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ORIGINAL RESEARCH

# The effects of augmented reality technology on learning achievement and attitude toward physics education

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## Abstract

This study aims to investigate the impact of learning materials developed with augmented reality (AR) technology on learning achievement and attitude toward physics education. In this study, a quasi-experimental design was used in which intact classrooms in two different classes in SMAN 1 Gununghalu, consisting of a total of 64 10th grade high school students, were randomly assigned to either the experimental or control group. The experimental group completed the "Keppler's Law" module of their course using AR technology, while the control group completed the same module using textbooks. The data was analyzed using an independent sample t-test. The result showed that the mean ratio of learning achievement in the experimental group was 80,62, whereas the mean ratio in the control group was 71,75. Meanwhile, the results for the attitude toward physics education for the experimental group were obtained at 69,28 and for the control group at 59,46. The study found that students in the experimental group were found to have higher levels of achievement and more positive attitudes towards the course than those in the control group. It has been suggested that AR technology could be a potential and effective technology for abstract concepts in physics education. Moreover, it has implications for the use of AR for physics education and recommendations for further studies.


**Keywords**: Keppler's Law · Learning Modul · Teaching Materials

## INTRODUCTION

Technological advances have brought about rapid development, which has led to the development of new technologies that enable computer-generated data to be used effectively in real environments. Digital technologies are used in the learning process with new methods and innovative ways (Baihaqi et al., 2021). Digital in education is one of the skills needed in the future (Grand-Clement, 2017). Educational technologies in physics teaching serve to improve the quality of physics courses through effective scientific activities, develop communication skills in physics courses, help students discover knowledge and enhance their problem-solving abilities and critical thinking (Srivastava & Dey, 2018).

One example of the contribution of digital technology that can be used in education is Augmented Reality (AR). AR technology has become possible to prepare effective and interesting technology-based instructional materials (Sahin et al., 2020). AR can be described

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as an interactive platform that presents a combination of virtual objects and the real world (Armajaya, 2017; Mahendra, 2016). Augmented reality (AR) is a technology that makes sure that virtual information generated by a computer is placed directly or indirectly in a real-world environment (Arici et a;., 2019). AR is one of the most developed technologies in 2016 and combines mobile learning with Augmented Reality applications (Johnson et al, 2013). In recent years, the term "*Mobile Augmented Reality*" has emerged for use on mobile devices (smartphones) that can be used anywhere and anytime (Karagozlu & Ozdamli, 2017)). When combined with mobile devices (smartphones), Augmented Reality Technology has a greater impact (Nincarean et al, 2013; Joan, 2015).

In educational contexts, AR technology increases students' interest and motivation through the interaction between real and virtual worlds (Erbas & Demirer, 2019). It is thought that the usefulness of AR in education. In the literature, there are many studies on the use of AR in physics education. AR technology can be used to make any class more colorful, interesting, and interactive. The effects of AR on students' satisfaction and achievement were found that students' achievement had improved and that they were satisfied with the AR system (Erbas & Demirer, 2019; Wang & Chi, 2012). AR technology would be useful in teaching magnetism in physics courses (Cai et a;., 2017). It was revealed that AR technology could enable visualization of the magnetic field (Abdüsselam & Karal, 2012) and contribute to the concretization of the subject. Augmented Reality can facilitate the development of critical thinking, problem-solving and communicating skills (Karagozlu & Ozdamli, 2017; Fidan & Tuncel, 2019), and Augmented Reality can develop students' cognitive abilities (Tuzan et al., 2018). AR technology can increase students' learning motivation (Fidan & Tuncel, 2019) and students' attitudes toward the course in positive terms (Pathoni et al, 2019). Additionally, students found AR-aided classes entertaining and enjoyed the application (Sahin & Yilmaz, 2020). It was concluded that the use of AR technology in courses enhanced student achievement and improved their attitudes towards the course.

In recent years, the researchers have investigated the use of AR technology to support the various learning approaches in education. Students have difficulty fully comprehending complex abstract concepts. For example, basic astronomy concepts are abstract in nature, which interferes with students' comprehension of the material and negatively affects their attitudes towards the course (Gundoglu, 2014). The use of AR applications for experimental activities with moon phase material can increase student motivation for learning and concentration during the learning process (Yen et al., 2013). Learning about the solar system using AR helps students with conceptual understanding, and students can be more active (Sin & Zaman, 2009). In the topic of the earth's rotation, it was found that a significant increase in learning outcomes (Lindre et al,m 2019) and other studies found that using AR in astronomy gets the results that students are more active, can be presented in a real way by a phenomenon, construct scientific comprehension of a phenomenon, and improve cognitive ability (Fleck & Simon, 2013).

In order to overcome these difficulties, it is necessary to make abstract concepts in physics more concrete through the use of visuals in teaching. Additionally, although various scientific topics have been covered in investigations into the impact of the use of Augmented Reality Technology on astronomy, none has been investigated as thoroughly as this one. One of the reasons for conducting this research with the advantage of the Augmented Reality application for one of the Astronomy materials is Kepler's Law. Kepler's law is one of the most difficult

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physics materials to be observed directly or contextualized as well as other astronomical materials (Syuhendri et al., 2019). So, Kepler's Law has not yet been investigated in detail. Accordingly, this study aims to fill this gap in the literature. The main aim of the study is to investigate the effects of AR technology on learning achievement and attitude in physics education.

## METODE

This study adopted a qualitative research approach, more detailed information on the methodology is provided below.

### Research Model

This study was based on a quasi-experimental design, which is a quantitative research method (Gribbons & Herman, 1997). A quasi-experimental design is adopted in this study because experimental and control groups are not formed randomly; instead, they are formed with already-existing classes. In this design, the experimental and control groups are compared with each other based on a pre-test to determine whether the groups have equal levels of knowledge and achievement. If the knowledge and achievement levels are equal in both groups, one of the classes is chosen to be the experimental group.

In this study, the students in the experimental and control groups were selected from two intact 10th grade classes (X MIPA 1 and X MIPA 2) in SMA Negeri 1 Gununghalu. Students' average grade in their previous science class was taken as their pre-test scores, which were compared using an independent samples t-test. This analysis showed that there was no significant difference in the mean values for X MIPA 1 (M = 66,56, SD = 8,66) and X MIPA 2 (M = 66,25, SD = 9,07), t (64) = 0,141, p = 0,888. Because there was no significant difference, then selected X MIPA 1 as the experimental group and X MIPA 2 as the control group.

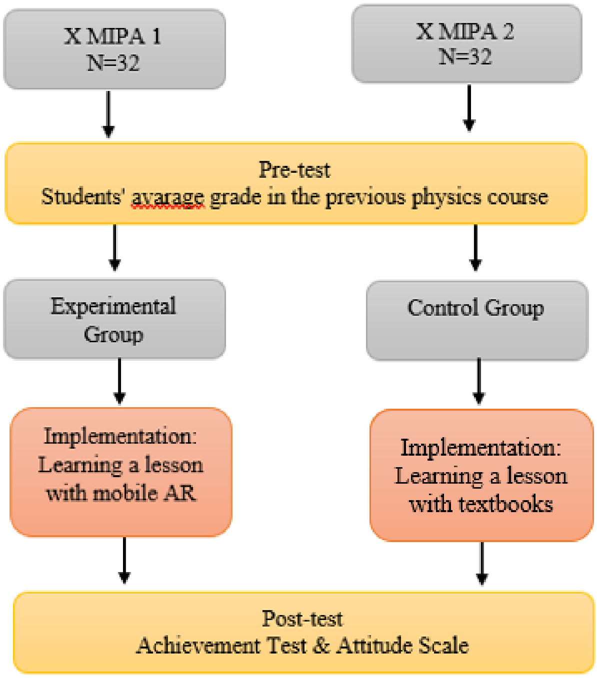


**Figure 1.** Procedure of Experiment

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Both groups took courses on "Kepler's Law". While the experimental group completed this topic with AR technology, and the control group completed this same topic using textbooks. In order to evaluate the experimental and control groups' learning achievement and attitudes in physics education, the "Physics Course Achievement Test" and the "Attitude in Physics Course Scale" were used. All data collection tools were applied at the end of the implementation period. The research model is shown in Figure 1.

### Participant

The study group of the research consists of 64 10th grade students at SMAN 1 Gununghalu. The mean age of the students is 16, and 53,12% of students are females (34 students) whereas 46,87% are males (30 students). They had never seen or used AR technology before. The demographic characteristics of student distribution regarding gender are given in Table 1.

**Table 1.** Gender Distribution

| Group | Female | Male |
|---|---|---|
| Experimental Group | 18 | 14 |
| Control Grup | 16 | 16 |
| Total | 34 | 30 |

In this study, convenience sampling was used. This method allows researchers speed and easy access to a sample. In this context, 10th grade classes in SMA Negeri 1 Gununghalu were assigned to either the experimental or control group.

### Design of AR-Based Learning Materials

Firstly, the topic "Kepler's Law" was chosen because of its potential to attract students' attention. Additionally, this topic involves many abstract concepts, and it is difficult to objectify these concepts in the learning process. That leads to a decrease in students' interest in the subject and negatively affects learning achievement. As the subject matter of "Kepler's Law" is difficult to perceive and requires students to use their imagination and think abstractly, it means that teaching should be concretized and enriched.

AR-based learning materials were designed and developed to solve this problem. These materials were prepared as a module, consisting of a total of 3 experiments (Kepler's Law 1 through 3) and the Introduction material in Solar Sytem.

### Main Implementation Process

Over the course of four weeks (16 hours), the subject was taught to the experimental group using technology Augmented Reality. Then, the control group was taught using a textbook and a simple experiment. The purpose of using technology Augmented Reality in the experimental group is to find the potential of technology AR in influencing learning's achievement and attitude student during course than conventional teaching using textbook During the lesson in the experimental group, the student was installed *"mobile augmented reality"* in their smartphone. They used a smartphone to experiment. The design of mobile Augmented Reality was shown in Figure 2.

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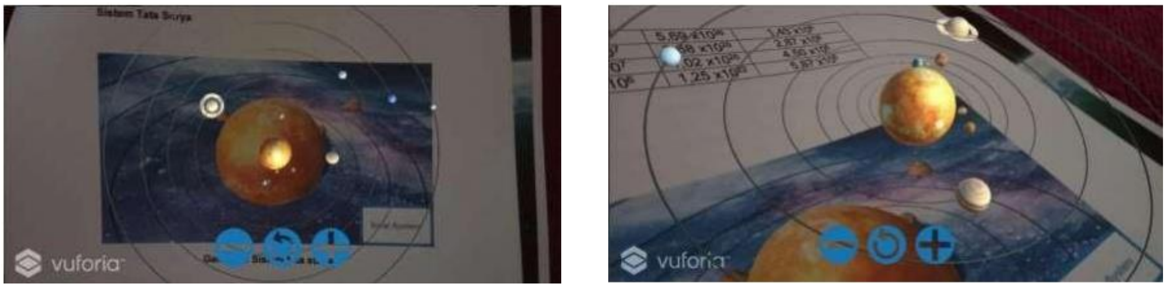


**Figure 2.** Design of mobile AR

Figure 2 show design of mobile Augmented Reality in this experiment, and procedure followed during the implementation phase can be found in Table 2.

**Table 2.** Implementation procedure

| Time | Physics Concept | Activity |
|---|---|---|
| 1st week | Kepler's Law 1 | An introduction to students about the learning material with AR technology<br>Teaching concept "Kepler's Law 1"<br>Experiment Kepler's Law 1 using mobile AR as directed in module |
| 2nd week | Kepler's Law 2 | Teaching concept "Kepler's Law 2" and Experiment Kepler's Law 2 using mobile AR as directed in module |
| 3rd week | Kepler's Law 3 | Teaching concept "Kepler's Law 3" and Experiment Kepler's Law 2 using mobile AR as directed in module |
| 4th week | The Solar System | Introducing the solar system using mobile AR and describe each typical characteristics and the activities in the learning material were completed.<br>The Attitude Towards physics course Scale and learning Achievement Test were applied. |

### Data Collection Tools

In the current study, the "Learning Achievement Test" and the "Attitude Towards Physics Course Scale" were used as data collection tools. The learning achievement test was based on a test developed by Arıcı (2013) and was adopted by the researchers. There were 25 multiple-choice questions. All of the multiple-choice questions had four options. Meanwhile, the 15-item "Attitude Towards Physics Course Scale" was used to determine the attitudes of students during the learning process. It is a 5-Point-Likert scale and is composed of 15 items.

### Data Analysis Tools

This study utilized descriptive and predictive analyses to process and interpret the data effectively. The analysis began with identifying and removing outliers and extreme data points to improve data accuracy and reliability. Following this, skewness and kurtosis statistics were examined for each variable to ensure the data met the assumptions of normal distribution. These steps aimed to prepare the dataset for further statistical testing. To explore differences between groups, an independent samples t-test was conducted. This approach allowed for a detailed comparison of the variables, ensuring robust conclusions about group-level variations and the broader patterns observed in the study.

## RESULTS

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Within the scope of the study, the learning achievement and attitudes of the students were determined. Detailed information on students' attitudes towards the physics education and the learning achievement of those in the experimental and control groups can be found on the result provided below

### Evaluation of learning achievement

In order to determine for any significant difference between the students in the experimental and control groups in terms of their learning achievements, an independent samples t-test was carried out and the results are presented in Table 3.

**Table 3.** Differences between the Learning Achievements of Students

| Group | N | Mean | SD | t | p |
|---|---|---|---|---|---|
| Experimental | 32 | 80.62 | 9.15 | 4.53 | .000 |
| Control | 32 | 71.75 | 6.25 | | |

As shown in Table 3, mean ratio of students who received learning supported by AR application was 80.62 whereas the mean ratio of students who received education without using AR application was 71.75. It can be seen that there is a significant difference in the level of learning achievement of students between the experimental and control group ($t = 4.53$ $p < .05$). This result found that students who use AR technology had higher levels of learning achievement compared to students in the control group

### Evaluation of attitude toward physics course

In order to reveal whether there is a significant difference in the course-related attitudes of students in the two groups, an independent samples t-test was carried out. The results can be found in Table 4.

**Table 4.** Differences in the Attitudes of Students towards Physics Course

| Group | N | Mean | SD | t | p |
|---|---|---|---|---|---|
| Experimental | 32 | 69.28 | 3.49 | 11.53 | .000 |
| Control | 32 | 59.46 | 3.31 | | |

Table 4 shows a significant difference in students' attitude towards the course ($t = 5.86$, $p < .05$), such that those whose science lesson featured AR technology had more positive attitudes towards the course compared to those who learnt via traditional methods.

## DISCUSSION

The current study aimed to identify the effect of AR technology on higher school students' learning achievement and attitudes towards their physics courses. The result showed that the students in the experimental group had higher levels of learning achievement and positive attitudes towards the course than those in the control group. This significant group difference can be taken as evidence of the positive effect of AR technology. AR applications related to "Kepler's Law" were developed and implemented in the experimental group because students find this topic very interesting. However, this topic contains mostly abstract concepts, and students generally have difficulty learning the relevant concepts and falling through to achieve meaningful learning (Syuhendri et al., 2019). With the help of AR applications, students were

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able to see these abstract concepts, achieve more meaningful learning, and enhance learning achievement than those in the control group. A significant difference was observed between the experimental and control groups in learning achievement. Physics courses with AR technology have higher learning achievement on physics course achievement tests than students in the control group who take physics courses using textbooks (Sahin & Yilmaz, 2020; Erbas & Demirer, 2019; Fidan & Tuncel, 2019; Yen et al., 2013; Fleck & Simon, 2013).

There are many reasons for the positive effect of AR technology on learning achievement. First, encountering this technology for the first time is a new and interesting experience for students. In the literature, it is stated that when new technologies are used in education, they attract students' interest to the course. Thus, students are active during the learning process (Sahin & Yilmaz, 2020; Shen et al., 2013). The experimental groups' have higher-level achievement may be due in part to the 3D objects of AR technology. According to the literature, AR provides the opportunity to see objects in 3D and examine them completely, which is much more effective than learning with 2D objects (Mahendra, 2016; Borrero & Márquez; 2012). Moreover, students actively participate in the lesson and ask the teacher more questions (Sahin & Yilmaz, 2020; Abdüsselam & Karal, 2012). In conclusion, it is clear that AR positively affects students' learning achievement.

Differences in the experimental and control group's attitudes towards the physics course were also investigated. Results indicated that the attitudes of students in physics courses that were taught via AR technology were significantly more positive than those who learned using textbooks. AR applications enhance students' motivations, students have positive attitudes towards their AR-based course, and AR applications are enjoyable and interesting during the learning process (Sahin & Yilmaz, 2020; Wojciechowski & Cellary, 2013). Specifically, AR is a new and interesting technology. Since AR uses 3D objects, students can observe these objects more concretely and can experience learning by doing, this implementation is more effective in the learning process (Borrero & Márquez, 2012; Abdüsselam & Karal, 2012). AR applications facilitate the development of positive attitudes towards the course (Pathoni et al., 2019). Another study was found that AR technology is of great importance in encouraging an active learning process that increases students' motivation and positively affects attitudes (Sahin & Yilmaz, 2020; Cabero-Almenara & Roig-Vila, 2019).

Within the scope of this study, the effect of AR technology on learning' achievement and attitudes towards the physics course were analyzed. However, its effect on the permanence of the knowledge acquired was not examined. This may be fruitful area for future studies to explore. This study has a number of limitations; first, AR applications are affected negatively by physical factors such as lighting, output quality and camera quality. Therefore, it is important to take measures to minimize the effects of these factors. Second limitation is the fact that only a single treatment was applied and the focus was on a specific environment in this study. In order to concretize and visualize abstract concepts and enable the observation of phenomena that are impossible to meet in real life. Technology Augmented Reality can be used for different course topics.

## CONCLUSION

The result of this study showed that the mean ratio of learning achievement in the experimental group was 80,62 whereas the mean ratio in the control group was 71,75. Meanwhile, the results

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for attitude toward physics education for the experimental group were obtained at 69,28 and for the control group at 59,46. Based on the results of this study, it can be concluded that students in the experimental group who learn a lesson using Augmented Reality Technology have higher levels of learning achievement and more positive attitudes towards the course than those in the control group who use textbooks in the learning process.

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