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The Effect of Augmented Reality Applications on Secondary School Students' Achievement of Atom Models and Theirs Attitudes

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Abstract: The aim of this study is to examine the effects of Augmented Reality (AR) applications, which are a new approach in education, on students' achievement and attitudes. For this purpose, on the basis of science education, a content, which was consistent with the syllabus, about atomic structure and atom models in the topic of structure and properties of matter was developed by the experts for the 7^{th} grade students in secondary education and AR applications were integrated into the content. The Vuforia SDK software was used to design the content. The study was conducted on 205 secondary school students from six classes enrolled in a school in province of Gaziantep, in 2017-2018 academic year. Experimental group (n=103) and control group (n = 102) were randomly assigned. In this study, pretest-posttest with control group quasi-experimental design was used. The data of the study were collected using the achievement test, the Augmented Reality Applications Attitude Scale (ARAAS) and a semi-structured interview. The quantitative data were analyzed using t test while the qualitative data were analyzed using descriptive analysis. The results of the statistical analysis indicated that the teaching method integrated with AR applications was a more successful method in promoting students' achievement of Atomic Structure and Atom Models compared to the traditional teaching method. In addition, students with a high level of interest in technology have been more successful in the tests than those with less interested. On the other hand, the data from the ARAAS applied to the experimental group indicated that student attitudes are positive, they are satisfied with using the AR, they do not carry concerns about use and they want to use them in different courses in the future. The experimental group students, through the semi-structured interview form, reported that the AR applications made significant contributions to the educational environment and the teaching process.

***Keywords**:* Augmented Reality, Science Education, Academic Success, Attitude, Atomic Structure, Atomic Models.

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Introduction

Today, learning environments that affect the quality of teaching are pretty important for students to access information easily and be effective in the learning process. Properly structured educational environments provide students rich learning experiences and enabling them to structure information correctly (Yasar, 1998). Most of the studies put forward in line with the researches emphasized the importance of learning environments on learning and stated that these purpose-designed environments provide effective teaching (Öztürk & Güven, 2012).

Wilson (1996) defined the needed environment as learning environments in order to identify problems and produce permanent solutions by using the available possibilities purposefully. There is a need, to be planned and programmed the learning environment to achieve its purpose, to be used appropriate methods and techniques, to be found the necessary materials (Karaman, 2011). Technology-supported learning environments based on a learner-centered conception are highly effective on students' perception and mental structuring. The development of technology brings along the development of learning environments and education concepts. In this context, the concept of learning environment should not be perceived as a narrow scope limited only to the classroom (Kim, Grabovski & Sharma, 2004).
In student-based teaching processes, with the use of technology, students can more easily understand and make the information they create permanent. In addition, the use of technology in learning environments enhances learning experiences, increases interest and motivation, simplifies complex information, and provides active learning opportunities for students. Therefore, the necessity of using technology in learning environments is an undeniable fact of today (Isman, Baytekin, Balkan, Horzum & Chopper, 2002).
Researches has shown that the use of technology in education and training enables an interactive interaction to make the learner from passive to active. Thus, an easier learning environment is provided by creating an effective learning environment (Garzón, & Acevedo, 2019; Şen, 2001). Augmented Reality (AR) applications are one of the computer-aided applications used in education in recent years and offer rich learning experiences by creating multiple learning environments.

AR can generally be defined as expanding complex three-dimensional (3D) graphics through mobile devices. (Starner, Mann, Rhodes, Levine, Healey, Kirsch, Picard and Pentland, 1997). The AR allows access to rich information content everywhere and enables simultaneous interaction between the physical world and digital objects by providing for a seamless analogy between the real world and the virtual layer (Hwang, Chu, Lin & Tsai, 2011; Novak, Wang & Callaghan, 2012).

AR applications used in learning environments have many benefits for teaching. In general, AR applications facilitate the planning and monitoring of plans in educational environments, offer new and different learning environments to the students, encourage research, enable easy learning, contribute to the socialization by increasing the cooperation among the students (Karal & Abdüsselam, 2015; Talan, Batdı &Yılmaz, 2022; Yılmaz & Batdı, 2016; Yılmaz & Batdı, 2021). AR concretizes abstract objects that cannot be obtained from the real world by rendering them in 3D and helps to make meaningful learning. (Finkelstein, Perkins, Adams, Kohl & Podolefsky, 2005; Shelton & Hedley, 2002; Yuen, Yaoyuneyong & Johnson, 2011). When looking at the content of the curriculum, the science course generally includes abstract subjects that students have difficulty in imagining. Therefore, considering the inadequacies of the factors that increase the quality of learning environments, it is thought that new approaches are needed for students to internalize the subjects. (Yigit & Akdeniz, 2003). The aim of this study is to investigate the effect of AR applications, which is a new approach in education, on the success and attitudes of secondary school students about atomic models that are not visible and which are difficult to understand. In this research, it is aimed that the

students learn both the concept of atom and the models of atom by experiencing and structuring correctly in their minds without leaving the real world. In this context, the research is expected to contribute to the literature on augmented reality and education.

Accordingly, the following research questions are sought an answer;

1) Is there a significant difference between the pre-test and post-test scores, achievement levels of the students in the experimental and control groups?
2) Is there a significant difference between the in the experimental group students' interest in technology and their posttest achievement scores?
3) Which level of the attitude of the students in the experimental group towards AR applications?
4) What are the student' views on the use of Augmented Reality technology in education and its impact on teaching?

Methodology

In this research, a mixed-method in which quantitative and qualitative research methods are used together was used. The aim of the mixed method is to ensure that the data obtained by different methods support each other and to adopt an integrative approach by combining the results obtained with quantitative research with the depth and detail objectives of qualitative research (Yıldırım and Şimşek, 2006).

Sample/Study Group

The sample group of the study consisted of total 205 students from six classes attending a secondary school located in Gaziantep in 2017-2018 academic year. Classes are predetermined. In the study, classes are divided into randomized experimental and control groups (Burak, 2022). Three classes are assigned as the control group and three classes as the experimental group. Experimental group 103; the control group consisted of 102 students.

Data Collection

Atomic models, achievement test, augmented reality and attitude scale were used as data collection tools. In addition, semi-structured interviews were applied to 20 randomly selected students from the experimental group.

While the achievement test on the atomic models of science course was created, the 7th grade science lesson of the 2017-2018 academic year was based on the MEB curriculum. The test, which was developed by the researchers and consisting of 23 questions, was examined holistically by experts and necessary corrections were made. Then, the pilot study was conducted on 61 students from 2 classes at the 8th grade level who had already learned this subject and the reliability coefficient of the test was calculated as Cronbach's Alpha 0,842.

In the study; Augmented Reality Applications Attitude Scale prepared by Küçük, Yılmaz, Baydaş and Göktaş (2014) was used. The sample of this attitude scale consisted of 167 secondary school students from 7 different secondary schools. Augmented Reality Applications Attitude Scale (ARAAS) is a 5-point Likert type, (1: Strongly Disagree, 2: Disagree, 3: Undecided, 4: Agree, 5: Strongly Agree) which has collected under 3 factors (satisfaction with use, anxiety of use, future use desire) and It consists of 15 items. The overall internal consistency coefficient of the scale has calculated as $\alpha = 835$.

After the AR applications, semi-structured interview forms were prepared by the researchers to get the opinions of the students in the experimental group about the program and its use in education. Interviews were conducted with 20 randomly students, selected from the experimental group. The forms consist of a total of 7 open-ended questions. By the feedbacks,

received in line with the views of the academicians, the questions were corrected, the forms took the final state.

Learning Material

The learning material was prepared through the Vuforia program by experts. While preparing the content of the program, the 7th grade MEB book for the 2017-2018 academic year is based on. The program is a marker-based high-level application. The main screen of the learning material is shown in Figure 1.

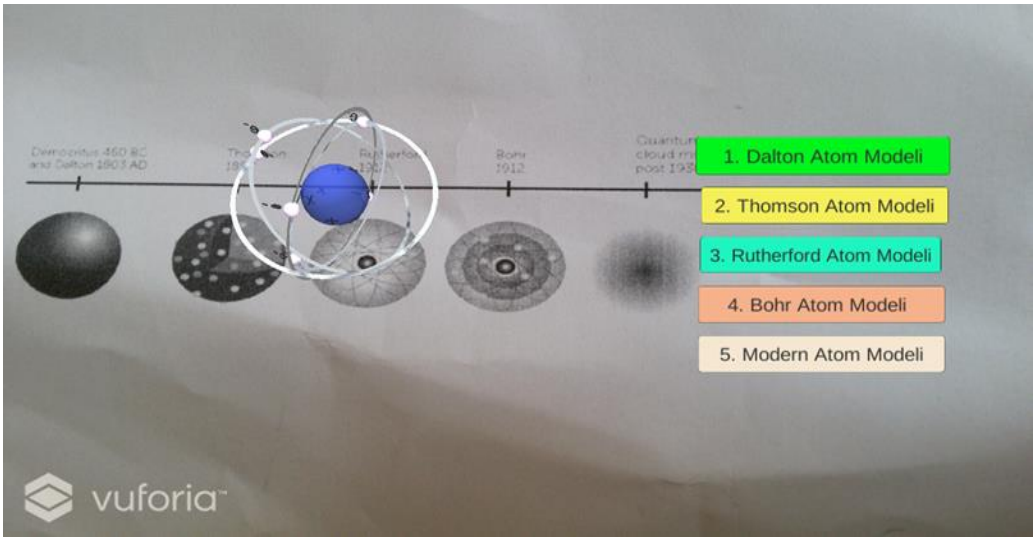

Figure 1. Vuforia program Atom models input screen

Process

In this study, pre-test and post-test design with control group, which is one of the quasi-experimental research models, is used. This pattern is shown in table 1.

Table 1
Pre-test and post-test quasi-experimental design with control group

Group	Pre-test	Application	Post-test
Experimental group	Achievement test	Augmented Reality-based teaching	Achievement test/ AR attitude scale
Control group	Achievement test	Traditional- teaching	Achievement test

Also, by conducting academic achievement and attitude test besides semi-structured interviews aimed students to express their ideas more clearly and concretely about the use of AR in teaching.

Data Analysis

The data obtained from the achievement test were analyzed through SPSS 20 package program. Independent sample t test results were examined on experimental and control groups, and ANOVA and Tukey tests were used to examine the relationship between students' interest level in technology and academic achievement.

The data obtained from the attitude scale were analyzed with SPSS 20 package program. In the study conducted for the students in the experimental group, the average scores for 15 questions in the range total of 15-75 points calculated and evaluations made.

Using the semi-structured interview forms applied to the students, the answers of the students for the questions were examined in detail and codes were formed for each question. The forms, in which these codes passed, were evaluated over frequencies and necessary analyzes made. He information about the analysis of data obtained can be stated in this section.

Findings

Is There a Significant Difference between the Achievement Test Pre-Test Scores of the Students in the Experimental and Control Groups?

In order to determine whether there is a statistically significant difference between the pretesting success scores of the experimental and control groups, an independent group's t-test was performed and the obtained results presented in Table 2.

Table 2
Results of independent group's t-test analysis regarding pretesting achievement scores of experimental and control groups

Group	n	M	SD	t	DF	p
Experimental group	103	14.15	5.05	-.593	202	.554
Control group	102	13.73	5.21			

Levene's test results, obtained after analysis, revealed that group variance could be acceptable as homogeneous. The results of the analysis show that the pre-test mean of the experimental group (M = 14.15, SD = 5.05) and the pre-test mean of the control group (M = 13.73, SD = 5.21) are very close to each other. Independent groups t-test results, which were made to determine that the difference between the pretest mean of the experimental group and the pre-test mean of the control group is not statistically significant, revealed that the difference between the averages was not statistically significant (t (202) = -.593, p> .05). In other words, the analysis' results led to the conclusion that before the procedure, the level of students' knowledge in the experimental and control groups could be considered similar to each other.

Is There a Significant Difference between the Achievement Test Post-Test Scores of the Students in the Experimental and Control Groups?

In order to determine whether there is a statistically significant difference between the post-test achievement scores of the experimental and control groups, independent group's t-test was performed and the obtained results are presented in Table 3.

Table 3
Independent group t-test analysis results of the data, obtained from post-test achievement scores of experimental and control groups

Group	n	M	SD	t	DF	p
Experimental group	103	18.25	3.59	-5.004	203	.000
Control group	102	15.21	4.98			

In order to determine whether there is a significant difference between the groups, t-test results of independent groups were examined and this result showed a significant difference between the control, experimental group and posttest success scores ($t(203) = -5.004$, $p < .05$). So there is a significant difference in favor of the experimental group depending on the method after application. This is a clear indication that AR practices positively affect student achievement compared to the traditional method.

Independent groups "t test" was used to determine whether there is a statistically significant difference between the level of interest in technology and achievement scores of the students in the experimental group and the results obtained are presented in Table 4.

Table 4
One-way variance analysis results to determine whether there is a significant difference in academic achievement scores according to technology interest levels

Level of the interest in technology	n	M	SD	F	p
Less	6	16.00	5.059		
Mid	50	19.02	3.951	3.339	0.039
Much	47	19.93	3.046		

In line with the answers given by the students to this question, it was seen that the average success score of the students who were very interested in technology was the highest ($M = 19.93$), and the average achievement score of the students who had little interest in the technology was the lowest ($M = 16.0$).

Also, a significant difference was found between students' interest in technology and achievement scores ($p < .05$, $F = 3.339$). Complementary calculations were made to determine which groups were between these differences and from post-hoc tests, the Tukey test was used. The statistical result obtained from this test is given in Table 5.

Table 5
Tukey HSD test results showing the relationship between students' level of interest in technology and academic achievement scores

Level of interest in technology		Mean Difference	SE	p
Less	Mid	-3.20	1.569	.137
	Much	-3.936	1.574	.037
Mid	Much	-0.916	0.738	.432

According to the post-hoc test results, It is seen that there is a significant difference between the students who are very interested in technology and those who are less interested in technology $p < .05$). This shows that students with a less level of interest in technology scored lower than the atomic model success test compared to students with a higher level of interest in technology.

Which Level is the Attitude of the Students in the Experimental Group towards AG Applications?

In order to determine the attitudes of the students in the experimental group towards AR applications, a 15-item "Augmented Reality Applications Attitude Scale" was used. The items were divided into 3 categories and scored according to student responses and descriptive analysis were performed. Firstly, the group averages were calculated on the scale which was evaluated over 75 points. The group average was calculated as 68.94 points.
As a result of factor analysis, the following data were obtained;

1) The averages of "use satisfaction" which consists of 7 positive expressions of students, was calculated as 4.5823 out of 5 points. This clearly shows that students are pleased with the course performed by AR application, and using this technology.
2) The averages of "use anxiety" which consists of 6 negative expressions of students, was calculated as 1.4095 out of 5 points. As these expressions were negative, students gave low scores to these expressions on a 5-degree scale and showed that they were not concerned about using AR applications in the course.
3) The averages of "future use desire" which consists of 2 positive expressions the students, was calculated as 4.6285 out of 5 points. This average is a clear indication that students want to use AR applications in the future and other courses too.

What is The Impression on Students in the Use of Augmented Reality Technology in Education and Its Impact on Teaching?

After the procedure, a semi-structured interview form consisting of 7 questions was applied to 20 students to enable students to express their feelings and thoughts against AR technology in more detail. As a result of these questions, students stated the advantages of AR applications in Table 6.

Table 6
Advantages of Augmented Reality applications

Advantages	**Frequencies (f)**
Makes subjects better understood	5
Lessons lapse more fun and enjoyable	6
Information become more permanent	5
Embodies abstract concepts	3
Lessons are easier to understand	5
Topics are processed faster	1
Awakens excitement and curiosity to school	1
Lessons are performed more realistically	1

Ö16 explained the advantages and disadvantages of AR applications as follows: "*If the advantage is used correctly, it can be very high quality works, because we see visually, the information becomes more permanent and we never forget it. We can open and examine in the time we forget by enlarging and shrinking. The disadvantage is that if the teacher releases the students if the program is used for entertainment, it can create chaos in the classroom.*" The answer "There is no one-to-one interaction with the teacher," which is given by a student, draws

attention to the question of the disadvantages of AR applications. The disadvantages of AR applications are given in Table 7 according to the students' statements.

Table 7
Disadvantages of Augmented Reality applications

Disadvantages	**Frequency(f)**
Students can disrupt the lesson	10
Does not provide one-to-one interaction with the teacher	1
In the classroom, chaos may be created and may be spoke in class	4
Don't effect	5

What are the disadvantages of AR applications? The fact that the majority of the students answered the question as "can disrupt the lesson" shows that the students are concerned about this issue. Also, another close answer to this is " it is spoken in class and creates chaos in the classroom" discourse. This shows that the students are concerned about talking in class. The answer "There is no one-to-one interaction with the teacher," which is given by a student, draws attention to the question of the disadvantages of AR applications. The student states that these practices limit teacher-student communication and explains this as a disadvantage. The students expressed the contribution of augmented reality applications in the learning environments as in figure 2.

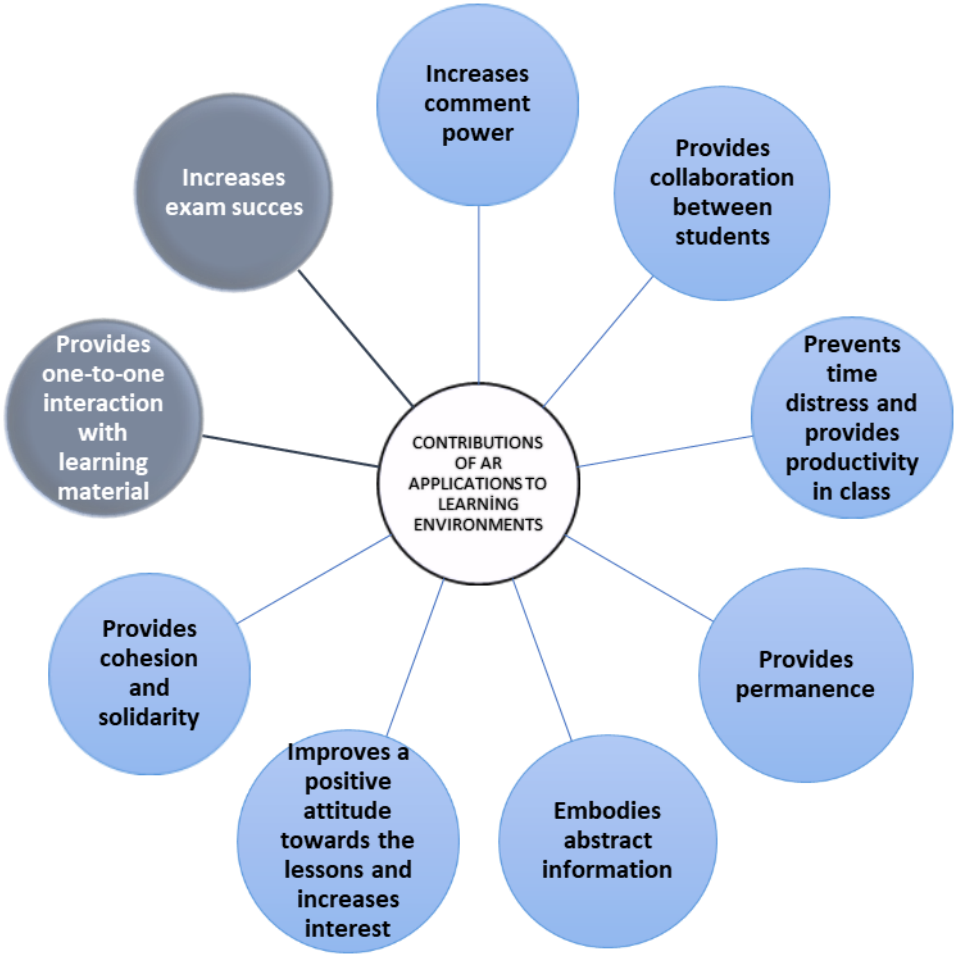

Figure 2. The contribution of augmented reality applications to learning environments

In addition to all these, the students expressed that they generally enjoyed the method of teaching, they had the opportunity to learn by doing and experiencing, and they wanted to use AR applications in other courses and subjects

Discussion / Conclusions and Suggestions

AR applications in formal education have the potential to be an important component in the learning environments of the future. Secondary school students, in science teaching, were pleased to use the application, especially because it offers multiple environments and addresses multiple senses in students. Besides, the data obtained from the attitude test shows that the students do not concern about using the application, and they want to use it in the future and other courses. AR attracts attention, increases desire and curiosity, enables students to enjoy the lesson, and as a result of them, students pay attention to the lessons and work more. These are the other results obtained.

In this study, the results obtained from the achievement tests show that AR applications positively affect student achievement (Abdüsselam & Karal, 2012; İbili and Şahin, 2013; İspir, Okumuş, Küçük & Yıldız, 2024; Shelton and Hedley, 2002; Vilkoniene, 2009). The success of the students on atom in the experimental group, showed clearly that AR applications provide meaningful and in-depth learning by attracting attention and interest to the subjects of science lessons which are especially difficult to understand (Kerawalla et al., 2006). In thislearnings, the fact that students see objects as if they are moving at the same time and see them live; that is, the close relationship between virtual and real objects is also a significant factor (Billinghurst, 2002; Küçük, Turan, Özkan, Taş, & Gürsoy2024; Wojciechowski & Cellary, 2013). Also, the AR applications' prevent concept confusion for subatomic particles (protons, neutrons, electrons) and facilitate concept teaching are other results obtained (Yen, Tsai & Wang, 2012).

As a result of the blending of subjects with AR applications, it is seen that the interests and desires of the students increased (Kerawalla et al., 2006; Rizov & Rizova, 2015; Yusoff & Dahlan, 2013). In addition, AR applications are influential in differentiating information as it provides learning by doing and experiencing (Dunleavy et al., 2009; Erbaş, 2016; Lin et al.,2011). Thanks to this application, students' curiosity and attention towards the lessons is increasing. As a result of this, students have a positive attitude towards AR applications and want to use the application in other classes too.

As a result of the studies, the contribution of AR technology to education seen today. Moreover, it is thought that it will contribute to education not only today but also in the future (Cheng & Tsai, 2012). The use of AR applications, especially in education, and the discovery of its potential, is very important both in terms of country education policies and country productivity. These applications, "How can it be used optimally in the school environment?" answering this question, integrating education is an important step in the transition between the real and virtual world (Billinghurst, 2002). This step is one of the top foundations that should be taken for the steady increase of student achievement and thus the quality of education. In order to realize the importance of these applications in education and to spread the usage area rather than prototype studies, educational researchers have a great responsibility.

Limitations and Recommendations

This study is limited to 205 seventh grade students in a province in the Southeast of Turkey. Since the subject of atomic models is available at different levels of education, it can be applied to different high school and university students.

Conflict of Interest: The authors declare that they have no conflict of interest.

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