180-201. https://files.eric.ed.gov/fulltext/EJ1184618.pdf

Aşçı, A. U. (2020). Examining the comic strips which takes places on the texts on secondary school Turkish language course books in terms of education of values. *The Journal of International Social Research, 13*(69), 868-889. http://dx.doi.org/10.17719/jisr.2020.4006

Berkowitz J., & Packer, T. (2001). Heroes in the classroom: comic books in art education art education. *Art Education, 54*(6), 12-18. http://dx.doi.org/10.1080/00043125.2001.11653471

Cantek, L. (2014). *Comic in Turkey*. İstanbul: İletişim.

Çetin, Y. (2010). Graphic novels. *International and Quarterly Journal of Cultural Studies, 85*, 193-198. https://www.millifolklor.com/PdfViewer.aspx?Sayi=85&Sayfa=190

Gavaldon, G., & McGarr, O. (2019). Exploring prospective teachers' future intentions to use technology through the use of comics. *Teaching and Teacher Education, 83*, 99-109. https://doi.org/10.1016/j.tate.2019.04.004

Guba, E. G., & Lincoln, Y. S. (1982). Epistemological and methodological bases of naturalistic inquiry. *Educational Communication and Technology Journal, 30*(4), 233-252. https://link.springer.com/content/pdf/10.1007/BF02765185.pdf

Gülersoy, A. E., & Türkal, B. (2020). Use of comics as a teaching material in social studies education in terms of its composition and development. *Journal of International Social Science Education, 6*(2), 299-326. https://doi.org/10.47615/issej.839497

Gündüz, U. (2004). *As a product of the popular culture, the cultural, social and political functions of the comics* (Unpublished master's thesis). İstanbul University, İstanbul.

Olson, R. D. (1993). "Say! dis is grate stuff": The Yellow Kid and the birth of the American comics. *The Courier, 28*(1), 19-34. https://surface.syr.edu/libassoc/305

Hosler, J., & Boomer, K. B. (2011). Are comic books an effective way to engage nonmajors in learning and appreciating science?. *CBE-Life Sciences Education, 10*, 309-317. https://doi.org/10.1187/cbe.10-07-0090

Jampel, I., Fahrurrozi, F., Artawan, G., Widiana, I., Parmiti, D., & Hellman, J. (2018). Studying natural science in elementary school using NOS-oriented cooperative learning model with the NHT type. *Jurnal Pendidikan IPA Indonesia, 7*(2), 138– 146. https://doi.org/10.15294/jpii.v7i2.9863

Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. *The American Journal of Occupational Therapy, 45*(3), 214-222.

Koutníková, M. (2017). The application of comics in science education. *Acta Educationis Generalis, 7*(3), 88-98. https://doi.org/10.1515/atd-2017-0026

Lazarinis, F., Mazaraki, A., Verykios, V., & Panagiotakopoulos, C. (2015). E-comics in teaching: Evaluating and using comic strip creator tools for educational purposes. *10th International Conference on Computer Science & Education* (ICCSE) 22-24 Temmuz 2015. Cambridge, UK. http://dx.doi.org/10.1109/ICCSE.2015.7250261

Lesmono, A. D., Bachtiar, R. W., Maryani, M., & Muzdalifah, A. (2018). The instructional based andro web comics on work and energy topic for senior high school students. *Jurnal Pendidikan IPA Indonesia, 7*(2), 147- 153. http://dx.doi.org/10.15294/jpii.v7i2.14245

Lichtman, M. (2006). *Qualitative research in education an users' guide*. Thousand Oaks: Sage Publications.

Lin, S. F., Lin, H. S., Lee, L., & Yore, L. D. (2015). Are science comics a good medium for science communication? The case for public learning of nanotechnology. *International Journal of Science Education, Part B, 5*(3), 276-294. https://doi.org/10.1080/21548455.2014.941040

Lin, S. F., & Lin, H. S. (2016). Learning nanotechnology with texts and comics: The impacts on students of different achievement levels. *International Journal of Science Education, 38*(8), 1373-1391. http://dx.doi.org/10.1080/09500693.2016.1191089.

Lo, P., Allard, B., Ho, K. K., Chen, J. C. C., Okada, D., Stark, A., ... & Lai, C. C. (2019). Librarians' perceptions of educational values of comic books: A comparative study between Hong Kong, Taiwan, Japan, Australia and New Zealand. *Journal of Librarianship and Information Science*, *51*(4), 1103-1119. http://dx.doi.org/10.1177/0961000618763979

Marianthi, V., Boulodakis, M., & Retalis, S. (2016). *From digitised comic books to digital hypermedia comic books: Their use in education*. Piraeus: University of Piraeus.

McCloud, S. (1993). Understanding comics. New York, HarperCollins, http://mm12.johncaserta.info/wpcontent/uploads/2012/10/Understanding%20Comics%20 [accessed at 21 December 2020]

McCloud, S. (2006). *Making comics*. Northampton MA: Kitchen Sink Press Inc.

McCloud, S., & Manning, A. D. (1998). Understanding comics: The invisible art. *IEEE Transactions on Professional Communications, 41*(1), 66-69. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=661632

Miles, M. B., & Huberman, A. M. (2016). *Qualitative data analysis: An expanded sourcebook* (2. Ed.), In S. Akbaba Altun & A. Ersoy (T. Eds). Ankara: Pegem.

Morel, M., Peruzzo, N., Juele, A. R., & Amarelle, V. (2019). Comics as an educational resource to teach microbiology in the classroom. *Journal of microbiology & biology education*, *20*(1), 1-4. https://doi.org/10.1128/jmbe.v20i1.1681

Olson, R. D. (1993). "Say! dis is grate stuff": The Yellow Kid and the birth of the American comics. *The Courier, 28*(1), 19-34. https://surface.syr.edu/libassoc/305

Olson, J. (2008). *The comic strip as a medium for promoting science literacy*. Northridge, CA: California State University. http://www.csun.edu/~jco69120/coursework/697/projects/OlsonActionResearchFinal.pdf [accessed 20 December 2020].

Patton, M. Q. (2014). *Qualitative research & evaluation methods*, M. Bütün & S. B. Demir (T. Eds). *Ankara: Pegem*.

Parsons, J., & Smith, K. (1993). Using comic books to teach. https://files.eric.ed.gov/fulltext/ED363892.pdf

[accessed 20 December 2020].

Phoon, H. Y., Roslan, R., Shahrill, M., & Said, H. M. (2020). The role of comics in elementary school science education. *Formatif: Jurnal Ilmiah Pendidikan MIPA, 10*(2), 67-76. http://dx.doi.org/10.30998/formatif.v10i2.6257

Pratt, H. J. (2009). Narrative in comics. *The Journal of Aesthetics and Art Criticism, 67*, 107-117.

Rota, G., & Izquierdo, J. (2003). "Comics" as a tool for teaching biotechnology in primary schools. *Electronic Journal of Biotechnology*, *6*(2), 85-89. https://scielo.conicyt.cl/pdf/ejb/v6n2/a03.pdf

Rozkosz E. A., & Wiorogórska, Z. (2016). Bibliostory-educational comic stories. A social constructivist approach to media and information literacy education for children and adolescents. In S. Kurbanoğlu et al. (Eds.), *Information literacy: Key to an inclusive society* (pp. 718-728). Springer. https://doi.org/10.1007/978-3-319-52162-6_70

Sarıbıyık, M. S. (2018). *The importance of historical graphic novels to cause the students to gain national conscience in elementary schools: The sample of Tarkan graphic novels* (Unpublished master's thesis). Giresun University, Giresun.

Silva, A. B., Santos, G. T., & Bispo, A. C. K. A. (2017). The comics as teaching strategy in learning of students in an undergraduate management program. *Mackenzie Management Review, 18*(1), 40-65. https://doi.org/10.1590/1678-69712017/administracao.v18n1p40-65

Sömen, T., & Akcanca, N. (2020). Digital educational comics in early childhood. In R. F. Ağmaz & F. Ergüleç (Eds.), *Digital technology and learning in early childhood education* (pp. 109-128). Ankara: Pegem.

Sömen, T. (2020). Comic as a teaching material in social studies In N. E. Akhan & S. Demirezen (Eds.), *Alternative subjects in social studies teaching* (pp. 349-379). Ankara: Nobel.

Şentürk, Ö. Ç. (2020). *The effect of argumentation-supported educational comics on students' environmental interests, motivation, and academic achievements and student experiences* (Unpublished doctoral thesis). Gazi University, Ankara.

Tatalovic, M. (2009). Science comics as tools for science education and communication: A brief, exploratory study. *Journal of Science Communication, 8*(4), 1-17. https://doi.org/10.22323/2.08040202

Tatlı, Z., & Akbulut, H. İ. (2017). Teacher Candidates Technology Using Competence in the Field. *Ege Journal of Education, 18*(1), 31-55. https://doi.org/10.12984/egeefd.328375

Tekmen, B. (2016). Theoretical foundations of teaching materials. In N. Ültay & E. Ültay (Eds.), *Teaching techniques and material development for preschool education* (pp. 42-58). Ankara: Pegem.

Tilley, C. L. (2008). Reading comics. *School Library Media Activities Monthly, 24*, 23-26.

Toh, T. L., Cheng, L. P., Jiang, H., & Lim, K. M. (2016). Use of comics and storytelling in teaching mathematics. In P. C. Toh & B. Kaur (Eds.), *Developing 21st century competencies in the Mathematics classroom* (pp. 241-259). Singapore: World Scientific.

Topkaya, Y. (2016). A comparison between impact of concept cartoons and impact of instructional comics in teaching value of sensation on natural environment. *Mustafa Kemal University Journal of Social Sciences, 13*(34), 259-272. https://dergipark.org.tr/en/download/article-file/226452

Topkaya, Y. (2014). *Impact of usage of comics on cognitive and emotional learning in citizenship and democracy education classes* (Unpublished doctoral dissertation). Atatürk University, Erzurum.

Topkaya, Y., & Şimşek, U. (2015). Impact of instructional comics on the attitudes towards cizitzenship and democracy education. *Journal of Computer and Education Research, 3*(6), 152-167. https://doi.org/10.18009/jcer. 26543.

Türkal, B. (2018). *Use of comics as a teaching material in social studies education in terms of its composition and implementation* (Unpublished master's thesis). Dokuz Eylül University, İzmir.

Uslu Üstten, A. (2014). *Youth Liteature.* Ankara: Grafiker.

Weber, K. C., Saldanha, T. C., Silva, K. K. D. S., Santos, P. M., Souza, D. D. & Arroio, A. (2013). Introducing comics as an alternative scientific narrative in chemistry teaching. *The Western Anatolia Journal of Educational Sciences, 4*(8), 1-14. https://dergipark.org.tr/en/download/article-file/39517

Yıldırım, A,. & Şimşek, H. (2016). Qualitative research methods in the social sciences (10. Ed.). Ankara: Seçkin.

Yılmaz, M., Üredi, L., & Akbaşlı, S. (2015). The Identification of Preservice Teachers' Level of Computer Competency and Their Perception of Technology Use in Teaching. *International Journal of Humanities and Education, 1*(1), 105-121. https://dergipark.org.tr/en/download/article-file/357543

Yang, G. (2003). *Strengths of comics in education.* http://www.humblecomics.com/comicsedu/index.html [accesed at 10 December 2020]

Yin, R. K. (2003). *Case study research design and methods* (3. Ed.). London: Sage.

Zaibon, S. B., Azman, F. N., & Shiratuddin, N. (2019). Instrument for evaluating digital educational comic. *International Journal of Advanced Computer Research, 9*(44), 316-324. http://dx.doi.org/10.19101/IJACR.PID107