

Student Opinions on Mobile Augmented Reality Application and Developed Content in Science Class

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Abstract –As one of the most important branches of science, natural science studies have never lost their currency. The purpose of this study is to examine the development process of Augmented Reality contents which were developed using a design-based research method with the purpose of using it in teaching of natural science topics and to look into student evaluations. In the study which employed design-based research model, developed contents were applied, analysed and re-designed with students constantly. The study group of the research consisted of forty 7th grade students at a private college in 2016-2017 fall semester. Augmented reality contents developed for science teaching were evaluated by teachers and students as effective. According to the teacher and student opinions, it was concluded that augmented reality contents of science teaching developed during design-based research process was nice, easily applicable and useful. It can be said that while developing educative materials for students, applying design-based research model and paying attention to material design principles secures the effectiveness of the developed material.

Keywords – Augmented reality, science learning, design based research

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1. Introduction

Effective learning of natural science topics makes sure that the person establishes effective communication in their future life and is not affected by the changes in working life [1]. It allows living the entire life including school, family, working and family relations with quality and makes sure that the person sees the world through different views. According to Bašer [2], natural science teaching must make sure that people improve their lives using science and deal with the world which becomes increasingly technological. Natural science learning aims at educating people who have scientific and rational thinking abilities, who are researching, questioning, accessing knowledge, effectively using and sharing the knowledge they reach, who possess effective communication skills, who have high creativity, and who are able to work in a cooperative and productive manner [3]. However, Colagrande, Martorano & Arroio [4] stated in their study that in natural science books the concepts were generally presented as “ready-made”, “finished”, and “true” and that teachers did not convey the nature of scientific knowledge to students but transferred the ready-made pieces instead, as a result of which natural sciences could be misunderstood. In addition, Akgündüz and Akınoğlu [5] claimed that in classes where natural sciences were taught with traditional methods, it was not possible to educate individuals with 21st century skills as the traditional class model lacked activities which urged students to think and research, as a result of which they could not gain skills for using knowledge effectively and solving problems and graduated with memorized knowledge.

As one of the most important branches of science, natural science studies have never lost their currency. An examination of the literature on natural sciences shows that one of the most prominent topics is how to make natural science teaching more effective. With the development of education technologies, new studies are added to the list. The fact that learning process continues for life is one of the reasons for which these studies continued constantly [6]. According to Holstermann, Grube & Bögeholz

[7] teachers play one of the most important roles in these studies and must create interactive learning environments where students could learn by themselves by having fun, explore their skills and abilities and work in teams. In addition, in natural science classes, students must be equipped with real-life experiences using appropriate education and teaching materials and applications such as animations, and permanent learning must be ensured by transforming abstract events into concrete. Several researchers such as Nincarean, Alia, Halim & Rahman [8] claim that although existing methods work, there is an increasing interest towards testing more useful methods for improving learning experiences by educators and researchers and that especially as technology becomes more popular, the technological integration gains importance [9],[10],[11],[12]. There are mobile applications used in the learning process [13],[14]. Augmented reality applications are an example of such applications. Media where virtual and real objects are used in combination are called augmented reality applications. They are created by adding virtual objects on real world images. The system creates interaction by working simultaneously [15].

For the abovementioned reasons, the purpose of this study is to examine the development process of augmented reality contents which are developed using a design-based research method with the purpose of usage in teaching of science topics as well as student usage of the foregoing.

Augmented Reality

AR based contents usually have the advantage of having more effective communication compared to web-based content presentations. In addition, augmented reality indicates to the applications which aim at improving user experiences such as virtual reality. According to Majid, Mohammed and Sulaiman [16] augmented reality was born after virtual reality. Unlike VR which is created with digitally-formed images, the content is viewed as digital layer on the user screen [17]. According to Johnson [18], augmented reality is characterised with the integration of content created with computer with real world layer, which increases reality. According to Hedley [19] augmented reality is an interface technology and new information experience method.

As mentioned by Horizon Report: Higher Education Edition, Augmented Reality was one of the most developed emerging technologies in 2016. Nevertheless, with the increase in ownership of emergence and mobile devices, mobile learning and augmented reality came to be used together [8]. In recent years, improvement of mobile devices made sure that content is reached through mobile

augmented reality (MAR) scanners every time and everywhere in a more practical manner. According to Demirer and Erbaş [20] augmented reality, which was only used in a computer-based fashion for years, was now also being used in mobile devices with developed applications. Mobile Augmented Reality (MAR) has four main components: (1) camera which is used to capture the target information, (2) marker which consists of the target information, (3) a mobile device which will process and store the target information whenever it is read, and (4) digital content which will be shown by camera when it reads the target marker [16].

In this context, the educational area has already started introducing augmented reality technologies [21]. Lin et al. [22] examined the usage processes of students by developing a mobile augmented reality application for geometrical learning activities. In their study, the researchers concluded that through MAR students performed the required tasks independent from their teachers and improved their motivation and tolerance levels. In their study conducted with 30 university students, Shelton and Hedley [23] taught the topic titled “relation between the earth and the sun” with augmented reality applications. According to the obtained results, students who worked with augmented reality completed the topics with fewer errors. In their literature search, Diegmann, Kraepelin, Eydend & Basten [24] displayed the advantages of using augmented reality applications in education. According to the results obtained by researchers, augmented reality applications have positive impacts on motivation, attention, concentration and satisfaction. In addition, they concluded that in learning processes which employ augmented reality applications, student-centred teaching and cooperative learning activities were conducted more effectively.

Design-based research

Wang and Hannafin [25] defined design-based research as a systematic but flexible methodology which is based on the cooperation between researchers and implementers and aims at improving education applications through repetitive analysis, design, development and application. Design-based research can be explained as a series of analytical techniques which balances positivist and interpretive paradigms and attempts to bridge education-related theories and applications [26]. In recent years, significant progress has been made in articulation of methodological and epistemological foundations for design-based studies and making it a teachable method [27]. Characteristics of design-based research [33], [34] are explained as follows:

- Solving complex problems in their real, authentic context in cooperation with implementers,
- Applying the integration of known and assumed design principles in order to present the appropriate solutions to problems,
- Performing meticulous and reflective investigation so as to test and sensitize innovative learning environments,
- Research and development in the cycle of beginning to use the design, analyse and redesign,
- Researches which have to pave the way for theories so as to share the results with implementers and other designers,
- The research has to explain how the designs work in authentic environments.

2. Method

Design-based research model was used in this study. Design-based research model is a research process which makes sure that new applications such as software or new theories can be designed [28]. The developed content was analysed by constantly applying with students and redesigned.

Participants

The study group of the research consists of forty 7th grade students at a private college in the fall semester of 2016-2017 academic year. 52 percent of the students are females and 48% are males. In addition, the mean age of the students is 11.

Data collection tool and application

In order to obtain the opinions of students on the final shape of the material in the end of design-based research process, the researchers developed a semi-structured interview form. The interview form consists of questions on the impact of augmented reality impact and evaluating educative contents used in augmented reality application. In order to validate the content, the questions were developed based on the literature. In order to determine whether the questions were clear and understandable, opinions of 5 experts from the field were sought and corrections were made. In the end of the application which was performed in two classrooms of 20 pupils each, interviews were made with 25 volunteer students in total, 12 and 13 students from each classroom. Each interview took approximately 20

minutes. The interviews were recorded with voice recorded in order to prevent loss of data. Data obtained from the interviews was analysed with in-depth content analysis method. Critical friends approach was employed in order to ensure reliability. One researcher analysed the texts and the other conducted double-check. Another expert who was not included in the study was asked to perform triangulation. The findings obtained from the analyses were presented in tables based on frequencies.

Development of materials

Before starting the design and application phase of the research, interviews were held with 7 science teachers at the education institution which delivered tablet-supported education and needs analysis was conducted. In order to perform the needs analysis, an interview form consisting of 5 questions was developed. In the interviews attempt was made to determine the topics where students had difficulty in science teaching and applications which are difficult to perform in classroom environment. New questions were asked based on the answers given during interviews and detailed discussions were made. In addition, the topics that they learned were discussed with 5 students who had taken science classes before and attempt was made to determine the topics they had most difficulty in learning. After the interviews, animations and 3Ds were determined, which would be included in augmented reality application. In addition, analyses were made on the technological competencies of teachers and students. According to the obtained results, teachers are effectively using computers, tablets and smart boards. Students are using their tablets for educative purposes. Students are accessing e-books through their tablets and virtual classes are used for communication purposes.

As a result of the interviews held with teachers, it is seen that it is in the 7th grade when abstract topics are most covered, which is also the grade that shows the highest need for material development with the purpose of using in science education. In addition, the results obtained from interviews conducted with students and teachers who took this course in previous semesters shows that materials should be designed for topics such as five senses organs, neural system, magnets, acids and bases, hormones and food chain.

In the next step, contents were developed based on regular feedback. In this process, the employability of the software was evaluated based on the opinions of teachers and students. After the contents were developed, five education technology experts, three science teaching experts and one

linguist were consulted and necessary changes were made on materials for redevelopment.

The developed contents were integrated into the Aurasma application so that contents could be reached through any mobile device where Aurasma is loaded. Figure 1. gives the steps followed during material development process and the actions of the cycle.

In the beginning of the animations which were developed based on the constant interviews and evaluations, following the introduction section where two characters (Ada and Mira) appear before the students, information follows on the topic. Then the new topic is explained and finally there is a process which shows that the animation ended.

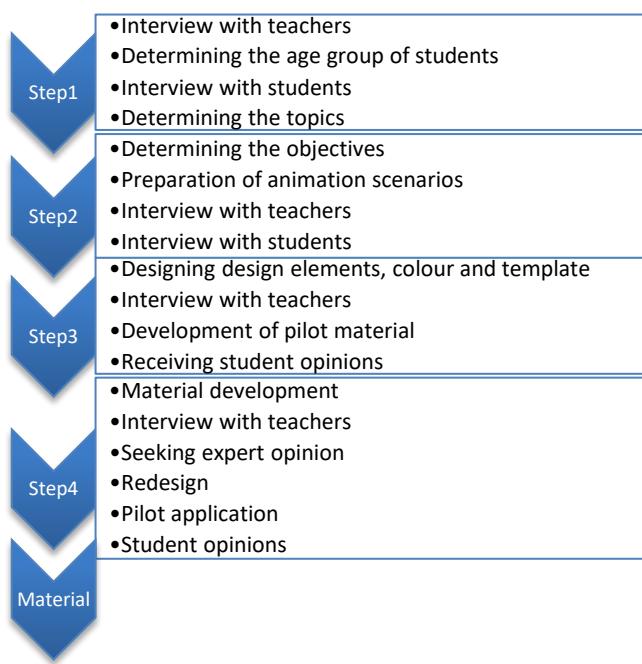


Figure 1: Material development cycle

Application

In the research, Aurasma, which is a ready mobile application, was used through the tablets distributed by school administration to the students. Aurasma is a platform compatible with IOS and Android operating systems, which ensures that AR applications based on simple picture recognition are developed (Smith, 2013). Stickers were prepared and stuck in the books of students in accordance with the animations and contents which were prepared as per the results obtained from needs analysis. At this stage, Adobe Photoshop and Adobe Flash Air CC programmes were used. Figure 1. gives the screen images in regard to the application used in the research. With the stickers seen in Figure 1., animations whose screen images are seen in Figure 1. are defined. Animations can be viewed when the

stickers are scanned with the tablet where Aurasma application is loaded.

As the first step of the application, science teachers of the sample group were given training on augmented reality applications developed for this research. In the following step, Aurasma application was loaded to the students' tablets, who were informed on the application and the application was used at science classes throughout the entire semester.

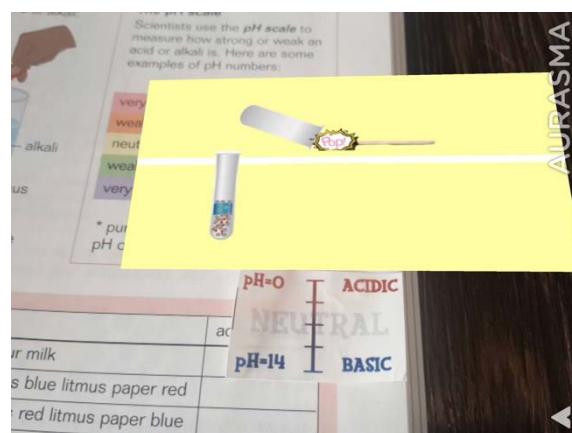


Figure 2: Sample screen images of AT application

Throughout the semester augmented reality applications were used within problem-based learning approach. Students were made into groups of four. Groups attempt to solve the problem areas given to students. They use augmented reality applications within this process. During the application students tried to solve the problems they were given in cooperation within their group. At the problem-solving stage, they watched animations through Aurasma program in order to be able to learn the new topic.

3. Results

Student opinions on the contents in AG application

The purpose of the study was to determine the student opinions on the positive aspects of AG application used in science teaching. For this purpose the students were asked the question "what do you think about the animations and other contents in the application?"

From the opinions of students who participated in the study, eight different themes were obtained namely "supporting learning", "explaining topic visually", "using characters", "covering the topics in short period of time", "being compensatory", "facilitating the understandability of topics", "uniting the books with animation", and "others". Frequencies in regard to these themes are presented below.

Table 1: Student opinions in regard to application contents

Opinions	f
supporting learning	25
explaining topic visually	11
using characters	8
covering the topics in short period of time	6
being compensatory	3
facilitating the understandability of topics	2
uniting the books with animation	2
Others	5

According to table 1, all students stated that AG application supported learning. Expressions of some students in this topic are given below.

“I liked animations as they explained the topics in a nice and attractive manner. Those animations were explanatory so that I could understand topics helped my learning.” (Student 2)

“Animations helped my learning as they tell the topics with nice, colourful and moving visuals in a short period of time.” (Student 4)

Some students expressed that AG application ensured visual explanation of topics which is one of its positive sides. Some of the students' expressions in regard to visual explanation of topics are given below:

“I really liked animations. Moving visuals way too appeal us and I understand topics better.” (Student 5)

“I liked the harmonious usage of animations and explaining the topics by viewing videos unlike books. One of the animations that I recall most was about food web as I love animals. I was happy to watch the topic on food web as an animation.” (Student 7)

“We learned science topics like watching cartoons, which was nice and catchy.” (Student 19)

Answers given by some of the students evaluated employment of characters in the application (Ada and Mira) as positive. Some of the answers given in regard to this opinion are presented below:

“It is a good thing that Ada and Mira characters were used as they were directing us while watching the animations. I think that understanding the content would be more difficult without them.” (Student 1)

“I think that using characters was useful. They made sure that animations attracted attention.” (Student 12)

“I think that using characters Ada and Mira and that they were speaking English was very good.” (Student 19)

The answers of some students showed that the AG application used made sure that the topics could be covered in a short period of time, which was another positive side. The opinions of two students in regard to covering the topics in a short period of time are presented below:

“I liked the fact that topics were covered shortly and briefly. It helped me a lot while studying. While studying from the book I had to spare a long time; with these animations I can learn the topic in a short period of time.” (Student 19)

“I think that it is nice that it tells the topics as a summary from the beginning to the end. It tells everything from the very start just like a teacher and it can be watched without requiring a long period of time, which is very suitable for repeating topics before a quiz.” (Student 23)

Some students thought that AG application was acting as a make-up class for missed topics or for learning new topics, which is a positive feature. Some of these expressions are presented below:

“Yes, there is something that I like about animations. Sometimes when I am studying at home I realise that there are topics that I do not understand and I cannot reach the teacher. This year I did not need to reach the science teacher as animations are helping me understand the topic.” (Student 24)

“Animations were very useful while studying. I was somewhat behind in science classes compared to my classmates and I was not able to receive full grades. I realised that I showed progress after I began studying with animations as I could learn the topics that I missed in class by watching animations and I believe that I fully completed the assignments.” (Student 25)

Some of the students stated that the used AG application facilitated the understandability of science topics. Student expressions in regard to this opinion are presented below:

“In addition to studying from book, being able to watch animation in regard to the topics made understanding new topics easier” (Student 19)

“If in science classes our teacher does not make us watch a video on the topic or if we do not do application in laboratory I could hardly understand the topic. This year it is enough for me to watch animations so as to understand the topics. I feel that they help me understand the topic.” (Student 20)

Some students stated that one of the positive sides of AG application was that the animations and content was viewed by scanning the sticker as a

support for the information in science books. Student expressions in regard to this opinion are presented below:

"When we hold the camera on the book the information in the book was animated, which impressed me a lot." (Student 8)

"Sticking stickers on the book and holding the camera of the tablet to this sticker and watching the animation was a first-time event which attracted my attention. Our science textbook became very interesting and fun for me." (Student 9)

Answers given as "others" in table 2 which are listed as positive sides of AG application include that AG application increased permanence of the learned elements, supported individual learning and, in addition, the colours, stickers and introduction parts used in animations. Student expressions in regard to these opinions are presented below:

"I loved the colours used in animations. I think that they were attractive and harmonious." (Student 1)

"I think that watching animations ensured that topics become catchier." (Student 10)

"This year when studying science class at home and doing my homework I noticed that I needed my teacher less as animations supported me in studying individually." (Student 24)

Student opinions in regard to the design of animations and contents in AG application

In the study, the aim was to determine the student opinions on the design of animations in AG application used in science teaching. For this purpose the students were asked the question "what would you like to say about the design of animations?"

The themes obtained from the answers of the students who participated in the study are evaluated under four main themes namely "colour", "character usage", "scripts" and "length". Table 2 provides the frequencies in regard to this evaluation.

Table 2: Student opinions in regard to the design of contents in AG application

	Opinions	f
Colour	Attractive	21
	Not attractive	3
	Intriguing	2
Character usage	Attractive	11
	Facilitating the understandability of the topics	7
	Unnecessary	5
	Insufficient time	2
	Making sure that animations are fun	2
	Facilitating the traceability of animations	1

Scripts	Script size being suitable	18
	Helping to understand the topic	4
	Script size being small	1
	Appearance on screen being sufficient	3
	Appearance on screen being insufficient	1
	Insufficient amount of script	2
	Sufficient amount of script	1
	Attractive	1
Length	Sufficient	22
	Insufficient	3

As can be seen in table 3, under the "colour" main theme of student opinions, the themes "attractive", "not attractive" and "intriguing" themes are gathered. Most of the students who participated in the study stated that they found the colours used in animations of the application attractive. Student expressions in regard to these opinions are presented below:

"I think that colours were very vivid and attractive. I liked it very much." (Student 6)

"I liked the colours used in animations. They are plain and not eye-straining." (Student 14)

Some students evaluated that the colours of the animations in AG applications were not attractive. Student expressions in regard to these opinions are presented below:

"Colours were not attractive. Animations would be better if different colours were used." (Student 8)

"The laboratory section which appeared at the beginning of animations was very good, but the background of other parts was changing and very pale. I think that this laboratory picture should exist in the background of animations, too. It would be more attractive." (Student 15)

"In the beginning, there was a laboratory and I thought that I would learn the topics at virtual laboratory. But then the laboratory disappeared and the background turned to light yellow. A better design should be made for background. It is not attractive in that way." (Student 16)

According to the answers obtained from students, two of them think that the colours of animations are intriguing. Student expressions in regard to this opinion are presented below:

"Animations were colourful and colours were rather suitable for supporting our learning. It made me curious." (Student 2)

"I think that colours were eyeful and beautiful. It made me wonder what the animations told." (Student 3)

The “character usage” main theme included the themes related to Ada and Mira characters used in the animations in AG application. Under this main theme, the main themes titled “attractive”, “Facilitating the understandability of the topics”, “Unnecessary”, “Insufficient time”, “Making sure that animations are fun”, “Facilitating the traceability of animations” and “others” themes were obtained. Most of the students believe that characters are attractive. Student expressions in regard to these opinions are presented below:

"It is a good thing that characters were used. These characters made animations attractive. It was nice that they were children and students like us. I could easily follow animations when they explained the topics." (Student 5)

"Using two different characters, one girl and one boy, and each animation being explained by one of these characters, was very useful. If there was only one character that appeared in every animation it could be boring. It was attractive that students like us covered the topics." (Student 7)

Some students answered that using characters facilitated the understandability of topics. Student expressions in regard to these opinions are presented below:

"It was useful to have Ada and Mira in animations. We could understand the topics better with their conversations and explanations." (Student 3)

"I think that adding characters to animations was useful as these characters are students like us and we watched them do experiments. If it were not for them understanding the experiments could be more difficult." (Student 13)

Some students, on the other hand, stated that they found using characters in animations unnecessary. Student expressions in regard to these opinions are presented below:

"I do not have any opinions on Ada and Mira, actually. Animations were already explanatory. They could be understood even without the characters." (Student 2)

"I was not attracted by the characters actually. I do not think they added much to the animations. For this reason using them was not necessary." (Student 11)

"We could as well do without the characters. What is important for me is that the material explains the topic. I am not much interested in details in class notes. Characters could well be avoided." (Student 24)

Two students think that the appearance period of characters in animations is insufficient. Student expressions in regard to these opinions are presented below:

"Characters should appear in the entire animations. They should explain and show everything. They appeared in very short sections of animations." (Student 15)

"It was nice that Ada and Mira were in the animations. But I think that they should appear more." (Student 21)

Two students stated that Ada and Mira characters ensured that animations were fun. Student expressions in regard to these opinions are presented below:

"That Ada and Mira were at our age and both were students made topics more amusing." (Student 9)

"I think that the characters used made sure that animations were not boring while learning science topics. If it were not for them the animations could look like a book. Science topics are usually difficult and for this reason class environment is serious. Animations became funnier with child figures." (Student 14)

One student believed that using characters in animations made traceability of animations easier. Student expression in regard to this opinion is presented below:

"I could easily follow the topics the animations with the explanations of Ada and Mira. They appeared and gave information in the beginning, ending and important moments of the animations. So, I could use the application and animations more easily." (Student 5)

Another main theme obtained from student opinions in regard to the design of animations in AG application are “scripts”. Under this main theme the themes titled “Script size being suitable”, “Helping to understand the topic”, “Script size being small”, “Appearance on screen being sufficient”, “Appearance on screen being insufficient”, “Insufficient amount of script”, “Sufficient amount of script” and “Attractive” were determined. Most students thought that the size of the script used in animations was sufficient. Student expressions in regard to this opinion are presented below:

"I think that the size of scripts was very good. They were in the size that we could read on the screen. Usually the scripts in the videos we watched and in

the course materials that our teachers prepared were the same size.” (Student 5)

“I think that script size was good, although I have problems in my eyes I could read them. I did not have any problems in this subject matter” (Student 13)

“We did not have any problems with the size of scripts. For example, there are pupils wearing eyeglasses in our class, and even they could read the scripts.” (Student 14)

Some students answered that using scripts in animations supported understanding of the topics. Student expression in regard to this opinion is presented below:

“There were scripts in the essential parts of the topics which directed me while learning a new topic and made me understand the topics more easily.” (Student 7)

“Using scripts in the animations was very useful as there was no sound feature and at least writing the names of the tools appeared on the screen and some direction given in speech bubbles made me understand the content more easily.” (Student 17)

“Scripts were able to explain every subject in detail and helped me understand.” (Student 24)

“If it were not for the scripts we would learn less as scripts made sure that we comprehend more information.” (Student 25)

One student, on the other hand, stated that the size of the scripts in the animations was small. The words of two students who agreed on these expressions are given below:

“I was able to read the scripts but I could read them more easily if they were larger. We have friends who wear glasses in our class, I think that writing the scripts larger would be better for them, too” (Student 16)

In regards to the appearance length of scripts in animations on the screen, three students stated that the length was enough while three students stated otherwise. Student expressions in regard to this opinion are presented below:

“I think that the scripts were rather readable and their appearance length was sufficient for reading.” (Student 21)

“Everything about the scripts was nice. Their timing and appearance length was very good. If the appearance length of the scripts on the screen was longer the animations could become boring.” (Student 23)

“Scripts were passing a little fast; they were disappearing before I understood and so I felt the need to watch some animations again.” (Student 13)

“Scripts were good but they could appear on the screen a little bit longer as the scripts were in English and some friends can have difficulty in reading.” (Student 18)

Two of the obtained student answers stated that the amount of scripts in the animations was insufficient whereas one student claimed that the amount of script was sufficient. Student expressions in regard to this opinion are presented below:

“Scripts could be monger. If there was more script, I could understand subjects better.” (Student 10)

“Longer scripts should be used in animation and more exposition should be provided. Due to lack of voice feature and the fact that scripts are summarised, watching each animation only once was not enough for me and I had to watch for a number of times to understand better.” (Student 19)

“That the scripts were in the form of short notes was very good. The subjects were also being given in visual form and more script would be meaningless and unnecessary.” (Student 11)

One student expressed that the scripts in the animations in application were attractive whereas another student claimed that they were not attractive. Student expressions in regard to this opinion are presented below:

“I think that scripts were attractive as they were placed so as to attract the attention to important points and emphasise them in short speech bubbles.” (Student 7)

“Scripts are not attractive at all. Instead of delivering the class with speech bubbles, voice feature should be in place and characters should be vocalized.” (Student 15)

In regard to the length of animations in AG application, two themes were obtained, namely “sufficient” and “insufficient”. It can be seen that there is not much difference between the numbers of students who think that the length of animations was sufficient and otherwise. Student expressions in regard to this opinion are presented below:

“I think that animations were didactic but I would prefer them to take longer and be more detailed.” (Student 1)

“Actually the animations were explanatory and I was able to understand the subjects. However, I feel that subjects are passing too fast and finishing early. I

think that animations could be a little bit longer.” (Student 2)

“Animations could take a little bit longer. For example, you are giving an example in animations or making an experiment about the subject. Doubling their number and extending their length can be better.” (Student 20)

“I think that the length of animations was sufficient for me to understand the subjects. They were in the fashion and length to tell the subjects clearly enough.” (Student 3)

“Animations were adjusted very well in terms of length, they were neither long nor short. They were explaining the subjects from a to z nicely. If they were shorter it could be not sufficient for us to understand the subjects. And if they were longer the animations could be boring.” (Student 6)

4. Discussion and Conclusion

In the first stage of the study which was the development of augmented reality contents for science education, a design-based research method was preferred. According to Kuzu, Çankaya & Mısrılı [29], design-based research method makes essential contributions to the design of technology-assisted educative materials and environments. The aim was to make sure that contents developed in order to be used in science education were well-designed and helpful for learning.

According to the teacher and student opinions on science education augmented reality contents developed in the process of design-based research, it was concluded that the design was nice, easily usable and filled with useful content.

According to the conclusions obtained from the study, it was found out that the science augmented reality contents developed throughout the period were used by students in problem-based learning process and the contents were supportive of learning, the visuals were effective in covering topics, characters used in materials were effective and provided effective use of time, as positive aspects. In their study on chemistry, Cheng and Tsai [30] argued that more information was transferred to students with the visuals provided by augmented reality applications and that permanent learning was realised. According to the obtained result, it can be said that effective learning can be achieved by

designing visuals better. In addition, another finding obtained is that the avatars used in animation had positive effects and attracted attention. Holly [31] stated that digital world was a part of our life and children were very fond of it; thus, avatars were a type of digital life and could be used in several learning activities.

Developed science education augmented reality contents were evaluated by students based on design principles which showed that usage of colours and characters was attractive and the script size and animation lengths were appropriate. In the study, materials were designed taking design principles into consideration and opinions of both teachers and students were obtained and necessary corrections were made, as a result of which students agreed that script size was appropriate. In addition, students also thought that the used colours was suitable, attractive and not eye-straining. Animations prepared as the content of augmented reality were designed so as to take shorter than 2 minutes and were seen sufficient by the students. Sood [32] argues that preparing mini videos which take 1-2 minutes for complicated subjects and using visuals and scripts in a balanced manner would ensure learning. Hazlett [33] states that in studies which take more than 12 minutes students spent only 3 minutes for videos which means that longer videos reduce engagement time of students. However, according to the obtained results, some students prefer longer animations.

To summarise, augmented reality contents developed for science teaching were assessed as effective by teachers and students alike. It can be said that while developing educative materials for students, applying design-based research model and paying attention to material design principles ensures that the developed material is effective. Naturally this study has some limitations just like other studies. One of these limitations is that the developed content is suitable only for 7th grade science class subjects. Another limitation is that the study is at qualitative dimension only and its impact on achievement is not evaluated. In the second step of the study, it is planned to add other science subjects and examine the impact on achievement and attitudes.

The hope is that with the help of the science class education augmented reality contents developed within the process of this study contribution will be made to the closing of material deficit in science teaching and direction will be given to future studies.

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