

Augmented Reality Applications in Science Experiment Practices

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Abstract: *The purpose of this paper is to explore the impact of augmented reality (AG) and the flipped learning model on the attitude of 4th-grade students towards the science and technology course and to determine the opinion of students concerning videos presented through AG. Another objective of the study is to determine parents' opinions concerning AG and FL in science and technology courses. A pre-test / post-test quasi-experimental design was used with the control group to obtain quantitative data. Qualitative data were also included in the analysis to support quantitative data obtained from a case study pattern. In the study, the Science and Technology Attitude Scale was used to measure students' attitudes. The Opinion Scale for Experimental Videos was used to evaluate video usage opinions in science and technology courses. Besides, parents' opinions concerning AG applications and the FL model were collected through the researchers' interview form. Independent sample t-test and ANCOVA tests were conducted to interpret the quantitative data of the study. Qualitative data were evaluated with the content analysis method. The results showed that the AR and FL model's application provides students with a positive attitude towards science and technology; it also helped them solve problems. Besides, families have also expressed positive opinions about AR and FL applications.*

Keywords: *Augmented Reality; Experiment Practices; Flipped Applications.*

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Introduction

Especially in the field of education, the usage of technology integration has increased. With these developments, several different applications in learning environments are being employed. Parallel to the results in data processing technologies, multimedia technologies such as animation, sound, graphics, and text in the education environment increase (Daşdemir and Doymuş, 2012; Bicen and Arnavut, 2020). In recent years augmented reality and flipped learning concepts have been highly preferred in learning environments within data processing technologies. An examination of the literature shows that augmented reality is defined as a derivative of virtual reality (Azuma, 1997). Gonzato, Arcila, and Crespín (2008) described augmented reality as the technology which ensures that a user can see the world as developed or expanded through text, sound, and other additional information. Another definition given by Özarıslan (2011) emphasizes that augmented reality refers to the environments where the real-world comes together with the virtual world on a real-time basis and reaches the user in the same sensory area. Another popular concept is flipped learning environments nowadays. The flipped learning approach is a learning model where learners prepare at home using previously installed videos and presentations before coming to class and internalizing the topic through activities inside the class. Thus, it is a learning model that operates in the opposite direction of the traditional education process (Dođan, 2015). Abeysekera and Dawson (2014) define flipped classrooms as a learning approach that shifts the time and place of classroom lecturing and homework differently from traditional lecturing structure and provides the students with more cooperative studying opportunities. Briefly, in flipped learning, the topics targeted for education are given to students in an online environment; homework, projects, and activities are performed in the classroom with the teacher.

Besides, using augmented reality and flipped learning applications in education-teaching environments is defined as elements that support learning. Using Augmented reality and flipped classroom approach in science teaching is beneficial for increasing the quality of science education, improving the reasoning abilities of students in science classes, helping them explore knowledge, increasing their problem-solving skills, and transferring hardly observable and dangerous situations in real life to students (Karamustafaoglu, akır and Topuz, 2012).

One of the objectives of science and technology courses today is to ensure that students use technology in the best manner, to teach them how to learn, to ensure that their thinking abilities are improved, and to educate them as researching and inquiring individuals (Lind, 2005). It is believed that to realize practical science and technology teaching at schools, information technologies such as augmented reality and flipped learning should be utilized.

Students face several challenges in science and technology classes. Students see especially the concepts in this course as abstract and difficult-to-understand. When covering these concepts, augmented reality applications must be utilized in the learning process, and learning activities are extended in visual and intellectual terms. Richer learning environments are prepared for students. Besides, such information technologies should be employed at a certain level to perceive and interpret the events presented in science classes in a multi-faceted manner. Their attention to the course can be kept alive (Akpınar and others, 2005).

Real models are specially used for concretizing the abstract concepts for younger students whose concrete thinking abilities are not developed. In this age group, individuals can make sense of information more efficiently by concretizing knowledge (McNeil and Uttal, 2009). Bruner (1966) mentions that using real objects is suitable and economical for individuals at every age who encounter abstract contexts for the first time. Nevertheless, Kaminski, Sloutsky, and Heckler (2009) state that while learning abstract concepts, using a limited number of 3D real objects will not be adequate. McNeil and Uttal (2009) claim that real objects can be useful only by providing students with practical guidance to use them. Sarama and Clements (2009) state that in computerized environments, students' advice while learning concepts could be provided by the system instantly by offering visuals concerning their circumstances. AG is an environment that includes 3D, animation, video, etc., support and establishes instant contact with the user (Ozdamli and Karagozlu, 2018). Bruner (1966) emphasizes that several objects should be used so that different abstract concepts pose some limitations in terms of economy and practicality of applications. Although computers, cameras, and software are needed in the beginning to create an AG environment (Furio, Gonzalez-Gancedo, Juan, Seguí and Costa, 2013), once they are established, adding and presenting new materials will ensure economy and convenience. Besides, today, some augmented reality applications do not require any technical knowledge and can be used merely by transferring the content to the media. Sırakaya and Seferoğlu (2016) stated that making mistakes and performing experiments in AG environments that otherwise could be

dangerous is costless and safe. Di Serio, Ibáñez, and Kloos (2013) emphasized that using AG provides a fun and enjoyable environment. Contrary to these positive features, there are results in the literature that indicate that using AG in crowded classrooms is difficult (Yoon, Elinich, Wang, Steinmeier, and Tucker, 2012). In addition to this, problems can be witnessed when suitable media is not designed, and excessive cognitive loading can result (Munoz-Cristobal et al., 2015; Dunleavy et al., 2009).

An examination of the literature shows that considering that the most effective method in science and technology laboratory applications is the employment of virtual and real equipment, mobile-assisted AG applications have the unique feature of presenting virtual and real experiences together (Akçayır, 2016). Thanks to flipped learning environments, students can use these technologies whenever they want. A flipped learning environment is defined as a learning model that shifts responsibility for the time spent inside and outside the classroom from teacher to student. It is focused not on the teacher but the learner (Bergmann and Sams, 2012; Johnson, Becker, Estrada and Freeman, 2014). A student-centered approach is followed in science teaching in today's education,

Bergmann and Sams (2012) stated that flipped learning students had such responsibilities as watching videos, asking appropriate questions, and completing and sharing their studies. In contrast, the teacher is responsible for helping them and providing expert feedback. Flipped learning involves content presentation in science and technology not by the student in class-time but by watching videos of the topic and discussing them with their peers in online communities. Learners can access these comprehensive resources whenever they want. Thus, a teacher can spare more time to contact each individual. The main objective is to allow learners to reach the information they need any time they want using the flipped learning model, an information technology (Johnson, Becker, Estrada, and Freeman, 2014). Sams and Bergmann (2013) claim that the flipped learning classroom approach's most essential feature is perceived as learners watching the videos at home that were previously produced by the teacher. Teaching the events that occur in science and technology class by supporting concrete teaching auxiliaries to recreate them in their minds helps the abstract information be shaped as concrete concepts (Atilboz, 2004). However, Colagrande, Martorano, and Arroio (2016) indicate that ideas are usually presented in science books as "ready-made," "finished," and "true." Therefore, the teachers fail to adequately give students the nature of scientific knowledge and that sciences could be misunderstood as they only share what is ready-

made. An examination of the literature on sciences shows that one of the most striking topics is how science education should be performed (Abdüsselam, 2014). Holstermann, Grube, and Bögeholz (2010) state that teachers have one of the most critical roles in these researches, which should provide interactive learning environments for students to learn with fun and explore their skills and abilities, and work in teams. Besides, by using suitable education-teaching materials in science courses, students must be equipped with real-life experiences by applications such as animations. It must be ensured that they concretize abstract events to perform permanent learning (Karagozlu and Ozdamli, 2017). Videos are among the technologies which can be used for this purpose. Studies have displayed several advantages of covering the classes using videos in a teaching environment (Güvercin, 2010; Tekdal, 2002). These can be listed as (i) cognitive benefits (more and better learning, keeping in memory, remembering), (ii) psychological benefits (motivation, the pleasure of education), and (iii) ease of visualizing the information (Pekdağ, 2010). Despite the several advantages of videos, the inadequacy of using videos in science and technology classes at the elementary level is noticeable (Güvercin, 2010). While organizing the learning environment, working with laboratories is a beneficial teaching strategy (Demir, Büyük, and Koç, 2011). Students can realize such acquisitions as developing psychomotor behaviors through experimentation, interpreting what they see, problem-solving, acquiring scientific process skills, etc. (Ergin et al., 2005). It is believed that if the students in videos watch experiments that will be performed in class in advance, their laboratory practices will improve. When they encounter a laboratory environment for the first time, students can be uneasy about experimenting with testing kits. For this reason, it is believed that students watching how to test using the flipped learning model are essential. Although there is not a single way of applying FL, the general wisdom is that recording the course content as a video and providing the students with that video as well as performing classroom activities under the guidance of the teacher relevant to the topic during class is appropriate (Tucker, 2012).

Literature search shows that activities and experiments performed at the laboratory suffer from time constraints (Akyıldız, Aydoğdu, and Şimşek, 2012; Onbaşı, 2015). One of the flipped classroom approaches' essential advantages is that they provide students with learning environments suitable for their speed, independent from time and space (Davies, Dean, & Ball, 2013; Bergman & Sams, 2012). Studies in the literature revealed that FL reduced students' anxiety levels (Marlowe, 2012) and increased their cooperative studying abilities (Strayer, 2012). Considering all these

advantages, using FL in elementary classes and revealing possible positive and negative effects is essential. This study is critical because it is one of the first studies on FL supported with augmented reality application and aims to increase science teaching effectiveness at the elementary level. As a result, it is necessary to determine students' and parents' attitudes and opinions regarding the method and process during home learning to benefit from the FL potential supported by augmented reality.

This paper aims to explore the impact of Augmented Reality and Flipped classroom applications on science and experiment class. Another objective of the study is to determine the attitudes of 4th-grade students towards the course and contents and parents' opinions concerning AG and FL applications in science and technology classes.

1.1. Related Researches

The literature search revealed many studies on AG applications and flipped learning environments, especially in recent years. Some of these studies are presented below.

Abdüsselam (2014) revealed that teachers could benefit from visualizing and concretizing magnetic fields when teaching physics, especially magnetism. Visualizing magnetic fields with three-dimensional shapes in an augmented reality environment could make students explain the difference between covered cases and facilitate comprehending the topic.

Çakır, Solak, and Tan (2015) conducted a semi-experimental study on the impact of teaching English words through augmented reality technology on student performance and determined that the classes covered with AG technology displayed higher academic achievement compared to types covered by the classical method. Another conclusion of this study is that it revealed that students' motivation towards used material is higher in the classes covered with AG technology.

Sırakaya (2015) concluded in his study that students believed that augmented reality learning material concretized abstract topics, facilitated comprehension of subjects, and ensured more active participation in classes. Besides, according to the study's results, it is found out that students believed that augmented reality learning material increased their attention and motivation for the course, made it more exciting and entertaining, and increased their communication with peers and teachers during class. It is also concluded that students could easily use augmented reality learning material and use it again.

Sırakaya (2015) conducted a study on the flipped classroom model's impact on academic success, self-managed learning preparedness, and

motivation. Sırakaya concluded that the experiment group's scores on general academic success, motivations, and permanence were higher than the control group, meaning that there was a significant difference in favor of the experiment group. Finally, it was concluded that the students in the experiment group, in general, had positive opinions on the flipped classroom model.

Taşkıran, Koral, and Bozkurt (2015) stated that augmented reality applications in foreign language teaching were fun materials for students. Also, it increased motivation, allowed learning by doing and living, and permitted active participation by learners in the learning process. Another conclusion of the study was that augmented reality applications concretized the abstract topics in foreign language teaching, made remembering the learned items more comfortable and allowed for high interaction and communication. However, research results also indicate that AG applications are time-consuming, although they are fun and motivating.

Akçayır and Akçayır (2016) explained that AG applications made an essential contribution to foreign language teaching. Besides, considering that AG applications can be used as assisting tools for students in learning words and today most students possess mobile devices, it has been found out that AG could be used in education environments without requiring any additional cost.

Akçayır (2016) studied the impact of augmented reality applications in science laboratories on the laboratory skills, attitudes, and workloads of university students and determined that experiment group students completed their experiments in a shorter period. According to the researcher, the possible reason experiment group students conducted their investigation in a shorter time is that they finished the experiment mechanism faster with the supporting materials. Thus, more time is left to students to discussing experiment results, which allowed them to make more measurements related to the experiment and contribute to developing their laboratory skills. Also, AG technology contributed to students' laboratory skills; it also ensured that they display a positive attitude towards the physics laboratory. In this paper, the interviews held with experiment group students revealed that they were delighted with using AG technology.

Aydın (2016) found no significant difference between Flipped classroom students and traditional classroom students on academic success, attitude towards programming, and self-efficacy perception. Nevertheless, there was a considerable difference between the attitudes of the two groups towards e-learning.

Karaman (2016) examined the impact of flipped classroom application on academic success and experiences. He concluded that students' academic success scores in the experiment and the control group were not different. Besides, it was displayed that students liked the model and thought it should be used in other courses and increased motivation.

Kocabatmaz (2016) examined the opinions of pre-service teachers. As a result, teacher candidates explained the flipped classroom as a model that allows for endless repetition. Besides, this study concluded that in addition to several positive features, pre-service teachers emphasized such negative parts of the flipped classroom model as the fact that the necessity of watching videos before class consumes too much time and problems are experienced in the internet connection.

Sağlam (2016) analyzed the impact of the flipped classroom model on students' academic success and attitudes in English class and found out that the flipped classroom model had a significantly positive effect on students' success and perspective traditional method.

Akgün and Atıcı (2017) researched the impact of flipped classrooms on students' academic success, and the results showed that the success of experiment group students increased with the flipped classroom application.

Güç (2017) studied the impact of flipped classroom application on rational numbers and operations with rational numbers; his examination of the data obtained from the pre-test application found out that both groups were equal in academic success. Also, an analysis of the data obtained from the post-test application displayed that the experiment group's test score was significantly higher than the control group's test score. This difference was in favor of the experiment group. Another finding of the study is that when the change in groups' attitude towards mathematic class is examined, a flipped classroom model's attitude towards maths did not constitute a statistically significant difference.

Şahin (2017) conducted a study on the impact of augmented reality on success and attitude. As a result, there is a significant difference between success and attitude towards students who covered the science and technology class in AG technology-supported learning environments and covered the course with the traditional method. Besides, at the end of this study, it was found out that students in the experiment group were satisfied with using AG applications, willing to use them, and did not suffer from anxiety while using these applications. Another conclusion of this study was that there are a medium level and significant relation positively between success and attitude towards students who used AG applications.

Sırakaya (2017) examined the gamified flipped classroom model and concluded that students usually had favorable opinions about the gamified flipped classroom model. Another finding of this study was that students came to the class prepared with this application, showed active participation, learned by having fun, and enjoyed increased interaction and motivation.

Augmented reality and flipped classroom applications were studied and examined in various fields recently. Based on the studies in the literature, it is seen that AG applications and the FL model have a positive impact on education. An examination of the literature showed that conducted studies are only on AG applications or only on the FL model. There are no studies in the literature that examine two applications together. For this reason, the purpose of this study is to investigate the impact of augmented reality (AG) and flipped learning model (FL) on the attitude of 4th-grade students towards the course, to determine the opinions of students towards videos presented with AG and parent opinions towards AG and FL applications in science and technology class.

2. Methodology

A semi-experimental pattern with a pre-test / post-test control group was employed to reach quantitative data in the study. Qualitative data were also included in the analysis to determine parent opinions and support quantitative data obtained through a case study pattern.

2.1. Participants

The study was conducted with 59 4th-grade students at a private elementary school in a district of the Turkish Republic of Northern Cyprus and their parents. The case sampling method was used for the experimental group (Patton, 1987). The experimental group consisted of 30 students, and the control group consisted of 29 students. Based on voluntarism, the opinions of 15 parents of the students in the experiment group were obtained.

2.2. Data Collection Tools

You may need to insert a page break to keep a heading with its text. In the study, the "science and technology attitude" scale was used to measure students' attitudes. The "opinion scale towards experiment videos" was used to measure their opinions concerning using videos as augmented reality content in science and technology. Also, student parents' opinions concerning AG applications were collected through the researcher's parent interview form to support quantitative data.

The attitude scale for the science and technology course was developed by Kenar and Balcı (2012) for 4th grade and 5th-grade students. The scale consists of 12 items and three dimensions in total. The measuring tool designed to determine students' attitudes towards science and technology class is a 5 Likert-type scale. The answering options in the scale are "Strongly Agree," "Agree," "Neither Agree nor Disagree," "Disagree," and "Strongly Disagree." The scale scores are between 1.00 and 5.00, indicating that as they approach 5.00, students' agreement level with the proposition is high. Individuals who received below 2.60 from the attitude scale towards the science and technology course accepted a negative attitude. Those who received 2.60 and higher scores were assumed to have a positive attitude.

Opinion Scale towards Using Experiment Videos was developed by Daşdemir and Doymuş (2012) for elementary school students. The scale consists of 18 items. Opinion Scale towards Using Experiment Videos (DVKYGO) uses a 5 Likert type scale. The expressions used in the scale are "Strongly Agree, " Agree," "Neither Agree nor Disagree," "Disagree," and "Strongly Disagree."

The interview form for AG applications used in the same study was developed for 4th-grade parents using the literature and obtaining expert opinion. The interview form consists of two open-ended questions.

2.3. General guidelines for the preparation of your text

Avoid hyphenation at the end of a line. Symbols denoting vectors and matrices should be indicated in bold type. Scalar variable names should normally be expressed using italics. Weights and measures should be expressed in SI units. Please title your files in this order conferenceacronym_authorslastname.pdf

2.4. Development of Materials

Before the application, videos were prepared concerning the experiments used experiment kits in the laboratory and were uploaded to the channel created on YouTube. Videos were integrated into the Augmented Reality application. In that way, it was ensured that any mobile device with the Augmented Reality application could access these videos. An examination of the literature on educative videos shows that complicated subjects could be given with 1-2-minute short videos to avoid cognitive overload (Sood, 2016). Opinions of field experts and information technologies were obtained on the prepared videos.

The steps of the process of material development:

1. Provision of experiment kits and recording of experiment videos
2. Obtaining the opinions of field experts and faculty members
3. Reorganization and improvement of materials in line with suggestions
4. Uploading experiment videos on YouTube channel
5. Creating tags for experiment videos using **Augmented Reality** software
6. Sticking the tags on experiment books

Researchers used experiment kits to support science and technology subjects' lecturing in the control group during the application. For example, magnets were brought to the classroom, and the magnets' poles were shown, and figures drawn on the board to indicate that the same poles pushed each other while opposite poles pulled each other. In the experiment group, experiment videos were used as AG material in addition to real objects. The prepared experiment videos gave information to students on how the experiments would be made using experiment kits. Tags were stuck on experiment books of students in the experiment group concerning the five different experiments created with the Augmented application's help (see Figure 1).



Figure 1 *Experiment Books*

Students requested that they watch the videos at home with their parents three days before the experiments were applied in the laboratory. In addition to the videos, information about experiment books and experiments was shared with parents through the social network group. The purpose here was to ensure that students learned the experiment's objectives and how it should be done before they come to the classroom. Students chose suitable experiment kits in line with the experiment videos they watched and performed the experiments themselves under teacher supervision in a laboratory class. Also, in the laboratory environment, teachers and students served question-answer activities to the purpose of the investigation and how it should be done, etc. (See Figure 2). The application continued for almost eight weeks. At the end of the application attitude towards course, the scale was applied as a post-test, and Opinion Scale towards videos prepared as AG content was used. Besides, the opinions of parents were obtained through opinion forms on these applications.

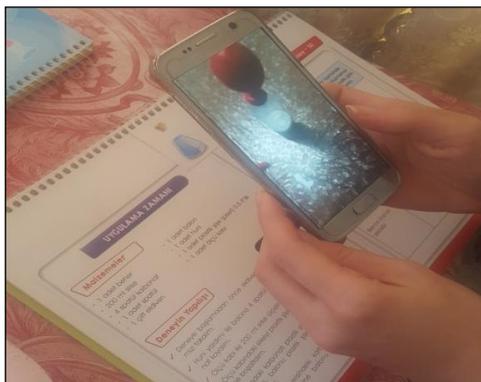


Figure 2 *Inflatable Balloon Experiment*

2.5. Analysis of data

For analyzing quantitative data, Kolmogorov-Smirnov, Skewness, and Levene tests were conducted first to determine if the distribution was normal and homogeneous. It was found out that the data were conforming to the parametric tests. Independent sample t-test and ANCOVA tests were conducted through SPSS 25.0 program. The qualitative data of the research were evaluated using the content analysis method. Before analyzing qualitative data, a general conceptual structure was formed, and the main themes and sub-themes were created after the analysis. Two of the

researchers coded data separately, and another researcher, who is an expert in the field, performed a double-check. At the end of this process, the "Reliability = disagreement/agreement + disagreement" formula was applied to coding. The harmony between the two coders was calculated as 93 percent—categories created after coding were tabulated as frequencies. Besides, obtained qualitative data were supported by making direct citations from the opinions of parents.

3. Results

This study explores the impact of experiments supported with AG technology and flipped learning environment on the attitude of 4th-grade students towards the science and technology course, determining students' opinion concerning videos presented via AG and the opinion of student parents on these applications. The obtained findings are shown below in line with this objective.

3.1. Pre-Test Results for Experiment and Control Groups

Students were randomly assigned to the experimental and control groups. A pre-test was applied to determine whether the attitudes of students towards science and technology were equal. T-test was used for an independent sample to examine the attitude of 4th-grade students towards the course. Pre-test results for the experiment, and control groups are given in the table below.

Table 1 Pre-Test Results for Experiment and Control Groups

Groups	<i>N</i>	\bar{x}	<i>S</i>	<i>t</i>	<i>p</i>
Experiment	30	2.44	.42		
Control	29	2.61	.44	-1.47	0.15

It is seen that the pre-test success score of control group students ($X = 2.61$) is close to the pre-test score mean value of experiment group students ($X = 2.44$). According to the t-test results for independent groups, it can be seen that there is no statistically significant difference ($p > 0.05$). This result shows that the previous attitude level of experiment and control group students is equal, which means they are suitable for the application.

3.2. Findings Concerning Gender of Students in Experiment and Control Groups

Findings concerning the gender of students in the experiment and control groups are given in Table 2. As shown in the table, 43.33% of the experiment group students are females, and 56.66% are males. On the other hand, 44.83% of students in the control group are females, and 55.17% are males.

Table 2 Findings concerning the gender of students in experimental and control groups

Groups	Gender	<i>f</i>	%
Experiment	Female	13	43.33
	Male	17	56.66
Control	Female	13	44.83
	Male	16	55.17

As shown in the table, it can be claimed that gender distribution is similar to each other in both groups.

3.3. Science and Technology Attitudes

In the study, experimental and control group results were compared to assess whether there was any difference between their Science and technology attitudes levels after the application. The Kolmogorov-Smirnov test was conducted to perform the ANCOVA analysis, and it was found that the data showed normal distribution, as the significance level was higher than 0.05. Later, the Levene test was used to check variance homogeneity, and it was determined that groups were homogeneous ($p > 0.05$).

Table 3 Science and technology attitudes of the experimental and control groups

Groups	Pre-test			Post-test		
	N	\bar{X}	S	N	\bar{X}	S
Experiment	30	2.44	.42	30	4.43	.42
Control	29	2.61	.44	29	3.69	.60

An examination of Table 4 shows that the attitudes for the Science and Technology course for the experimental group ($x=2.44$; $S=.42$) increased after augmented reality and flipped classroom application ($x=4.30$, $S=.45$). Similarly, the control group's Science and Technology course attitude ($x=2.61$; $S=.44$) marginally increased at the end of the application ($x=3.70$, $S=.59$). During analysis, the pre-test scores of groups were kept under control to eliminate any impact of pre-test scores on post-test scores.

Table 4 Science and technology attitude scores and corrected average scores

Groups	N	\bar{X}	\bar{X} (d)
Experiment	30	4.43	4.44
Control	29	3.69	3.68

As can be seen in Table 4, when the corrected average scores obtained from the attitudes are examined, it can be said that the attitudes of the experimental group are higher compared to the control group. ANCOVA results concerning whether the difference between the corrected Technology and Science attitude scores of the two groups is significant are presented in Table 5.

Table 5 Science and technology covariance analysis results

Source	Sum of squares	df	Mean square	F	p
Pre-test attitude	.02	1	.02	.26	.61
Group	.55	1	.55	29.61	.00
Error	15.81	55	.29		
Total	969.88	59			

According to the covariance analysis results in Table 6, when the test scores of the experimental and control groups are controlled, it can be seen that the difference between the scores is significant ($F(1,55)=2944.61$, $p<0.05$). Eta square value for determining the size of this impact in favor of the experimental group was calculated as 0.35. The impact value indicates a small effect at .01 level, medium impact at .06 level, and an enormous impact when it is higher than .14. According to this result, it can be said that science

and technology experiments conducted with augmented reality and flipped learning affected the attitudes of students towards science and technology classes.

3.4. Determining Student Opinions on Experiment Videos Presented through AG and FL Environment

Descriptive statistical results performed to examine the opinions of 4th-grade students concerning experiment videos supported by AG technology and FL environment in science and technology teaching are given in Table 6.

Table 6 Experimental group statistics results

Opinions	\bar{x}	S
1.Subjects covered in experiment videos attracted my attention more.	4.37	0.99
2.Experiment videos helped me solve problems about the subject.	4.67	0.66
3.Usage of experiment videos made me think about the subject in more detail.	4.67	0.66
4. Usage of experiment videos urged me to do research.	4.53	0.94
5. The experiment videos made me feel like I was in the science and technology classroom.	4.73	0.58
6. Experiment videos should always be used in science and technology classes.	4.50	0.94
7. Experiment videos should be used in other courses, too.	3.87	1.41
8. Usage of experiment videos made me concentrate on the subject.	4.27	1.26
9. I liked the topics covered in the experiment videos.	4.53	0.78
10. Covering the class with experiment videos is very nice.	4.53	0.89
11. Usage of experiment videos helped me think creatively.	4.20	1.19
12. I was not able to learn the subjects as experiment videos were very complicated.	2.33	1.64
13. Usage of experiment videos in courses is very	4.30	0.99

beneficial.		
14. Experiment videos helped me understand the subject better.	4.30	0.95
15. Covering the class with experiment videos is boring.	2.00	1.36
16. Usage of experiment videos caused disorder in the classroom.	1.40	0.93
17. Usage of experiment videos made comprehension of subjects more difficult.	1.43	0.77
18. Experiment videos should not be used in science and technology classes.	2.03	1.38

As can be seen in Table 6, it is found out that the answers given by students concerning the experiment videos supported by AG technology and FL environment are in a positive direction. It is also revealed that these applications mostly helped students solve problems related to the subject and ensured that they think in more detail about the issue and like the class. The students' most positive attitude was witnessed in the expression "experiment videos made me like science and technology class." This finding is parallel to the reason for the increase in attitudes towards science and technology.

On the other hand, a minority of students stated that covering classes with experiment videos was boring and that these applications were too complicated. According to these findings, it can be claimed that the attitude of 4th-grade students on experiment videos supported with AG technology and FL environment is favorable.

3.5. Examination of Parent Opinions on AG Applications and FL Environment

Under this title, parents of students' opinions in the experiment group concerning AG applications and the FL environment were used as an independent variable in this study, and researchers' comments researchers based on these opinions will be provided.

The repeated common points were identified in answers given to the parents' questions to determine the advantages and limitations of using AG applications and FL model together in 4th-grade science and technology classes, shown in the form of frequency tables. It was followed by an interpretation of the situation which occurred according to this table.

Table 7 Opinions and Frequencies on AG Applications and FL Environment

Positive opinion	f	Negative opinion	f
Ensuring visuality	10	Inadequate class hours	1
Addressing multiple sense organs	9	The intensity of the course curriculum	1
Permanent learning	8	Lack of hardware	1
Easy and effective learning	7		
Interesting and intriguing	7		
Attention-grabbing	7		
Motivating	7		
Learning by doing-living	5		
Providing ease of learning	5		
Active participation	5		
Fun learning environment	3		
Reducing anxiety level			

According to the frequencies in Table 7, parents thought that using AG application and FL environment in 4th-grade science and technology classes was affirmative. They stated that especially visuality ensured more permanent, easy, and effective learning. Expressions of some parents concerning this opinion are presented below:

"Using AG applications and FL model ensured that students see the practical side of theoretical knowledge and led to more permanent learning. Also, I think that students will be more conscious of what to do in the classroom if they watch the experiment at home in advance." (Parent 1)

"If experiments are supported by repetition, AG applications, and FL model, more permanent learning occurs." (Parent 2)

"Depending on the intensity of subjects, I think that supporting the course with AG applications and FL model and enriching it in terms of visuality increases the interest of children in the course. Besides, I believe that when children watch videos about science and technology courses at home and then perform application at a laboratory, more permanent learning occurs." (Parent 11)

"Supporting experiments with AG applications and FL model provides ease of learning and helps the student be in interaction." (Parent 13)

Besides, parents expressed that supporting experiments with AG applications and FL environment would help students actively participate in the class and interact with others. They also stated that these applications served to attract the attention of and develop students' curiosity, were fun

and attractive in content formation, and helped reduce students' anxiety level before the experiment. Expressions of some parents concerning this opinion are presented below:

14) *"These applications ensure that the student is active and in interaction." (Parent*

13)
"When they watch an experiment with AG applications, they become more curious and interested." (Parent 13)

"Performing experiments by supporting with AG applications and FL model reduces the anxiety in students before the experiment and guides them in how they should do the experiments." (Parent 8)

"I believe that supporting experiments with AG applications and FL model has several positive aspects. Thanks to multimedia elements, permanent learning is ensured, and content becomes fun and interesting. This method provides convenience in learning; it also saves time and money." (Parent 11)

"I think that watching the experiments that they will make in science and technology class in advance and obtaining information, and using AG applications and FL model for this purpose, is very beneficial. These applications address multiple sense organs, and thus learning becomes more permanent. With flipped learning, students learn subjects at home, and they can have more time to contact the teacher to ask about the points that they did not understand." (Parent 6)

"Experiment courses should involve learning by doing and living, and AG applications minimize the loss of time in these classes." (Parent 9)

"Multimedia tools such as visuality and sound address multiple sense organs of children; thus, learning is more permanent, and motivation sources such as attention, curiosity, and interest are developed in the child. Due to the flipped learning model, my son began to ask more questions after watching the video, researching the internet, and using encyclopedias. (Parent 4)

Some parents also indicated that these applications were cost-saving, served as supporting tools, increased success, ensured intense concentration and convenience to the teacher, added practicality. Did as a guide and helped cognitive-emotional development psychomotor developments, provided focusing, and added researching-inquiring abilities.

"My daughter scanned stickers on her book through tablet and read the information about the experiment they would do every week, watched the experiment performed by her teacher, and prepared questions about the subject. She searched for the points that she wondered about the experiment before she entered the class. I think that with this application, researching-inquiring abilities and technology-usage skills of my daughter improved." (Parent 5)

"I noticed that reading course notes about experiments at home and starting to watch the experiment at home in advance increases the interest of the child for the course, that the child focuses on the subject, asks questions to us, and begins to research on the internet." (Parent 10)

There was only one parent who stated a negative opinion in the study. The parent complained about the intensity of the curriculum and time constraints. The expressions of the parent with a negative opinion are presented below:

"The fact that the course is 4 hours a week negatively affects these applications. Also, the course curriculum's intensity and the teacher's haste to cover all topics restrict the usage of AG applications and the FL model in science classes. Hardware deficiencies in classrooms can also affect these applications negatively. Also, I think that performing experiments with AG applications has some negative aspects. These are loss of time, high costs, hardware deficiencies, and inadequacy of both students and teachers in using technology." (Parent 15)

Besides, one parent recommended that laboratory class hours should be increased so that supporting laboratory classes with AG applications and FL model could be more effective:

"Laboratory class is only once a week. I believe that experiments supported with AG applications and FL model should be increased and children should be given more opportunity to perform applications." (Parent 12)

4. Discussion and Conclusion

The study results reveal that science and technology experiment applications performed with AG and FL environment positively affected students' attitude towards the course. Similarly, Akçayır (2016) concluded in his interview with students that AG technology ensured that students display a positive attitude towards the physics laboratory. Besides, several studies in the literature concluded that AG applications and the FL model positively affected students' perspectives (Aydın, 2016; Sağlam, 2016; Şahin, 2017).

At the end of the conducted study, students' opinions on experiment videos supported by AG technology and FL environment indicated that these applications helped solve questions and ensured that they think on the subject in more detail and like the course. Similarly, Abdüsselam (2014) revealed several positive aspects of AG applications in his study. He concluded that using these applications helped students concretize the subjects, explain the differences between cases covered in activities more efficiently, and find easier ways to comprehend the subject.

When the parent opinions concerning usage of AG applications and FL environment in the context of 4th-grade science and technology class is examined, it is seen that they stated that especially visuality ensured more permanent, convenient, and practical education. Studies in the literature concluded that AG applications made learning (Abdüsselam, 2014) and remembering subjects more comfortable (Taşkıran, Koral and Bozkurt, 2015; Akgün and Atıcı, 2017), that these applications contributed to permanence (Akçayır and Akçayır, 2016; Kocabatmaz, 2016) and that FL teaching increased permanence (Sırakaya, 2015).

Besides, according to the study's findings, parents stated that these applications address multiple sense organs and are attractive and intriguing for students. It was also concluded that these applications effectively attracted students' attention, motivating them, providing ease of learning and active participation, and creating an entertaining learning environment. An examination of the literature shows that several studies have been conducted which could support these results. It was concluded that AG applications increased the motivation of students (Tan and Lui, 2004; Barreira et al., 2012; Di Serio, Ibanez, and Kloos, 2013; Mahadzir and Phung; 2013; Çakır, Solak and Tan, 2015; Sırakaya, 2015; Taşkıran, Koral, and Bozkurt; 2015; Karaman, 2016; Sırakaya, 2017). Therefore, that it made the course interesting and entertaining (Sırakaya, 2015; Taşkıran, Koral, and Bozkurt; 2015; Sırakaya, 2017), and the FL model and AG applications ensured active participation (Akgün and Atıcı, 2017; Sırakaya; 2017).

According to the study results, parents stated that these applications helped reinforce what is learned, raise awareness concerning the subjects, create a positive attitude, increase success, generate low-cost environments and ensure active listening in the classroom environment. Likewise, in his study, Şahin (2017) revealed that AG applications positively impacted students' success and attitude in science teaching. Also, Akgün and Atıcı (2017) concluded that the FL model increased the success of students. Besides, it was supposed that the FL model reinforced what is learned (Kocabatmaz, 2016). It was concluded that AG applications increased academic success (Barreira et al., 2012; Perez, Lopez and Contero, 2013) and that AG applications did not impose any additional cost due to the high ratio of possessing mobile devices among students today (Akçayır and Akçayır, 2016). Likewise, Atasoy, Gün, and Karoğlu (2017) stated in their study that AG materials could be beneficial in carrying to classroom environment the applications which could be costly in education environments.

In the study, few parents remarked that this application had negative aspects. They mentioned that these applications could have detrimental effects on teaching due to insufficient class hours, the course curriculum's intensity, and some hardware deficiencies. When the literature is examined, Taşkıran, Koral, and Bozkurt (2015) concluded that AG applications were time-consuming, whereas Akçayır (2016) found out that these applications helped create time to discuss experimental results. In this paper, parents emphasized that these applications ensured time-saving in experiments.

Another conclusion of the study is that parents stated that these applications allowed learning by doing and living and help students enjoy reduced anxiety levels before experiments. Likewise, Taşkıran, Koral, and Bozkurt (2015) concluded that AG applications allowed learning by doing and living. Besides, Şahin (2017) concluded that students did not suffer from anxiety while using AG applications in science teaching conducted with AG technology.

Parents who provided a negative opinion in the research mentioned that these applications could negatively affect education due to hardware deficiencies and inadequacy of teachers' and students' technology usage. In his study, Kocabatmaz (2016) explored that the FL model requirement that videos should be watched before the class took too much time and problems arose in internet access. Karaman (2016) concluded that teachers and students had to be informed accurately in applying the FL model. Such an information activity could contribute to the elimination of student and teacher inadequacy in these applications. AG applications and FL environment should be covered as subjects in teacher education and on-the-job training programs.

In summary, according to this study's conclusions, it has been concluded that AG and FL model applications helped 4th-grade students develop a positive attitude in science and technology experiment classes, think in detail on the subject, and like the course and solve problems. Besides, it is revealed that parents feel that AG and FL environment applications ensured visibility in learning, effectively addressed multiple sense organs, provided comfortable, permanent, and practical knowledge, and were time-saving. Future studies can include 5th-grade students in the research. Another limitation is that in the application, which was performed with a flipped learning model, students were only provided with experiment videos and lecture notes. Future studies can offer students learning activities that can be performed at home.

Research findings have displayed that students are willing to use different applications. Accordingly, different learning environments and applications should be offered to students in teaching. Students' and teachers' education needs concerning AG and FL environment applications should be determined, and studies should be prepared on different designs to reflect the classroom environment. Large-scale studies on AG and FL environment applications should be conducted with broader participation.

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