

EFFECT OF AUGMENTED REALITY ON STUDENTS' LEARNING OUTCOMES IN ATOMIC THEORY: AN EXPERIMENTAL STUDY

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Abstract: This study was carried out to determine the impact of Augmented Reality on students' interests and learning outcomes by analyzing posttest data using SPSS and Independence Samples t-test. This was an experimental research with a Randomized Posttest Control Group Design, which used Augmented Reality in experimental group. The subject was class XII students of Prawira Marta Sukoharjo High School 2024/2025 Academic Year. The material was Atomic Theory with the Discovery Learning model. The instruments were Atom Visualizer application, Atomic Theory module, Student Worksheet (LKPD), posttest, Student Perception Questionnaire, SPSS Test Selector 2.4, and skill domain assessment observation sheet. Data collected from Student Perception Questionnaires, posttests, and documentation. Posttest data is processed by Score Acquisition Percentage. The results of the experimental class were 55% of the Good Category and 45% of the Very Good Category, while the control class amounted to 73% of the Enough Category and 27% of the Good Category. Posttest data analyzed by SPSS tool to get number of mean and deviation, while hypothesis conclusion is made using Independence Samples t-test. The significant value indicates a number less than 0.05 which could be interpreted that H1 was accepted because very significant mean between control and experiment group.

Keywords: atomic theory; augmented reality; posttest.

INTRODUCTION

The goal of the SDGs in the field of education in Indonesia is to equalize access to quality education for Indonesian children by optimizing relevant skills for the future (Nurfatimah et al., 2022). Quality education is very closely related to the role of teachers because teachers should be able to design learning that is always renewable and adaptive so that it can create a productive and glorious generation (Simarmata et al., 2024). Currently, there is a dynamic change in

the field of education by providing wider opportunities for students to improve their skills broadly, namely through digital technology (Destari, 2023).

The use of technology in a learning both as a tool/media and a learning reference is a form of application of national education goals that are incorporated into learning while preparing students to be more ready to compete in the future (Amadi, 2022). There are many ways that teachers can take to increase their interest in learning, skills, understanding, and learning



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outcomes themselves, one of which is the use of multimedia in the classroom (Suryandaru, 2022).

The use of multimedia in Chemistry learning can provide benefits for both teachers and students because currently students are much more skilled in operating gadgets so that the achievement of learning goals compiled by teachers can be met (Jaiz et al., 2022).

Augmented Reality (AR) is one of the latest breakthroughs in the field of technology and can be applied to the learning of Chemistry. AR technology displays complete information and 3D models that are incredibly interesting that make it easier for learners to understand concepts and make learning methods more interactive (Mufida et al., 2022). Previous research has shown that the use of Augmented Reality can help learning objectives be achieved because it can present visualizations of abstract theories (Nistrina, 2021). This is in line with other research that states that android-based technology media makes learning more interactive, practical and easy to use by both teachers and students (Yudha et al., 2023). In addition, AR has many advantages that can be useful for learning Chemistry such as attractive appearance, efficient and not difficult operation, free, and taking place in real time (Akbar & Djakariah, 2024). With AR, Chemistry teachers can prepare Atomic Theory material in more detail with the presence of illustrations of Atomic Models in 3D to help students understand the mechanism of the components that make up atoms (Midak et al., 2021).

In the learning of Atomic Chemistry in class X of Prawira Marta High School, several obstacles were found, namely students found it difficult to imagine atomic models and the components that make up atoms. In

addition, the variety of learning methods applied in the classroom where teachers only give lectures and assignments to students to summarize the material causes students to lack understanding of Atomic Theory. The limitations of the methods that take place in the classroom make the concept of Chemistry difficult for students to understand (Aris et al., 2020). Teachers can improve the effectiveness of learning in the classroom by presenting technology so that students can access more material resources, learning is more interactive, and students' literacy skills are getting better (Said, 2023). This is in accordance with previous research which noted that the presence of technology allows students' understanding to improve when studying Atomic Theory and its models (Mufida et al., 2022).

The purpose of this study is for researchers to integrate Augmented Reality technology in Chemistry learning of Atomic Theory material in class X of SMA Prawira Marta Sukoharjo to determine the impact of the use of Augmented Reality on students' interests and learning outcomes by analyzing posttest data using SPSS and Independence Samples t-test devices.

METHOD

This research is an experimental research carried out at Prawira Marta Sukoharjo High School, Central Java. The experimental method was chosen because it can show facts related to the initial assumptions in the study being studied. The subject of this study was 20 students of class X who were randomly divided into two classes, namely 9 students in the experimental class and 11 students in the control class. The learning model used is Discovery Learning with

Atomic Theory material. The Augmented Reality service used is the Android-based application Atom Visualizer. The instruments of this research are the Atom Visualizer application, the Atomic Theory learning module, the Student Worksheet (LKPD), the posttest, the student perception questionnaire, the SPSS Test Selector 2.4 tools, and the skill domain assessment observation sheet filled out by peers. Data collection techniques are in the form of student perception questionnaires, posttests, and documentation.

The design used in this study is the Randomized Posttest Only Control Group Design where there are two groups consisting of the experimental class and the control the treatment is only given to the experimental class, and the conclusion of the treatment that class, has been applied is seen from the results of the posttest of students in both groups. In the experimental class, students were given the treatment of applying Augmented Reality to the learning of Chemistry material on Atomic Theory. The research design is presented in Figure 1.

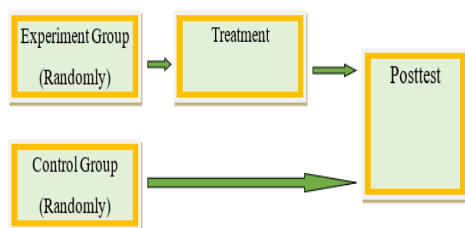


Figure 1. Randomized Post-Test Control Group Design

Posttest score processing uses Score Acquisition Percentage (Formula 1) (Harefa et al., 2020). The Score Acquisition Percentage formula was chosen to get the right comparison of the posttest results of both the experimental

class and the control class.

$$P = \frac{J_{\text{skor}}}{J_{\text{max}}} \times 100 \% \quad (1)$$

Where P is the Percentage of Score Gained, Jscore is the number of scores obtained by students, and Jmax is the maximum number of scores. The Percentage of Value Acquisition category, which is a value range of 0%-20%, is the Very Less Category; the range of 20.1% - 40% is the Less Category; the range of 40.1 – 60% is the Enough Category; and the range of 60.1% - 80% Good Category; and 80.1% - 100% Very Good Category (Rasna et al., 2023).

Analyze the results posttest using t-test or t-Test with the type of Independent Samples t-Test (Formula 2). This analysis can be applied by comparing the average in two unrelated groups (experimental class and control class) (Magdalene & Krisanti, 2023). Independent Samples t-Test requires H_0 as the initial hypothesis which means there is no noticeable average difference between the control class and the experimental class. In addition, there is also H_1 as a choice hypothesis which can be interpreted as a striking difference in the average of the two groups. If the significant value > 0.05 then H_0 is accepted, and if the significant value < 0.05 then H_0 is rejected and H_1 is accepted.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}} \quad (2)$$

Where x_1 and x_2 are the mean or average, s_1 and s_2 are variances, and n_1 and n_2 are the number of samples in each group.

RESULTS AND DISCUSSION

Based on a predetermined design, namely the Random Posttest Control Group Design, the division of students in the control class and the experimental class is carried out randomly without looking at the competence of each student in mastering the Atomic Theory material. In the control class, the method used is the lecture method and each student gets a sheet of the Periodic Table. An atomic model is drawn on a whiteboard and students are asked to identify the components that make up the atom. Students have difficulty identifying protons, neutrons, and electrons. In addition, students cannot imagine how electrons travel through the nucleus of an atom.

Meanwhile, in the experimental class, the teacher provides material through the lecture method, then asks students to make small groups and follow the guidance on the LKPD. The treatment in the experimental class is that students use Augmented Reality Atom Visualizer technology which has many features, namely the Bohr Atomic Model, Quantum Mechanics Atomic Model, Periodic Table, and synchronized on the Wikipedia link so that it is easier for students to get additional information. The Atom Visualizer view is presented in Figure 2.

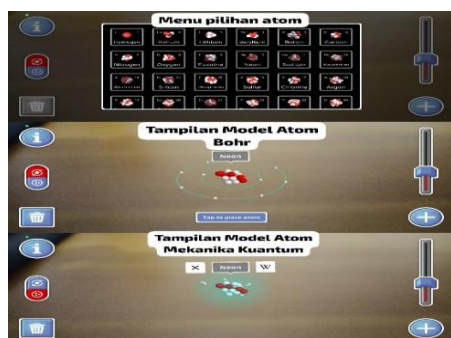


Figure 2. Atom Visualizer View

The operation of AR begins by searching for atoms in the Periodic Table menu in the lower right corner. In the Bohr Atomic Model menu, the number of components that make up an atom can be clearly identified. Large red and white spheres represent atomic nuclei (protons and neutrons), while white spheres surrounding the nucleus of an atom in their trajectory are electrons. Next, students change the atomic model by using the Quantum Mechanics Atomic Model. In this model, electrons move randomly around the nucleus of an atom with an easily identifiable number of atomic components. The speed of electron movement can be set with a tomoh on the right side of the screen. Students seemed enthusiastic and tried to see different elements. AR apps require Android 8.0 (Oreo) Operating System and a camera that supports ARCore. Not all android smartphones support this application so one group uses the device together.

After that, students work on the questions on the LKPD sheet and fill out the Student Perception Questionnaire regarding the use of Augmented Reality in Atomic Theory material by checking the answer column provided. The Student Perception Questionnaire is presented in Table 1. Furthermore, posttests are given both in the control class and the experimental class. The percentage of posttest scores is shown in Table 2.

During the lecture session in the control class, students showed confusion in distinguishing atomic models and identifying atomic components in atomic models. This is in accordance with previous research that there are often misunderstandings in students in studying atomic structures because the understanding of concepts possessed by students is not optimal (Nufus &

[Silfianah, 2023](#)). The absence of learning media has been proven to affect students' interest in learning which ultimately has an impact on the lack of understanding of the material being studied ([Febrina & Setiawan, 2024](#))

Unlike the experimental class, students in the experimental class showed high enthusiasm when exposing the Atomic Model through AR technology. Augmented Reality is a new breakthrough in the field of technology

that has a computerized mechanism by combining the display of graphics on electronic devices with original images, accompanied by additional information that can be accessed at any time so as to provide an experience to its users ([Arena et al., 2022](#)). In previous research, it was stated that AR has been applied to several fields, including in the world of education, because of its ability to present learning materials that have high comple-

Table 1. Student Perception Questionnaire Using Augmented Reality Atomic Theory Materials

Question	Strongly disagree	Disagree	Ordinary	Agree	Strongly Agree
Using Augmented Reality Apps, I know the position of the components that make up atoms (protons, neutrons, and electrons)	-	-	-	55%	45%
Through Augmented Reality, I get a concrete/real picture of Bohr's atomic model	-	-	-	33%	77%
Through Augmented Reality, I get a concrete/real picture of the atomic model of Quantum Mechanics	-	-	-	33%	77%
The use of Augmented Reality helps me in understanding Atomic Matter	-	-	22%	55%	22%
The use of Augmented Reality makes it easier for me to identify Bohr's atomic model and Quantum Mechanics	-	-	45%	55%	-
The use of Augmented Reality makes it easier for me to distinguish between Bohr's atomic model and Quantum Mechanics	-	-	45%	55%	-
Augmented Reality is the right medium for learning Atomic Chemistry because of its attractive visual appearance	-	-	-	-	100%

Table 2. Posttest Score Acquisition

	Very Less	Less	Enough	Good	Excellent
Control Classes	-	-	72%	27%	-
Class Experiment	-	-	-	55%	45%

xity to be explored and studied, making it easier for today's students who have become accustomed to using devices and have a direct impact on their learning interests (Al-Ansi et al., 2023). This is in line with previous research that uses a bibliometric approach, data shows that the trend tends to increase in terms of research on the application of AR in secondary schools in the last decade. This even has a significant impact on large countries such as the United States and China because of the many fields that can utilize this technology service (Triansyah et al., 2023).

The Discovery Learning model was chosen because it can be applied to small groups, optimizes learning efficiency because the teacher is no longer the center of learning, and emphasizes discovery in the material studied (Nababan et al., 2023). This learning model has been applied in previous research and the results show the emergence of student independence in the learning process and positive results on student achievement (Ramadhani, 2021). This learning model has a significant impact on students in their efforts to find solutions and improve students' competence in describing the material being studied (Salma & Sumartini, 2022).

The posttest results in the experimental class presented in Table 2 show very good scores. Android-based applications are proven to make learning more exciting and interesting, practical, easy to use, and of course the use of android applications in the classroom is adjusted to the learning plan that has been prepared (Damayanti et al., 2022). In addition, students can build and understand the abstract concept of atomic structure better with the presence of visual media support means (Wijaya, 2020). This is in accordance with previous research where AR applied to a learning shows a positive impact on students both in terms of learning interest, competence, and analytical power (Elisa & Wiratmaja, 2019).

According to Figure 3, a total of 73% of the students in the control class are in the Moderate category with a score range of 40.1-60. A total of 27% of the students in the control class and 55% of the students in the experimental class were in the good category with a score range of 60.1-80. Meanwhile, the Very Good category with a score range of 80.1-100 is only owned by students from the experimental class alone, amounting to 45%. From the above description, the use of Augmented Reality in the experi-

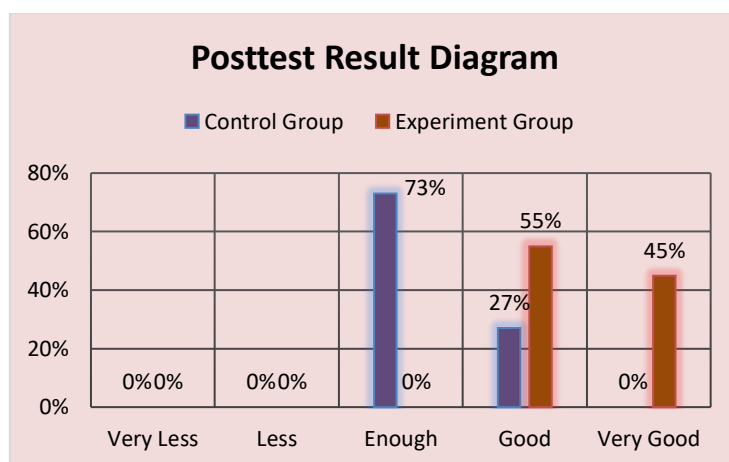


Figure 3. Posttest Result Diagram

Table 3. Posttest Analysis with SPSS Test Selector 2.4

Statistics		Experimental Classes	Control Classes
N	Valid	9	11
	Missing	-	-
Mean		84,4	65,45
Median		80	60
Variance		27,7778	87.2727
Standard Junction		5,2705	9,342
Maximum Value		90	80
Minimum Values		80	60
Range		10	20

mental class has a positive impact on the results of the posttest. The posttest data results were processed using the SPSS Test Selector application to obtain the variance and standard deviation values of the two groups. The values of variance and standard deviation are used in the t-test formula to obtain significant values in proving the hypothesis. The percentage of posttest analysis with SPSS tools is contained in Table 3.

Using Formula 2, the values of variance and standard deviations were analyzed and the results showed that the value of t was 5.41707 and the value of p was 0.00019. This can be interpreted as a very striking difference in the value of p . A p -value smaller than 0.05 indicates a significant mean difference in both the experimental class and the control class so that H_0 or the initial hypothesis is rejected and H_1 or alternative hypothesis is accepted.

CONCLUSION

The use of Augmented Reality in learning Chemistry Atomic Theory Materials is proven to increase students' interest in learning and learning outcomes. Based on the Percentage of Gains, the average posttest result in the experimental class was 84.4 higher than

that of the control class, which was 65.45. The posttest results of the experimental class were 55% Good Category and 45% Very Good Category, while the control class had a percentage of 73% Enough Category and 27% Good Category. Posttest data was analyzed using the SPSS application and using the Independence Samples t-test formula. A significance value of 0.00019 is less than 0.05 or 5% proving that the alternative hypothesis (H_1) is accepted and H_0 is rejected, which can be interpreted that there is a significant influence on the given treatment. The Student Perception Questionnaire showed a 100% answer percentage that Augmented Reality technology with an attractive visual display is the right medium for Atomic Theory material.

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