The Effect of Augmented Reality (AR) Based Multimedia ATLAS: Volcanic Series Volcanism Material on Learning Outcomes of Students of SMAN 2 Blitar

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ABSTRACT

The presence of Augmented Reality (AR) technology in education supports multimedia advances in learning, one of which is ATLAS: Volcanic Series. The use of multimedia in learning can facilitate the understanding of the material by students, so that good learning outcomes are achieved. The purpose of this research is to know the effect of Augmented Reality (AR) based multimedia ATLAS: Volcanic Series volcanism material on student learning outcomes at SMAN 2 Blitar. Quasi experimental is the type of this research and post-test only group design. As the method, the subjects in this study were students of class X (IPS 3 & IPS 4) SMAN 2 Blitar. Collecting data using quantitative methods through post-test results. The t-test technique (Independent Sample T-test) was carried out for data analysis in order to determine the effect of Augmented Reality (AR) based multimedia ATLAS: Volcanic Series on volcanism material on students' scores or learning outcomes in geography lessons. The results of this 2-week study show that multimedia based on Augmented Reality (AR) ATLAS: Volcanic Series volcanism material has a significant effect on learning outcomes at SMAN 2 Blitar.

KEYWORDS

Augmented Reality, Students Learning Outcomes

INTRODUCTION

Geography learning, particularly in volcanism, still requires significant improvement efforts. One primary challenge is the inadequate allocation of time, which results in the material being delivered in a cursory manner (Kindy, 2018). Due to these time constraints, educators often cannot cover the material thoroughly, leading to a superficial understanding among students and subsequently impacting their learning outcomes (Putra et al., 2023). According to Proits, learning outcomes reflect what students have learned and are indicative of the effectiveness of the educational process (Elde Mølstad & Karseth, 2016).
Achieving high learning outcomes is essential as they reflect the quality of education provided (Nasution, 2017).

Learning outcomes encompass changes in students' behavior and abilities following the learning process, manifesting in cognitive, affective, and psychomotor domains (Novita, Sukmanasa & Yudistira Pratama, 2019). However, students often do not achieve the desired learning outcomes, frequently due to difficulties in mastering the material (Nurhasanah & Sobandi, 2016). Many students struggle during the learning process, which is evident from their performance falling below the Kriteria Ketuntasan Minimal (KKM) standard (Miski, 2015). The KKM is a benchmark indicating the minimum competency standards that students must meet, highlighting the necessity for improved learning strategies.

According to the Pearson Learning Curve report in 2014, Indonesia ranks 40th among countries in global indicators of cognitive abilities, reflecting a relatively low position (Hasyim & Saputro, Matkli Dimas Astrianto, Fadillah, 2013). Effective use of learning media is one way to enhance students' cognitive abilities and learning outcomes (Falahudin, 2014). Appropriate learning media can make the learning objectives more achievable by fostering student engagement and understanding.

Learning media act as crucial conduits in the educational process (Rohani, 2019). As stated by Teni Nurrita (2018), learning media are tools for conveying teaching materials. Utilizing these media optimally can enhance the quality of learning, as they help teachers deliver content more effectively (Untari, 2017; Ramadhan, 2024). Despite the availability of diverse learning media, many teachers do not utilize them to their full potential (Abdullah, 2017).

The level of knowledge attainment varies significantly with the use of different senses. Al-Samiraa'I, as cited in Mahnun (2012), notes that the sense of sight contributes 75% to knowledge attainment, while the sense of hearing accounts for only 13%. Other senses, such as taste, touch, and smell, collectively contribute only 12%. Therefore, a learning environment rich in visual aids can positively impact students more effectively than text alone (Sunardi, Sahputra & Hidayah, 2021). Effective learning media must meet the highest standards of knowledge attainment.

Teachers must select learning media based on specific considerations to support learning objectives effectively. Miftah (2013) asserts that learning media should be effective, efficient, and attractive. Additionally, chosen media must align with technological advancements, necessitating the integration of technology into the learning process (Effendi & Wahidy, 2019; Salsabila & Putra, 2024). Augmented Reality (AR) represents one such technological advancement that can be incorporated into learning media (Rindantiya et al., 2024).

In this study, we introduce AR-based learning media named ATLAS: Volcanic Series, developed by Johan Azrul Farid, tailored to meet the needs of class X students studying volcanism. This media includes various topics such as the process of volcanism, volcano distribution maps, volcano structures, volcano classifications by shape and activity, eruption factors, types of eruptions, volcanism products, disaster mitigation, and earthquake simulations, enhanced with text, images, videos, and 3D animations.

Research by Kamaruddin et al. (2021) demonstrates significant improvements in learning outcomes with the use of AR, particularly in biology lessons. Similarly, research by Yessi (Oktaviani et al., 2020) shows that AR can significantly increase students' interest in science material, thereby improving
The Effect of Augmented Reality (AR) on their learning outcomes. Consequently, further research is warranted to explore the impact of AR on learning outcomes at higher educational levels, such as high school geography.

This research employs AR ATLAS multimedia: Volcanic Series within the Discovery Learning model framework. Discovery Learning engages students actively, fostering deeper retention of the material compared to rote memorization (Kristin & Rahayu, 2016). This learning model is chosen to enhance students' mastery of the material, aiming to achieve optimal learning outcomes (Panjaitan et al., 2021). Therefore, the Discovery Learning model is applied to guide learning activities using AR ATLAS: Volcanic Series.

The objective of this study is to investigate the effect of AR on student learning outcomes, particularly in geography lessons focusing on volcanism and its impacts on life. The findings are expected to encourage educators to consider AR-based multimedia like ATLAS: Volcanic Series as effective learning media to support student outcomes in geography.

METHOD

Research Design

This study employs a quasi-experimental design, specifically utilizing the post-test only control group design. The research involves an experimental class and a control class to compare the effects of the intervention. The experimental class uses AR ATLAS-based multimedia: Volcanic Series with the Discovery Learning model, while the control class uses the Discovery Learning model without AR ATLAS: Volcanic Series. The purpose of this design is to measure the impact of the AR-based multimedia on student learning outcomes. The research duration is two weeks, focusing on the material of Volcanism and its Impact on Life. Both classes will complete a post-test in the form of essay questions to assess learning outcomes after the intervention.

Research Subject

The subjects of this research are students of Class X IPS at SMAN 2 Blitar for the academic year 2021/2022. There are five X IPS classes, from which two classes were selected as research subjects using a non-probability sampling technique. This technique involves purposive or judgment sampling, where samples are chosen based on specific criteria set by the researcher. In this case, the selection was based on the average value of the End of Semester Assessment (PAS) to ensure equivalence between the classes. Class X IPS 3 and X IPS 4, each comprising 33 students, were chosen. A lottery determined that X IPS 3 would be the experimental class and X IPS 4 the control class.

Data Collection Techniques and Instruments

Data collection was conducted through post-tests consisting of essay questions designed to measure learning outcomes. The development of these test instruments involved conducting validity and reliability tests.

1. Expert Validation

The validity of the test items was assessed using SPSS Statistic 25 with the Pearson Product Moment (Bivariate Pearson) method. Each item's validity was determined by comparing the Pearson correlation coefficient to the critical value from the $r$ table.
a. If the Pearson Product Moment Value > $r$ table, the question is valid.
b. If the Pearson Product Moment Value < $r$ table, the question is invalid.

2. Question Reliability

The reliability of the test items was evaluated using SPSS Statistic 25 with Cronbach’s alpha (α). The reliability level was assessed by comparing Cronbach’s Alpha Value to the $r$ table at a 95% confidence level.

a. If Cronbach’s Alpha Value > $r$ table, the question is reliable.
b. If Cronbach's Alpha Value < $r$ table, the question is unreliable.

Data Analysis

Data analysis involved several steps to measure learning outcomes, including normality and homogeneity tests, followed by hypothesis testing using the t-test. Data analysis was carried out to measure learning outcomes including normality test with Kolmogorov Smirnov to see the normality of the sample. Furthermore, the homogeneity test was carried out with the Levene Test. Data that has been normally distributed and declared homogeneous is then carried out hypothesis testing with the t-test formula (Independent Sample T-test).

1. Normality Test

The normality of the data was assessed using the Kolmogorov-Smirnov test in SPSS Statistic 25 with a 95% confidence level.

a. If the significance $\geq$ 0.05, the data is normally distributed.
b. If the significance < 0.05, the data is not normally distributed.

2. Homogeneity Test

The homogeneity of the data was tested using the Levene Test in SPSS Statistic 25 at a 95% confidence level.

a. If the significance $\geq$ 0.05, the data is homogeneous (variances are equal).
b. If the significance < 0.05, the data is not homogeneous (variances are different).

After ensuring the data met the normality and homogeneity prerequisites, hypothesis testing was conducted using the Independent Sample T-test to compare the learning outcomes of the experimental and control groups. Student learning outcomes were classified according to the following categories based on the percentage scores:

<table>
<thead>
<tr>
<th>Klasifikasi</th>
<th>Percentage</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>91-100</td>
<td>Very High</td>
</tr>
<tr>
<td>B</td>
<td>76-90</td>
<td>High</td>
</tr>
<tr>
<td>C</td>
<td>61-75</td>
<td>Fair</td>
</tr>
<tr>
<td>D</td>
<td>55-60</td>
<td>Less</td>
</tr>
<tr>
<td>E</td>
<td>$\leq$ 54</td>
<td>Very Less</td>
</tr>
</tbody>
</table>

Source: Permendikbud No. 104 (Nuh, 2014)

3. Question Validation

To determine the validity of the test items, SPSS Statistic 25 with the Pearson Product Moment (Bivariate Pearson) method was used. The level of validity was assessed as follows:
The Effect of Augmented Reality (AR)...

4. Question Reliability

To test the reliability of the test items, SPSS Statistic 25 with Cronbach’s alpha (α) was employed, comparing the results to the r table at a 95% confidence level.

a. If Cronbach’s Alpha Value > r table, the question is reliable.

b. If Cronbach’s Alpha Value < r table, the question is unreliable.

RESULT AND DISCUSSION

Research Results

This study obtained data on learning outcomes through post-test scores from both the experimental and control classes after the learning process. The sample consisted of 66 students from two X IPS classes at SMAN 2 Blitar, each with 33 students. The experimental class used AR ATLAS-based multimedia: Volcanic Series with the Discovery Learning model, while the control class used the Discovery Learning model without the AR multimedia.

The results indicated a significant difference in learning outcomes between the experimental and control classes, with the experimental class achieving a higher mean score. This suggests that the use of AR-based multimedia ATLAS: Volcanic Series positively impacts student learning outcomes. The distribution of post-test scores is presented in Table 2.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Value Range</th>
<th>Qualification</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Experiment</td>
<td>Control</td>
</tr>
<tr>
<td></td>
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<tr>
<td>A</td>
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<td>10</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>76-90</td>
<td>High</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>C</td>
<td>61-75</td>
<td>Fair</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>D</td>
<td>55-60</td>
<td>Less</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>≤ 54</td>
<td>Very less</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

The experimental class demonstrated better performance, with 39% of students achieving high scores compared to 33% in the control class. Furthermore, 30% of students in the experimental class attained very high scores, while only 9% of the control class did so. These results highlight the efficacy of AR ATLAS multimedia in enhancing learning outcomes.

The validity and reliability of the test instruments were confirmed using SPSS Statistics 25. The validity test for the essay questions, assessed using the Pearson Product Moment, yielded r values for the questions as follows: 0.748 for question 1, 0.633 for question 2, 0.658 for question 3, 0.714 for question 4, and 1.00 for question 5. Since these values exceed the r table value (0.344), the questions are considered valid. The reliability test showed a Cronbach’s alpha value of 0.709, indicating that the questions are reliable.

Post-test scores were analyzed using normality and homogeneity tests. The normality test, conducted with the Kolmogorov-Smirnov test, revealed significance values of 0.200 for both experimental and control classes, indicating normal distribution. The homogeneity test yielded a significance value of 0.066, confirming that the data are homogeneous.
Subsequent hypothesis testing using the Independent Sample T-test in SPSS Statistics 25 aimed to determine the significance of the AR multimedia’s impact on learning outcomes. The results are summarized in Table 3.

**Table 3. Hypothesis Test Results**

<table>
<thead>
<tr>
<th></th>
<th>Independent Sample T-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Levene's Test</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>F = 3,487, Sig. = 0.066</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>F = 2,999, Sig. = 59,642</td>
</tr>
</tbody>
</table>

The T-test results show a significance value (2-tailed) of 0.025, which is less than 0.05. This indicates a significant effect of AR ATLAS-based multimedia: Volcanic Series on student learning outcomes. Additionally, the mean value of the experimental class was higher than that of the control class, further supporting the effectiveness of the AR multimedia.

Based on the prerequisite tests and hypothesis testing, it is evident that H0 (no significant effect) is rejected and H1 (significant effect) is accepted. Therefore, the use of AR-based multimedia ATLAS: Volcanic Series significantly improves learning outcomes in the volcanism material for students at SMAN 2 Blitar.

**Discussion**

The findings of this study demonstrate that the AR ATLAS: Volcanic Series-based multimedia significantly impacts the learning outcomes of students at SMAN 2 Blitar. This is evidenced by the hypothesis testing results, which show a P-value of 0.025, indicating a significant effect (P < 0.05). The experimental class, which used the AR ATLAS multimedia, achieved higher post-test scores compared to the control class, which did not use the multimedia. This suggests that the interactive and engaging nature of AR ATLAS: Volcanic Series enhances student comprehension and retention of the volcanism material.

Firstly, AR ATLAS: Volcanic Series presents volcanism material in an engaging manner by incorporating text, videos, and 3D illustrations that visualize volcanic structures and eruption types. Such visual aids attract students’ interest and facilitate a deeper understanding of the content (Aditama et al., 2019). The interactive nature of the multimedia, which includes feedback mechanisms, allows students to actively navigate and engage with the material, further reinforcing their learning (Shalikhah, 2017).

There is a significant difference in the learning outcomes between the experimental and control groups. The experimental group, which used AR ATLAS multimedia, consistently achieved higher scores. This highlights the inadequacy of traditional verbal teaching methods for certain complex topics like volcanism, where visual and interactive tools are essential for effective learning (Hamid et al., 2020).

Volcanism material, which is inherently theoretical, requires students to explain, understand, relate, and analyze various concepts and their impacts on life. The control group, relying solely on textbooks, struggled due to the limited illustrations and static nature of the learning resources. In contrast, the AR ATLAS multimedia provided dynamic and interactive content, which significantly enhanced students' understanding and retention.

Secondly, the AR ATLAS multimedia offers direct experiential learning, which is crucial for deepening students' comprehension of complex concepts (Magfirah...
Rasyid, 2016). Setyawan et al. (2019) also emphasized that AR technology provides direct learning experiences, involving students actively in the learning process. In this study, students used the AR ATLAS to explore various aspects of volcanism, including volcano classifications, eruption impacts, mitigation strategies, and self-saving techniques during volcanic events.

Interactive learning experiences, as facilitated by AR ATLAS, significantly improve the quality of education by involving students directly in the learning process. Silberman, as cited by Irham & Wiyani (2016), argued that hands-on experiences are the most effective way to understand and retain new information. This study confirms that direct involvement through AR multimedia leads to more profound and lasting learning outcomes.

Previous research by Hakim & Windayana (2016) found a 71% improvement in student grades through the use of multimedia, and Suwarna (2014) reported a 53% increase in student scores with AR multimedia. These findings align with the results of this study, demonstrating that multimedia tools make material more accessible and comprehensible for students.

The learning outcomes in this study were measured against the competency standards (KD 3.5) for analyzing the dynamics of the lithosphere and its impact on life, focusing on volcanism. The post-test, consisting of essay questions, assessed higher-level cognitive skills such as analysis, synthesis, and evaluation (Sudjana, 2014).

The implementation of the Discovery Learning model, guided by the AR ATLAS multimedia, followed six stages: stimulation, problem statement, data collection, data processing, verification, and generalization (Kemendikbud, 2013). These stages ensured that students were actively engaged in hypothesis formulation, problem-solving, and drawing conclusions, thereby fostering deeper cognitive processing.

In the stimulation stage, students familiarized themselves with AR ATLAS: Volcanic Series. Groups of 6–7 students used smartphones to operate the multimedia. During the problem statement stage, each group identified different aspects of volcanism and formulated hypotheses. In the data collection stage, students used the multimedia to gather information, which was then processed and documented in group worksheets during the processing stage. The verification stage involved group presentations and peer reviews, enhancing communication and critical thinking skills. Finally, in the generalization stage, students, with the teacher's guidance, summarized their findings.

The Discovery Learning model, integrated with AR ATLAS multimedia, encouraged active learning and critical thinking. Students formulated hypotheses, solved problems, and drew conclusions independently, leading to deeper understanding and retention of the material.

CONCLUSION

This study conclusively demonstrates that the use of Augmented Reality (AR) based multimedia, specifically the ATLAS: Volcanic Series, significantly enhances the learning outcomes of students at SMAN 2 Blitar. The experimental class, which incorporated the AR ATLAS: Volcanic Series into their learning activities, achieved notably higher post-test scores compared to the control class, which did not use this multimedia tool.
The hypothesis testing results, with a P-value of 0.025, indicate a significant positive impact of AR multimedia on student learning. This finding is further supported by the higher mean scores in the experimental class, underscoring the effectiveness of AR technology in making complex theoretical concepts like volcanism more comprehensible and engaging for students.

The AR ATLAS: Volcanic Series multimedia offers an interactive and immersive learning experience through a blend of text, images, videos, and 3D illustrations. This approach not only captures students' interest but also promotes active participation and deeper cognitive processing, which are essential for mastering complex material. The dynamic and interactive nature of the AR multimedia facilitates a better understanding and retention of the volcanism concepts, as evidenced by the superior performance of the experimental group.

Based on these findings, it is recommended that educators integrate AR-based multimedia, such as the ATLAS: Volcanic Series, into their teaching strategies to enhance learning outcomes. This technology can transform complex subjects into more accessible and engaging content for students, thereby improving their overall academic performance. Future research should explore the application of AR in various subject areas and educational levels to validate and expand upon these results, potentially leading to broader educational advancements.

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