USING AUGMENTED REALITY IN BIOLOGY TEACHING*

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ABSTRACT

In this study, prospective teachers' views on Augmented Reality (AR) in biology teaching were examined. The study was designed as a case study. The study participants consisted of 16 prospective teachers who took Instructional Technologies and Material Design in the third grade of the Biology Teaching Department of the Faculty of Education of a state university in the spring term of the 2018-2019 academic year. During the application process, AR activities were carried out with the students. The data of the study were obtained using the interview form and the "Mobile Augmented Reality Questionnaire" developed by Küçük, Kapakin, and Göktaş (2015). After the activities, prospective teachers were asked for their views about AR in biology teaching. As a result, it was observed that future biology teachers mostly expressed positive thoughts about AR activities. Some advantages of the AR activities were as follows: concretising the subjects; retention; being exciting and entertaining; repetition capability; and multimedia support. Apart from these advantages, some disadvantages were emphasised such as internet connection cut off, the necessity to keep the phone stable, passivation of the students over time, being costly, and not being suitable for every subject. Prospective teachers also suggested extending AR activities in schools, ensuring equality in accessing technological tools, using these activities in different lessons and developing various applications.

Keywords: *Augmented reality, biology teaching, prospective teachers.*

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INTRODUCTION

The increasing demand for computers and mobile devices leads to a rise in the number and diversity of applications. One of the reflections of this in education is the "Augmented Reality (AR)" technology that has become popular recently. AR technology is defined as a technology where the real world and virtual images are combined and simultaneous interaction between real and virtual objects is provided (Azuma, 1997; Çınar & Akgün, 2015; Uluyol & Eryılmaz, 2014; Yılmaz & Batdı, 2016). According to Azuma (1997), AR is a variation of virtual environments. Virtual reality technologies put the user in a completely artificial environment. In this artificial environment, users cannot see the real world around them. On the contrary, AR allows the user to see the real world with virtual objects superimposed or combined. Therefore, augmented reality complements reality rather than completely replacing it. According to another definition, AR is a set of technologies that integrate reality with digital technologies (Berryman, 2012).

Dunleavy and Dede (2014) state that existing examples of AR are divided into two categories: location-based and image-based. Location-based AR applications include the use of GPS services in mobile devices, and image-based AR applications include QR codes and the digital representation of 2D targets with the help of the mobile device camera. These categories in AR applications are used to make educational technologies more effective (Stirbu, Murphy & You, 2012).

According to Azuma (1997), there are three features in the scenes produced with AR. Reality and virtuality coexist in these scenes; images are real-time and interactive, and the scenes are perceived in three dimensions. Up until today, AR applications have been used in many fields such as advertising, marketing, engineering, manufacturing, agriculture, architecture, construction, entertainment, health, and military fields (Azuma, 1997; Barfield, 2015; Egger & Masood, 2020; Feiner, 2002; Hansen, Wieferich, Ritter, Rieder & Petigen, 2010; Huuskonen & Oksanen, 2018; Karatay, 2015; Koşan, 2014; Küçük, Kapakin & Göktaş, 2015; McCarthy & Uppot, 2019; Sayımer & Küçüksaraç, 2015; Uğur & Ceylan, 2014). Due to its positive effects on education and learning, AR technology is becoming widespread in educational processes (Ibáñez & Delgado-Kloos, 2018; Sayımer & Küçüksaraç, 2015).

The positive effects of AR technology in the field of education are emphasised as follows:

- It helps students learn about difficult experiments and subjects that are complex and costly to explain. In addition, it provides a realistic simulation environment for presenting subjects such as astronomy, geography, and physical sciences (Shelton & Hedley, 2002).
- AR environments bring innovations to the learning environment to obtain correct information and inferences and thus provide a better understanding and examination of this information and inferences (Abdusselam & Karal, 2012).
- AR environments improve critical thinking, creative thinking, and problem-solving skills of the students (Dunleavy et al., 2009; Ivanova & Ivanov, 2011).
- AR environments provide a learning environment suitable for students' own learning pace and learning style (Hamilton & Olenewa, 2010; Zimmerman et al., 2016).
- AR environments make learning entertaining, thus facilitating the learning process and increasing the interest and motivation of the students (Chen et al., 2017; Chen & Tsai, 2012; Delello 2014, Fleck & Simon, 2013; Küçük, Yılmaz & Yüksel, 2014; Singhal et al., 2012; Tomi & Rambli, 2013).
- Interactive and well-designed AR environments supported by multimedia elements not only enable the student to participate actively in the process but also help to increase retention of learning (Chen et al., 2011; Chen & Tsai, 2012; Dunleavy et al., 2009; Wojciechowski & Cellary, 2013; Wu et al., 2013; Yen, Tsai, & Wu, 2013).

Apart from all of these advantages, it has also been emphasised that there may be some disadvantages such as interfering with communication between students, causing eye problems, requiring technological equipment, and teacher's lack of technology experience (Akçayır & Akçayır, 2017; Klopfer & Squire, 2008; Yılmaz & Batdı, 2016).

As observed, AR applications are used in different disciplines. For example, to perceive the concepts of the earth and the solar system more easily in astronomy lessons, the three-dimensional shapes of these concepts prepared through AR applications can be displayed (Lee, 2012). In chemistry lessons, it is possible to follow the movements of atoms and molecules in three dimensions with this application. For biology lessons, examining the human body and organs in detail and seeing the organs in their real size and shapes constitute more permanent and effective learning (Lee, 2012). In addition, there are examples showing that it is used effectively in the subject of magnetism in physics lessons (Abdusselam, 2014) and in anatomy lessons for medical education (Küçük, Kapakin, & Göktaş, 2015).

Although it is indicated that AR environments would bring many educational achievements, research on this field are still at the onset. Therefore, it is important to conduct studies in different educational levels and by addressing different variables in the learning process (Martin et al., 2011; Wu, Lee, Chang, & Liang, 2013). It is observed that AR technologies are primarily involved in studies for engineering and medical students at the university level. From this point of view, it is believed that AR activities in biology teaching, where visual technologies are frequently used, would shed light on future studies and build a more effective learning environment. In this context, the study aims to use AR activities in biology teaching and examine prospective teachers' views about these activities. For this purpose, the answers to the following research questions have been sought.

- What are the views of prospective biology teachers about the positive aspects of AR activities?
- What are the views of prospective biology teachers about the negative aspects of AR activities?
- What are the suggestions of prospective biology teachers regarding the use of AR activities?
- How is the distribution of the responses of the prospective biology teachers to the "MAR Questionnaire"?

RESEARCH METHOD

Research Model

The study was designed as a case study. The main feature of the case study is the in-depth investigation of a situation (Yıldırım & Şimşek, 2013).

Participants

The study participants consisted of 16 prospective teachers who took Instructional Technologies and Material Design in the third grade of the Biology Teaching Department of the Faculty of Education of a state university in the spring term of the 2018-2019 academic year.

Data Collection Tool

The data for the study were obtained from 16 participants studying at the Biology Teaching Department of the Faculty of Education through an interview form containing three open-ended questions and using the "Mobile Augmented Reality Questionnaire" developed by Küçük, Kapakin, and Göktaş (2015). The open-ended questions in the interview form aimed to examine prospective teachers' views about the advantages, limitations, and suggestions of using AR activities in biology teaching.

Mobile Augmented Reality Questionnaire

The survey developed by Küçük, Kapakin and Göktaş (2015) consists of 23 affirmative Likert-type statements. The items of the study used in the research process were evaluated with a five-point scale expressed as "Strongly Agree", "Agree", "Undecided", "Disagree" and "Strongly Disagree". The Cronbach Alpha reliability coefficient for the original survey was found to be .93. For this study, it was calculated as .87.

Data Analysis

The qualitative data obtained in the study were analysed by content analysis. Content analysis is to combine similar data into themes and concepts, and then interpret and present them in a way that the reader can understand (Yıldırım & Şimşek, 2013). The data obtained from the prospective biology teachers through interviews were analysed and interpreted by the researchers using Nvivo 11.0 software. Quantitative data were presented using descriptive statistics.

Activity Process

Before the activity started, students had been informed about AR and its activities for two lesson hours. To prepare the AR material, students installed the Aurasma (HP Reveal) program on their phones. Two-dimensional pictures on the materials prepared through Aurasma were introduced as markers. Then the animations or videos that would appear upon displaying these pictures were matched with the images. When students scanned these pictures via the Aurasma program with their mobile phones, they were able to see the generated multimedia materials on their screens. The researchers conducted an exemplary lecture with the support of AR for the students to understand the use of the program better. After explaining the life cycle in bryophytes, the life cycle chart (Figure 1 below) created with AR support on a worksheet was handed to the students. The students filled the worksheet by watching the animation created on the scheme through Aurasma.

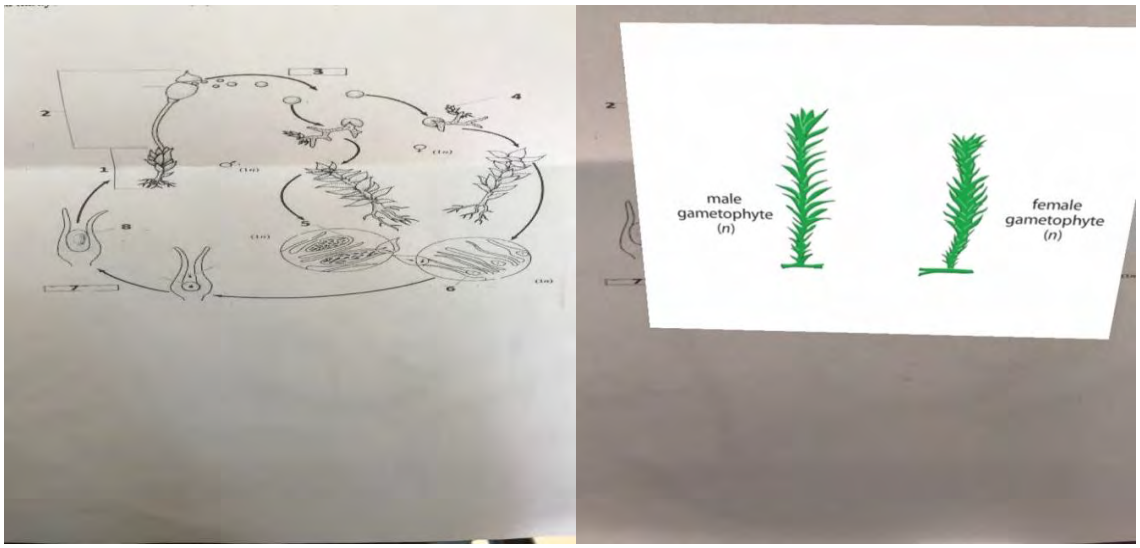

Figure 1. *AR-supported sample worksheet*

Then, for four weeks, the students presented the subjects of their choice by using the materials they created. Students prepared AG-compatible materials on the muscular system, aerobic respiration, viruses, nitrogen cycle, and heart anatomy. In Figures 2 and 3 below, AR-supported worksheets created by the students and the contents displayed on the mobile phone screen are presented.

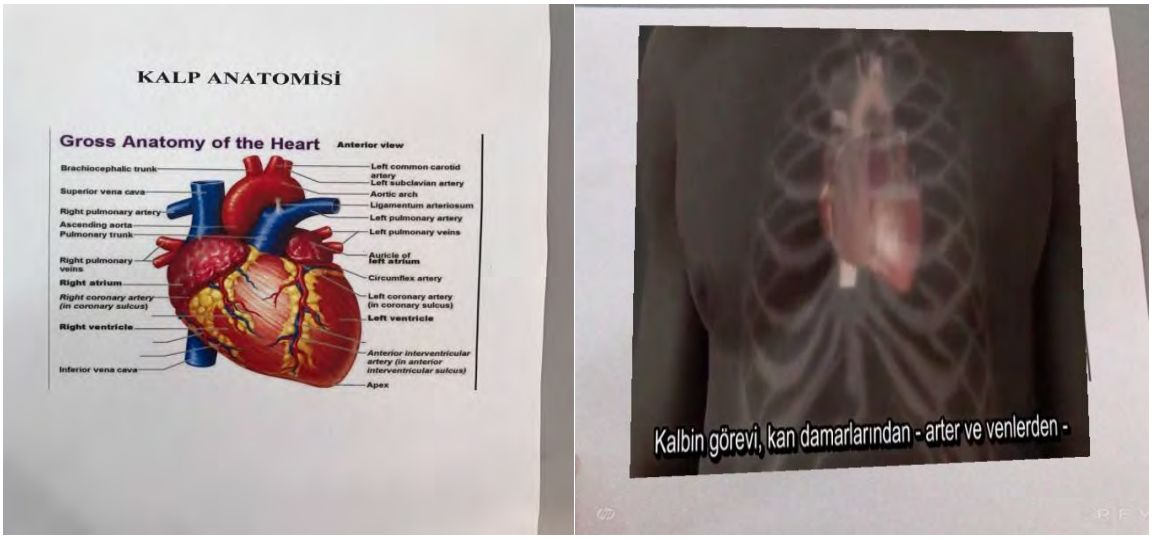

Figure 2. *AR-supported material generated by students*

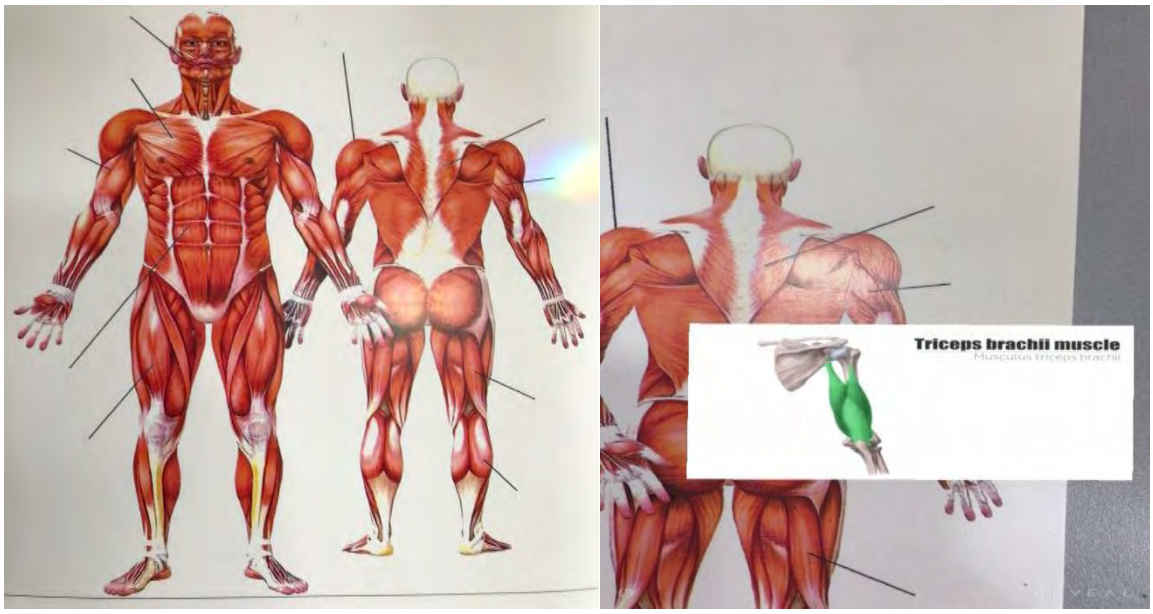

Figure 3. *AR-supported material generated by students*

FINDINGS

The study's findings are discussed within the framework of the positive aspects and limitations of using AR activities in biology teaching and suggestions for their use in biology teaching.

Positive Aspects

The codes obtained from the students' views about the positive aspects of AR activities are given in Table 1 below.

Table 1. *Codes of students' positive views about AR activities*

Codes	f
Concretisation of subjects and abstract concepts	13
Attracting students' attention	7
Increasing retention in learning	6
Facilitating learning	3
Making the lesson entertaining	2
Increasing participation in the lesson	1
Providing the opportunity to repeat the subject	1

As seen in Table 1 above, examining the positive views about Augmented Reality (AR) activities in the lessons, the students emphasised that AR helped concretise the taught subjects (information) and abstract concepts the most. Students believe that the multimedia features used in the AR activities increase the comprehensibility of the taught information and abstract concepts by making them more concrete. Student A1 states that *"since learning takes place through visual, video etc., elements, this application concretises the subjects".* Another issue the students mostly agree on is that the AR attracts students' attention and increases the memorability of the subjects. Student A5 states that *"it is a very good application as it makes learning permanent by allowing the use of picture, video and audio features together"*, in terms of making the lesson more attractive. Additionally, student A3 points out that *"AR attracted the students' attention as it was interesting".* Other positive aspects are that AR activities "facilitates learning", "makes the lesson entertaining", "increases participation to the lesson", and "provides an opportunity to repeat the subject."

Negative Aspects

The codes obtained from the students' views on the limitations of AR activities are given in Table 2 below.

Table 2. *Codes of students' negative views about AR activities*

Codes	f
Requiring internet connection-connection problems	10
Requiring technological equipment (smart phone/tablet)	4
The possibility to increase phone addiction	2
Passivating students	2
Shortage of content	1
High cost	1
Technical problems	1
Being not applicable to all subjects	1
Prohibition of the use of mobile devices in schools	1
The possibility to create laziness	1
Having to keep the phone stable all the time	1

While examining the negative views about AR activities, it was seen that the students mainly emphasised the need for internet connection and connection problems arising while using the application might interrupt the lesson. Student A12's opinion on the issue is as follows: *"since many operations are carried out over the internet, students can get distracted from the lesson in case of a connection problem".* Another issue emphasised by the students is that AR activities require technological equipment. Regarding the issue, student A7 expressed that *"as not every student has a smartphone or tablet, not all students can use this application".* In addition, two students believe that AR activities can passivate students, and two of them think that they can increase phone addiction. Regarding the issue, student A1 commented that *"as phone addiction will increase much, students will become more passive in skills like writing or reading. And this will make learning difficult".* Codes regarding the other negative views about AR activities are; "having to keep the phone stable all the time", "high cost," "technical problems," "prohibition of the use of mobile devices in schools," "shortage of content", "the possibility to create laziness", and "being not applicable to all subjects."

Suggestions

The codes obtained from the students' suggestions about the future use of AR activities are given in Table 3.

Table 3. *Codes of students' suggestions about AR activities*

Codes	f
Extending AR activities in schools	2
Additional features should be added to the AR application	1
Extending the use of the internet in schools	1
Using AR activities in different lessons	1
Using AR activities in the laboratory environment	1
Developing different AR applications	1
Using AR activities for individual learning	1
Using AR activities for collaborative learning in the classroom	1
Using AR activities in group work	1
Using AR activities in subjects with high visuality	1
Providing equal access to technological tools	1

Examining the negative views about AR activities, two students stated that extending AR activities in schools would contribute to learning. Student A9 stated that *"putting this program into effect in all schools will be beneficial for students".* In addition, student A14 believes that equal conditions should be provided for students to access technological tools to use AR applications. A14's views on the issue are as follows: *"All students should be under equal conditions in terms of technology".* On the other hand, student A3 stated that an additional feature should be added to the application that enables the video to continue even if the mobile device is not on the picture: *"a feature that ensures the continuation of the videos after leaving the phone should be added to the AR application".* The codes related to the other suggestions of the students for AR activities are "using AR activities in different lessons", "using AR activities in the laboratory environment", "developing different AR applications", "using AR activities for individual learning", "using AR activities for collaborative learning in the classroom", "using AR activities in group work", and "using AR activities in subjects with high visuality".

Findings from the Mobile Augmented Reality Questionnaire

Descriptive statistics of the responses of prospective teachers to the MAR Questionnaire are given in Table 4 below.

Table 4. *Descriptive statistics on MAR Questionnaire*

	N	Min	Max	Avg	SD
I would like textbooks to be supported by MAR in the future.	16	3	5	4.13	.500
I would like MAR applications to be used in our lessons in the future.	16	4	5	4.25	.447
I would like to use MAR applications as an individual learning tool in the future.	16	4	5	4.38	.500
I liked the use of sounds in MAR.	16	4	5	4.44	.512
I liked the use of pictures in MAR.	16	4	5	4.56	.512
I liked the use of three-dimensional animation videos in MAR.	16	4	5	4.63	.500
I was pleased with multimedia (picture, sound, video) applications in MAR.	16	2	5	4.31	.793
I was pleased with the use of MAR materials during class hours.	16	2	5	4.06	.854
I was pleased to work with the course materials created with MAR outside of class hours.	16	2	5	4.00	.816
MAR applications created a sense of reality.	16	2	5	4.25	1.000
MAR applications concretised the subject.	16	4	5	4.56	.512
MAR applications were useful in my individual studies.	16	3	5	4.38	.619
MAR applications increased my interest in the lesson.	16	4	5	4.38	.500
MAR applications provided a flexible (access anytime, anywhere) learning environment.	16	3	5	3.94	.680
I can easily use special software/applications (Hp Reveal etc.) required for MAR.	16	3	5	4.00	.816
Using MAR technology while studying does not distract me.	16	2	5	3.75	.775
I can manage the technical features (special applications, internet connection, etc.) required for MAR.	16	2	5	3.63	.719
I believe MAR enhances learning performance.	16	1	5	3.94	1.063
I believe MAR provides effective and efficient learning.	16	3	5	4.13	.619
I believe MAR enhances learning motivation.	16	4	5	4.44	.512
I was pleased that MAR software interacts with the course content.	16	3	5	4.25	.683
I was pleased with the features of special software/applications (Hp Reveal etc.) used for MAR.	16	3	5	4.06	.443
I did not experience any problems with the internet connection while using MAR.	16	1	5	3.06	.998
GENERAL AVERAGE	**16**	**3.43**	**4.73**	**4.15**	**.352**

It is observed from Table 4 that students agree with the following items the most: "I liked the use of three-dimensional animation videos in MAR" (4.63), "I liked the use of pictures in MAR" (4.56), and "MAR applications concretised the subject" (4.56). On the other hand, it was determined that they agree with the

following items less: "I did not experience any problems with internet connection while using MAR" (3.06), "I can manage the technical features (special applications, internet connection, etc.) required for MAR" (3.63), and "Using MAR technology while studying does not distract me" (3.75). It was observed that the views of prospective teachers were generally positive.

DISCUSSION AND CONCLUSION

It was observed that prospective biology teachers mostly express positive views about AR activities. Through examining the prospective teachers' views about the advantages of AR activities, it was emphasised that they contributed to the concretisation of abstract concepts, especially with the help of multimedia features. Examining the responses given to the MAR Questionnaire, it was observed that the prospective teachers mostly agreed with the items stating that they liked the use of pictures, animations and videos in the applications; MAR activities concretised the subjects, and they increased interest and motivation. According to Köse, Ayas, and Taş (2003), it is important to develop and use teaching activities to activate students' visual and intellectual structures while explaining abstract and complicated concepts.

The prospective teachers stated that apart from concretisation of the concepts, the practices carried out were interesting, increased the retention in learning, made learning more accessible, entertaining, increased participation in the lesson, and provided the opportunity to repeat the subject. In the literature, other studies are reflecting similar results. Arı and Sivri (2020) stated that as a result of the AR activities they performed in the General Biology course, students who participated in the study had opinions in the direction that the use of AR Technology in education would increase the interest in the lesson, help them concretise abstract cases, and make great contributions to the laboratory lessons. In their study on thematic comparative analysis of augmented reality applications in education, Yılmaz and Batdı (2016) stated that in the learning environment dimension of augmented reality applications, the following themes emerged: "being easily accessible by integrating with education", "visualised learning environments are interesting", "enabling detailed examination of the dangerous/rare materials", and "visualisation of theoretical knowledge increases retention." The theme "arousing interest and curiosity in the student" was included in the affective dimension with its positive effects on motivation and attitude. Kerawalla et al. (2006) concluded that working with visual objects in a 3D environment and augmented reality applications had increased student motivation and participation. Abdusselam and Karal (2012) also emphasised in their studies that students' attention spans were shorter in traditional classroom environments, and their interests could be easily distracted. In contrast, the AR environment was intertwined with technology, concretising abstract concepts and facilitating comprehension, thus increasing students' interest and attention span. Apart from these, similar to the results of this study, many studies indicate that students are pleased with the use of AR applications in education (Cai et al., 2013; Di Serio et al., 2013; Martín-Gutiérrez et al., 2010; Wojciechowski & Cellary, 2013).

Examining the views of prospective biology teachers about the disadvantages of AR activities, internet connection problems and the necessity of technological hardware (smartphone, tablet) was mainly emphasised. Apart from these, the following disadvantages were also emphasised: increasing phone addiction, possibility to passivate students, high cost, technical problems, not being suitable for every subject, and the necessity to keep the phone stable. Examining the answers given to the MAR Questionnaire, items related to internet connection problems and managing technical features came to the fore. In a study conducted by Uluyol and Eryılmaz (2014), it was emphasised that there were some negative aspects of AR activities in addition to their contributions. Some of these negativities are that technological applications can prevent communication between students, create eye problems and need technological equipment. It is understood that some students' lack of technological knowledge causes them to think negatively about using

these applications. Similar results have been obtained in other studies on this situation (Klopfer & Squire, 2008). Dunleavy et al. (2009) emphasised the necessity of providing technical support to users against problems that might occur in AR activities.

Through examining the suggestions of prospective biology teachers regarding the future use of AR activities, it was observed that they made suggestions toward extending AR activities in schools, ensuring equality in accessing technological tools, using these AR activities in different lessons, developing additional applications, and adding a new feature to the AR application. According to Çetinkaya and Akçay (2013), delivering tablet PCs to every student in primary and secondary schools within the FATIH (Movement of Enhancing Opportunities and Improving Technology) Project scope provided an opportunity for AR activities. In addition to enriched-book applications, various AR applications should be developed and applied. Essential hardware (camera, GPS feature etc.) and software must be provided for the tablets to be used.

Innovative applications such as AR have been taking place in the literature every passing day. Although there are not many experimental studies on the effects of these relatively new applications in the education system, many studies indicate that these learning approaches can respond to the needs and requests of the students in the 21st century and provide innovative solutions to the existing pedagogical problems (Deterding et al., 2011; Sarıtaş & Yıldız, 2015; Zicherman & Cunningham, 2011).

Suggestions

In the light of these findings, the following suggestions can be made:

- It can be suggested to include such applications inappropriate subjects in today's learning environments, considering the positive effects of the application.
- Sufficiency for technological equipment in the classes should be increased by taking measures to minimise potential technical problems.
- Although the program used in the activity is efficient, the fact that the mobile device has to be kept stable on paper is seen as an important disadvantage, especially during video viewing. Improvements can be made regarding this feature.
- Alternative applications are needed for educational practices.
- Teachers and prospective teachers can be informed on using AR applications in learning environments through training.
- Future studies can be conducted on the cognitive and affective effects of AR applications on students.

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