Investigating Student Attitudes toward Augmented Reality

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ABSTRACT

This study aimed at identifying the attitudes of secondary school students toward AR applications and to investigate the change in these attitudes according to different variables. The study also aspired to determine the relationship between attitudes toward AR and achievement. The general survey model was used in the study. The study group was composed of 54 7th graders attending there separate classes of a state school. In order to determine student attitudes toward AP applications in educational environments, students were first provided with the experience for 4 weeks (16 lessons). Research findings show that students have positive attitudes towards AR applications. Gender, ownership of personal computers and mobile devices were not found to change attitudes toward AR applications. While daily Internet use was not found to affect AR attitudes, it was found that attitudes differed significantly according to frequency of playing computer games. Research findings show a meaningful relationship between AR attitudes and achievement.

Keywords: *elementary education; media in education; virtual reality.*

INTRODUCTION

Augmented Reality (AR) is defined as the technology in which virtual objects are interactively overlaid on real time images (Azuma, 1997, 1999). In a similar definition, Milgram and Kishino (1994) point to the fact that AR is an active and interactive environment generated by adding virtual data over real time images. As can be derived from these definitions, AR, in simple terms, is the synchronous overlay of real time images with virtual objects (Ibanez, Serio, Villaran, & Delgado-Kloos, 2016; Sin & Zaman, 2010). Although these definitions may give the impression that it is an ordinary technology, AR has unique characteristics such as enriching or augmenting reality with the help of virtual objects. In this sense, it offers users a surreal environment which cannot be perceived by sensory organs (Sırakaya & Seferoğlu, 2016).

Definitions of AR have undergone changes along with the impact of advanced technology. First definitions in the field regard AR as a derivative of virtual reality and virtual environments (Azuma, 1997, 1999). In time, digital data such as videos, animations, 3D models and GPS (Delello, 2014; Perez-Lopez & Contero, 2013) are also added to elements such as text, sound and graphics to enhance the real time images. Although various similar definitions of AR exist, it is evident that the concept is still confused with the concept of virtual reality and sometimes AR is even used in place of virtual reality. Hence, it will be beneficial to explain what AR is *not* to present its difference from other concepts.

What Augmented Reality Is Not?

It is important to understand the concept of virtual reality in order to comprehend AR. Virtual reality is a simulation model that provides a sense of reality by allowing interactive communication between the user and the dynamic environment generated by computers (Bayraktar & Kaleli, 2007). Therefore, computer-generated 3D environments are found in virtual reality and its most characteristic feature is the simulation of the user's physical presence in the environment. The user is in the virtual environment generated completely digitally and there is no interaction with the real world. This creates alienation and isolation for the user from reality. On the other hand, AR enhances the reality with the help of virtual data. It does not create an alternative real time but it uses the real time images as background and enhances it with the help of virtual images added on real time images (Billinghurst, 2002; Kerawalla, Luckin, Seljeflot, & Woolard, 2006; Sin & Zaman, 2010).

The features necessary for an application to be regarded as AR are: (1) it should connect the real and the virtual, (2) it should have simultaneous interaction, (3) it should be 3D (Azuma, 1997). The position of AR in the real-virtual continuum is depicted in Figure 1 by Milgram and Kishino (1994). It is the mixed reality environment.

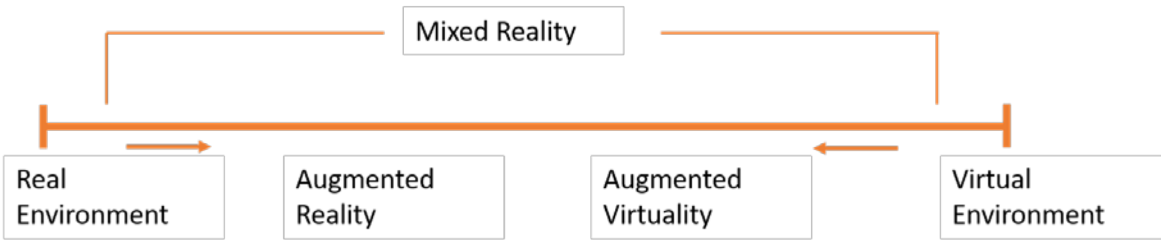

Figure 1. Reality-Virtuality Continuum (Milgram & Kishino, 1994)

AR applications are basically categorized into two based on the technology being used: image based AR and location based ARAR (Cheng & Tsai, 2013). Virtual models are added over real time images in image based AR. İmage based AR is differentiated as marker based and markerless AR based on the place where the model will be added. The place of the virtual model is defined by taking the position of the marker as reference in marker based AR. In markerless AR, where the virtual model will be added is not defined before. This study utilized marker based AR. Location based AR identifies the location of the user via various technologies and allows placement of virtual data over real time images.

Augmented Reality in Education

Recent advances in mobile technologies and widespread use of mobile devices have cleared the way to using AR technologies in different areas such as military, engineering, medicine, tourism and advertisement. With its advantages, AR has already attracted attention in educational spheres. It is observed in recent years that educational use of AR is on the rise (Wu, Lee, Chang, & Liang, 2013). Table 1 presents the findings of studies conducted on contributions of AR to educational environments.

Table 1 Advantages of AR use in education

Pedagogic Benefits	Researcher(s)
It attracts student attention to classes	Delello (2014), Tomi and Rambli (2013)
It increases motivation towards classes	Kerawalla et al. (2006), Perez-Lopez and Contero (2013)
It concretizes abstract concepts	Abdüsselam and Karal (2012), Cai (2013), Gün (2014), Shelton and Stevens (2004)
It allows easy comprehension of complex topics	Kaufmann (2003), Núñez et al. (2008), Shelton and Hedley (2002), Yen, Tsai and Wu (2013)
It allows teaching of cases which would be impossible to generate in classroom environments	Kerawalla et al., (2006), Shelton and Hedley (2002), Yuen, Yaoyuneyong and Johnson (2011)
It ensures safe application of dangerous experiments	Wojciechowski and Cellary (2013)
It develops student imagination and creativity	Klopfer and Yoon (2004)
It supports authentic learning	Wu et al. (2013), Yuen et al. (2011)

Pedagogic Benefits	Researcher(s)
It provides enriched learning experiences	Fjeld and Voegtli (2002), Sin and Zaman (2010)
It supports learning by doing	Dunleavy, Dede and Mitchell (2009), Singhal, Bagga, Goyal and Saxena (2012)
It ensures student centered learning	Delello (2014)
It provides students with opportunities to use their own learning styles	Bujak et al. (2013)
It provides situational learning opportunities	Wu et al. (2013)
It supports constructive learning	Delello (2014)

Table 1 presents many advantages of AR use in educational environments. Besides these advantages, AR has the potential to develop skills which are expected from today's learners, such as problem solving, group work, versatile assessment and understanding different perspectives (Schrier, 2006). As opposed to virtual environments, AR provides all these advantages without alienating students from classroom reality and therefore allows students to form natural interactions with virtual objects and physical environments around them (Matcha & Rambli, 2013; Sin & Zaman, 2010).

Visualization opportunities presented to students by AR are especially noticeable in Table 1. Students find the opportunities to examine objects from all angles and in different locations with the help of 3D lesson materials developed with AR (Shelton & Hedley, 2002; Shelton & Stevens, 2004). Hence, abstract concepts that are difficult to visualize are learned more easily (Kaufmann, 2003; Núñez et al., 2008; Shelton & Hedley, 2002; Wu et al., 2013) by concretizing them (H. Cai, 2013; Shelton & Stevens, 2004). Also, superior to traditional tools, multimedia materials such as texts, pictures, audio, video and animations can be used (Wang, Kim, Love, & Kang, 2013). Hence, AR environments that can address more than one sense ensure that students actively participate in the process and acquire permanent learning (Dunleavy et al., 2009; Wojciechowski & Cellary, 2013; Wu et al., 2013). It can be argued that AR is an effective tool with this advantage that can be used to educate primary and secondary school students who have difficulty in comprehending abstract topics (Piaget, 1976) because of the cognitive stage they experience at those ages.

Literature review for this study presented various AR studies conducted on secondary school students. Table 2 presents these studies according to study topics.

Table 2 AR Studies Conducted on Secondary School Students

Topic	Subtopic	Researcher(s)
Mathematics education	Geometric objects	İbili (2013)
	Prisms	Gün (2014)
	Geometric objects	İbili and Şahin (2013)
	Geometric objects	Atasoy, Tosik-Gün and Kocaman-Karoğlu (2017)
Physics education	Optical	Cai, Chiang and Wang (2013)
	Electrostatic	Echeverría et al. (2012)
Chemistry education	Periodic table	Iordache, Pribeanu and Balog (2012)
	Chemical reactions	Wojciechowski and Cellary (2013)
	Molecules	Cai, Wang and Chiang (2014)
Biology education	Digestive system	Vilkoniene (2009)
	Ecology	Huang, Chen and Chou (2016)
	Water cycle	Kamarainen et al. (2013)
Astronomy education	Solar system	Medicherla, Chang and Morreale (2010)
	Solar system	Sırakaya (2015)
Museum education	Science Museum	Yoon, Elinich, Wang, Steinmeier and Tucker (2012)
	Museum education	Klopfer and Yoon (2004)
	Art Museum	Damala, Cubaud, Bationo, Houlier and Marchal (2008)

Topic	Subtopic	Researcher(s)
History education	Cultural heritage	Ardito, Buono, Costabile, Lanzilotti and Piccinno (2009)
	Medieval history	Huizenga, Admiraal, Akkerman and Dam (2009)
Language education	Foreign language education	Küçük, Yılmaz and Yüksel (2014)
	Grammar	Dunleavy et al. (2009)
Informatics education	Information technologies	Korucu, Gençtürk and Sezer (2016)

Table 2 shows that AR technologies are used in different classes in secondary education. It is evident that AR use in educational environments provides many benefits in the education and training process. It can be argued that using AR technologies in classroom environments is more effective in teaching objects and cases that are impossible to bring to classroom and in teaching abstract concepts and complex issues and topics (Walczak, Wojciechowski, & Cellary, 2006).

Since cognitive development in secondary school students follows a path from concrete to abstract, children in this age range learn things more easily when they see them concretely (Piaget, 1976). The AR environment facilitates teaching abstract concepts which are difficult to mentally visualize (Kaufmann, 2003; Núñez et al., 2008; Shelton & Hedley, 2002; Wu et al., 2013) with the help of multimedia elements such as texts, pictures, audio and video (Wang et al., 2013) and 3D models (Shelton & Hedley, 2002; Shelton & Stevens, 2004). In this sense, AR generates an alternative in teaching secondary school students who have difficulties in comprehending abstract concepts based on their current cognitive period. In line with the multitude of AR studies conducted on secondary school students (see Table 2), it is thought that AR applications will be more common and widespread in teaching secondary level students. Based on these reasons, this study was conducted on secondary school students experiencing concrete operations stage of their cognitive development.

Student attitudes toward AR will be important in ensuring the expected educational acquisitions and dissemination of AR practices in schools. Attitudes can be defined as individuals' response toward objects and conditions that generate guiding and leading impact over situations (İnceoğlu, 1985). That is to say, attitudes are not behaviors but tendencies that steer individuals to certain behaviors. The Technology Acceptance Model (TAM) developed by Davis (1989) to present the factors that affect individuals in accepting technology also mentions the significance of attitudes. According to the TAM, attitudes shape the intent that is determinant in displaying the behaviors. Positive attitudes toward technology have direct bearing on its use. Individuals' attitudes in accepting new technologies vary and as a result of this variance, the integration process may end in adaptation or refusal of these technologies (Akça & Özer, 2013). Student attitudes toward the new technology will influence its effective and productive use in the classroom. Thus, it can be argued that identifying student attitudes towards AR applications is crucial to ensure successful integration of AR technology into educational settings. However, the scarce number of previous AR studies conducted to present student attitudes to AR applications is noteworthy. This study is believed to contribute to literature in this respect.

Besides determining student attitudes toward AR applications, it is important to understand the change of direction in these attitudes. Knowing what situations cause change in AR attitudes may play a significant role in achieving success in integrating AR technologies into instructional settings. Limited number of studies in this field has shown that students' demographic characteristics were not examined during these studies. Considering that today's students use technology effectively in every stage of their lives, it can be argued that differences in levels of technology use may change their AR attitudes. Based on the rationale presented here, this study intended to identify secondary school students' attitudes toward AR applications and examine the issue in terms of different variables. It is believed that findings of this study will be benefit researchers in developing and integrating AR applications which will be widely used in future educational settings. The research question and sub problems related to the research question are as follows:

Research question:

- What are the attitudes of secondary school students towards augmented reality applications?

Sub problems:

  - Do secondary school students' attitudes towards augmented reality applications differ according to gender?
  - Do secondary school students' attitudes towards augmented reality applications differ according to personal computer ownership?
  - Do secondary school students' attitudes towards augmented reality applications differ according to mobile device ownership?
  - Do secondary school students' attitudes towards augmented reality applications differ according to period of daily Internet use?
  - Do secondary school students' attitudes towards augmented reality applications differ according to frequency of playing computer games?
  - Is there a relationship between secondary school students' attitudes towards augmented reality applications and their achievement?

METHOD

Research Design

Survey model was used in the study. Survey studies determine characteristics such as views, attitudes and abilities (Fraenkel & Wallen, 2006). Survey studies aim at presenting the case which is related to the topic of the study *as is* (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2008). Hence, survey studies aim at determining the attitudes, beliefs, thoughts, expectations, and demeanors characteristic of a group (Creswell, 2012).

Study Group

The study group was composed of 54 7th graders attending separate classes of a state school. Since the students in the study group were required to have AR supported instructional experiences, purposive sampling method was used in identifying the group. In purposive sampling, the researchers determine the sample themselves based on the purpose of the study (Fraenkel & Wallen, 2006). In this study, experience in AR supported instruction was used as a criterion in determining the study group. The students were taught the 4-week "Solar System" Unit via SpaceAR application. Students were divided into groups of four and were distributed tablets with SpaceAR application. The teacher kept the markers necessary to activate AR activities and gave the markers relevant to specific AR activities to student groups in order to activate related AR activities. The requirement of previous involvement with AR learning materials in classes in order to be able to identify attitudes toward AR limited the study group in terms of number. Table 3 presents the demographic information of the study group.

Table 3 Demographic Information for the Study Group

Variables	Groups	n	%
	Female	30	55.6
Gender	Male	24	44.4
	Total	54	100
	Yes	31	58.5
Ownership of personal computer	No	22	41.5
	Total	53	100
	Yes	32	59.3
Ownership of mobile devices	No	22	40.7
	Total	54	100

AR Learning Material

In order to determine student attitudes towards AP applications in educational environments, students were first provided with the experience for 4 weeks (16 lessons). With this aim in mind, marker based AR application (SpaceAR) developed by Sırakaya (2015) was used. The main goal of SpaceAR is to provide for students and teachers with 3D displays of the space environment and the events in this environment which are difficult to visualize or monitor due to lack of various means under real time conditions. SpaceAR was developed by taking the acquisitions and activities of the "Solar System" unit included in the 7th grade Science and Technology Class and includes 22 AR activities (celestial bodies, stars, Solar System, planets, spacecraft etc.) based on the activities in the textbook. Views of 2 field experts, 2 teachers and 3 technical experts were taken into consideration during the development process. Figure 2 provides screenshots of SpaceAR.

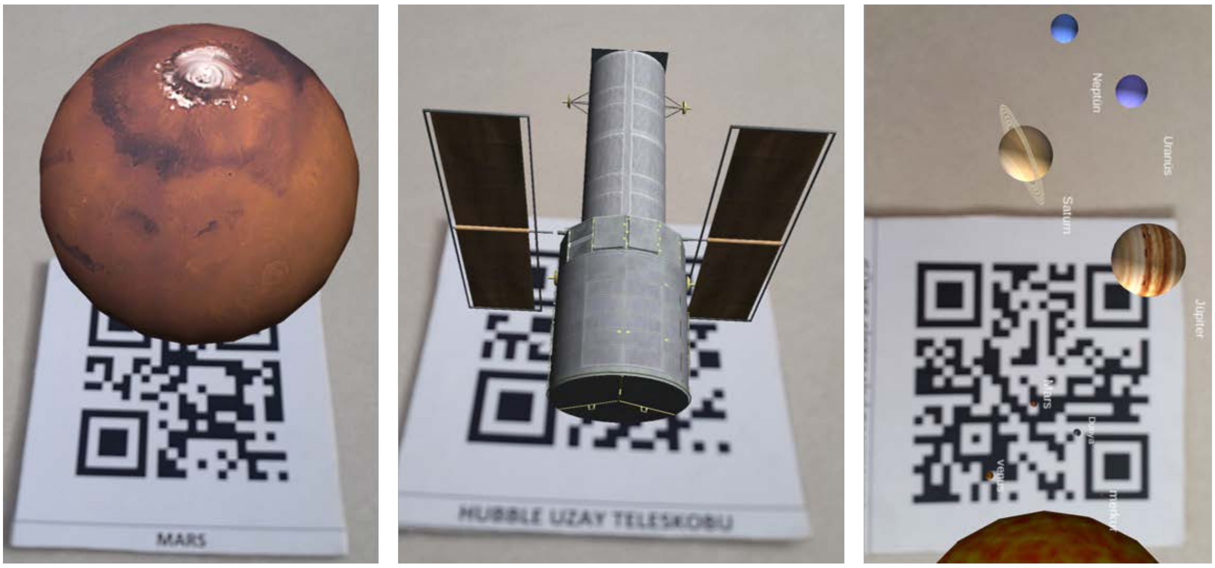

***Figure 2*. SpaceAR application screenshots.**

Data Collection Tools

The Personal Information Form, Achievement Test and Augmented Reality Applications Attitude Scale in Secondary Schools were used in the study as data collection tools.

Personal Information Form: We developed the form to collect data related to participants' demographic information and level of technology use (gender, ownership of personal computers, ownership of mobile devices, period of daily internet use, frequency of playing computer games). Similar studies in the literature were used when developing the personal information form (Atasoy, Tosik-Gün, & Kocaman-Karoğlu, 2017; Korucu et al., 2016).

Augmented Reality Applications Attitude Scale: The scale developed by Küçük, Yılmaz, Bayda, and Göktaş (2014) has three factors (satisfaction from use, anxiety to use, willingness to use) and 15 items. The scale developed to ensure content and face validity was checked by 4 field experts and 1 language expert and revised as necessary. The lowest and highest scores possible from the 5-point Likert type scale are 15 and 75 respectively. High scores point to positive attitudes towards AR applications. Internal consistency for the whole scale (1. factor α = .862; 2. factor α = .828; 3. factor α = .644) was found as (Cronbach alpha) α = .835. Internal consistency reliability coefficient for the scale was calculated as .91 in this study. The obtained values show that the scale is a valid and reliable tool to assess secondary school students' attitudes towards AR applications.

Achievement Test: Achievement test developed by Sırakaya (2015) was used to determine students' knowledge levels and to test their achievement. KR-20 reliability coefficient of the test with 27 multiple-choice questions was found to be .75. The lowest score that can be obtained from the achievement test is 0 and the highest score is 27 when the students answer all questions correctly. Analyses pointed that 3 questions were at simple level, 17 at medium-difficulty level and 7 questions were difficult. In order to provide easy interpretations of test scores, necessary inversions were made and the test can be scored over 100. Internal consistency reliability coefficient for the scale was calculated as .80 in this study.

RESULTS

What are the attitudes of secondary school students towards augmented reality applications?

Attitudes of students who used AR applications in classes were identified in the framework of the study. Findings are provided in Table 4.

Table 4 Student Attitudes towards AR Applications

N	$\bar{X}$	sd	Min	Max
54	62.94	12.87	32	75

Table 4 shows that students who used AR applications in lessons had positive attitudes towards AR ($\bar{X}$ =62.94).

Do secondary school students' attitudes towards augmented reality applications differ according to gender?

The study also examined whether students' AR attitudes changed according to gender. The findings are presented in Table 5.

Table 5 Change in attitudes towards AR applications based on gender

Gender	N	$\bar{X}$	S	sd	*t*	p
Female	30	61.97	13.82	52	-.620	.538
Male	24	64.17	11.75			

Table 5 presents that while male students' attitudes towards AR applications ($\bar{X}$= 64.17) were more positive compared to those of female students ($\bar{X}$=61.97); the difference was not statistically significant ($t_{(52)}$ = -.620, p >.05).

Do secondary school students' attitudes towards augmented reality applications differ according to personal computer ownership?

The study also examined whether students' AR attitudes changed according to ownership of personal computers. The findings are presented in Table 6.

Table 6 Change in attitudes towards AR applications based on ownership of personal computers (PC)

Ownership of PC	N	$\bar{X}$	S	sd	*t*	*p*
Yes	31	63.80	13.51	51	.496	.622
No	22	62	12.39			

Table 6 shows that while the AR attitudes of students who owned personal computers ($\bar{X}$=63.80) were more positive compared to students who did not own PCs ($\bar{X}$=62) the difference was not found to be statistically significant ($t_{(51)}$ = .496, p >.05).

Do secondary school students' attitudes towards augmented reality applications differ according to mobile device ownership?

The study also examined whether students' AR attitudes changed according to ownership of mobile devices. The findings are presented in Table 7.

Table 7 Change in attitudes towards AR applications based on ownership of mobile devices

Ownership of mobile device	N	$\bar{X}$	S	sd	*t*	*p*
Yes	32	61.19	13.87	52	-1.215	.230
No	22	65.5	11.07			

Table 7 shows that while the AR attitudes of students who did not own mobile devices ($\bar{X}$=65.5) were more positive compared to students who owned mobile devices ($\bar{X}$=61.19) the difference was not found to be statistically significant ($t_{(52)}$= -1.215, p>.05).

Do secondary school students' attitudes towards augmented reality applications differ according to period of daily Internet use?

The study investigated whether AR attitudes of students who were taught with AR applications differed according to students' daily internet use. Table 8 presents AR attitude averages according to daily internet use.

Table 8 AR Attitude Means According to Daily Internet Use

Daily Internet use	n	$\bar{X}$	sd	*F*	*p*
Less than 1 hour	35	47.11	8.141	.236	.871
Between 1-4 hours	15	48.20	6.837		
Between 4-8 hours	2	45.00	11.314		
More than 8 hours	2	50.50	.707		
Total	**54**	**47.70**	**6.817**		

Table 8 shows that the group with the highest level of attitude towards AR applications is composed of students who used internet for more than 8 hours a day ($\bar{X}$= 50.5) while the lowest means were found in the group of students who used internet daily between 4-8 hours ($\bar{X}$=45.00). Analysis of variance shows that students' AR attitudes did not present significant differences according to their daily use of internet ($F_{(3-50)}$= .236; p>.05).

Do secondary school students' attitudes towards augmented reality applications differ according to frequency of playing computer games?

The study examined whether AR attitudes differed according to frequency of playing computer games. Table 9 presents mean AR attitudes based on playing computer games.

Table 9 Mean AR Attitudes Based on Frequency of Computer Game Playing

	Frequency of playing computer games	n	$\bar{X}$	sd	*F*	*p*	Significant difference
1	I play frequently PC games	11	54.09	15.267	3.002	.039	1-3
2	I sometimes play PC games	13	63.07	10.515			
3	I rarely play PC games	24	67.33	10.869			
4	I never play PC games	6	61.33	14.610			
	Total	**54**	**62.94**	**12.872**			

Table 9 shows that the highest AR attitudes were found in the group who rarely played computer games ($\bar{X}$= 67.33) while the lowest AR attitudes were found for the group who frequently played computer games ($\bar{X}$=54.09). Results of analysis of variance show that students' AR attitudes significantly differed according to frequency of playing computer games ($F_{(3-50)}$= 3.002; p < .05). Results of the Tukey test conducted to determine the source of difference presented that students who rarely played computer games had more significantly positive attitudes towards AR applications compared to students who played computer games frequently.

Is there a relationship between secondary school students' attitudes towards augmented reality applications and their achievement?

Pearson Correlation analysis was conducted to determine whether there was a significant relationship between students' AR attitudes and their achievement. Table 10 presents the findings of this analysis.

Table 10 Descriptive Statistics for AR Attitudes and Achievement and Results of Pearson Correlation Analysis

Variables	N	$\bar{X}$	Ss	*r*	*p*
AR Attitude	54	62.94	12.87	.458	.000
Achievement		60.36	18.02		

Table 10 shows a statistically significant medium level positive relationship between AR attitudes and achievement (r = .458, p < .05).

DISCUSSION AND CONCLUSION

This study was conducted to investigate secondary school students' AR attitudes based on different variables and to determine the relationship between AR attitudes and achievement was undertaken with the participation of 54 7th graders attending a state school. SpaceAR teaching material used in the framework of the study was developed under the supervision of field experts, technical experts and teachers. Before data collection, students were taught the Solar System Unit in the Science and Technology Class for four weeks with the help of SpaceAR application. Therefore, students were provided a learning experience using AR.

Research findings show that students have positive attitudes toward AR applications. This finding is supported by studies that pointed to secondary school students' positive attitudes towards AR applications (Atasoy, Tosik-Gün, & Kocaman-Karoğlu 2017; Küçük, Yılmaz, & Göktaş, 2014). It is believed that this result is related to advantages of AR applications in educational environments. Previous studies also pointed that AR attracted student interest towards the lesson (Delello, 2014; İbili & Şahin, 2013; Perez-Lopez & Contero, 2013; Yen, Tsai, & Wang, 2012) and increased their motivations (Delello, 2014; İbili & Şahin, 2013; Taşkıran, Koral, & Bozkurt, 2015). It is also known that AR use helps students develop positive thoughts and attitudes toward classes (Gün, 2014; İbili, 2013). Positive attitudes towards AR can be explained with the increased interest and motivation generated by AR use. It can also be argued that positive attitudes towards AR applications are related to provision of active and interactive learning environments via enhancement of reality. It is believed that AR supported classroom environments that are different from the use of traditional materials and environments create positive impact on student attitudes.

According to another finding of this study, AR attitudes do not differ based on gender. This finding is supported by the studies which found that male and female students' AR attitudes were highly similar and there were no significant differences in AR attitudes based on gender. (Atasoy, Tosik-Gün, & Kocaman-Karoğlu 2017; Korucu et al., 2016). Many studies conducted on AR point to the fact that AR technology is utilized by students with great ease (Özarslan, 2013; Sırakaya, 2015; Sin & Zaman, 2010; Taşkıran et al., 2015; Tian, Endo, Urata, Mouri, & Yasuda, 2014; Tomi & Rambli, 2013). It is believed that no gender differences in AR attitudes may be related to ease of use by all participants without any problems. Previous studies also reported ease of use as an important factor that affected AR attitudes (Ibanez et al., 2016; Wojciechowski & Cellary, 2013). According to the TAM, ease of use in a technology and perceptions that the technology is beneficial positively contribute to individuals' attitudes towards the relevant technology (Davis, 1989). In this context, it can be argued that ease of use in AR technology was effective hence the finding that secondary school students had positive attitudes towards AR applications regardless of gender.

Ownership of personal computers and mobile devices was not found to change attitudes toward AR applications. While students who owned personal computers or mobile devices were found to have more positive attitudes towards AR applications, the difference was not statistically significant. Today's students who were born and raised in a digital age are in a special generation called Z generation. Z generation students who effectively use technology in all domains of their lives can use digital tools in the classroom without any prior training. In his interviews with secondary school students, Sırakaya (2015) found that they did not need any prior training for AR applications and that they already knew how to use these tools. The finding that ownership of personal computers and mobile devices did not affect AR attitudes may be related to self-confidence of Z generation in this area and the fact that they regarded themselves as competent in using technology.

It was found that daily internet use did not change the attitudes toward AR applications. Finding a similar result, Atasoy, Tosik-Gün, and Kocaman-Karoğlu (2017) reported that while duration of internet use did not have significant effect on attitudes towards AR; individuals that often use internet had lower attitude scores. This finding may be related to the fact that students who use technology less may perceive it as more attractive. Students who use technological tools more may have come across settings similar to AR environments previously. Therefore, this application may have lost its innovative aspect for these students and is not regarded as innovative as it could have been otherwise. Wojciechowski and Cellary (2013) who emphasized a similar situation and reported that students' positive attitudes toward AR applications may have decreased over time.

Another result obtained in this study shows that AR attitudes significantly differ according to frequency of playing computer games. Compared to students who frequently played computer games, student who rarely played computer games had significantly more positive AR attitudes. This finding may be related to the realistic graphics presented in computer games. Computer games open the realistic virtual games and interaction to their players. AR applications present realistic 3D models as well and therefore students who frequently play computer games may have been less affected by these environments. However, students who rarely played computer games may have been more affected by the space environment designed very similarly to the real space environment and therefore they may have developed more positive attitudes. Students today expect to be taught by using technology since they are accustomed to computer environments. In this context, AR can be used as an effective tool to increase student interest towards school. Also, students' familiarity with 3D computer games may provide the necessary foundation to implement the AR technology to wider audiences (Wojciechowski & Cellary, 2013).

Research findings show a meaningful relationship between AR attitudes and achievement. Therefore, it can be argued that having that more positive attitudes will ensure achievement. It is believed that this finding will contribute to literature. Küçük et. al. (2014), who reports a similar finding, states that successful students have more positive attitudes towards AR applications and emphasizes the positive relationship between achievement and AR attitudes. Traditional learning methods and environments are not sufficient anymore to attract student interest in lessons (Somyürek, 2014). With its advantages and its features, AR is an important tool that can meet the needs of today's students (Wojciechowski & Cellary, 2013). Indeed, many studies in the literature reported that AR use increased student achievement (Abdüsselam & Karal, 2012; Korucu et al., 2016; Özarslan, 2013; Shelton & Hedley, 2002; Sırakaya, 2015; Vilkoniene, 2009). Based on this, it can be argued that AR technology is a tool that can be used to increase student achievement.

In general, research results show that students displayed positive attitudes toward AR applications and that these attitudes did not significantly differ according to the variables investigated in this study. The fact that positive attitudes were not dependent on the investigated variables shows that AR applications can be effectively used in educational settings with various student groups. This result shows that AR applications can be used easily even in heterogeneous classrooms.

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