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The Effect of Augmented Reality Integrated Traditional Games Nglarak Blarak to Improve Critical Thinking and Graphical Representation Skills

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Abstract

Learning activities related to students' real-life experiences may create meaningful learning. Integrating traditional games into the physics classroom can reconstruct local knowledge into scientific knowledge. The use of technology can affect student learning achievement. One of the technologies currently attracting attention is Augmented reality (AR). This study investigates the impact of AR-integrated traditional games Nglarak Blarak on students' critical thinking and graphical representation skills. In this study, a quasi-experimental design was used, consisting of 62 10th junior high school students. Class A completed the "work and energy" concept of their physics learning using AR technology, while class B used PowerPoint and textbooks. Class A students had higher critical thinking and graphical representation skills scores than those in class B. In addition, it was found that the critical thinking and graphical representation skills of students in class A who used AR technology showed a significant correlation. The results of this study can be used as a reference for integrating technology and indigenous knowledge in physics learning.

Keywords: Augmented reality, Critical thinking, Graphical representation, Traditional games

Introduction

Physics is considered to be difficult by many students. In some literature, students view physics as conceptually complicated and abstract (Lavonen et al., 2005; Morales, 2017). Learning physics must bring students into real-life situations, and students will find physics concepts more relevant (Whitelegg & Parry, 1999). Teachers must teach how to sequentially apply the scientific methodology to develop students' ability to apply similar strategies in daily life. Also, through convincing a suitable teaching strategy, students can find the physics course understandable and achieve a good learning outcome (Gebbels et al., 2010; Vavougios et al., 2016).

According to previous studies, students' experience relating to concrete, real-life examples in physics concepts may create meaningful learning (Baran et al., 2018; Pavkov-Hrvojević & Bogdanović, 2019). Meaningful learning can help students engage in learning and improve their learning achievements. Creating fun learning activities that allow students to experience physics concept examples related to the environment surrounding students is feasible for attracting students' interest in learning physics.

Local culture can be brought into the physics classroom to build a learning environment that relates to students' daily life, making the learning process meaningful. Existing indigenous knowledge integrated into physics education creates effective hybridization, incubation, skill acquisition, and sustainable development (Anthony, 2017). Besides, integrating local culture into school curricula has an advantage in perceiving national identity for students (Liliarti & Kuswanto, 2018). Indonesia is a big country that consists of a lot of ethnic groups. In Indonesia, various local cultures have potencies to be integrated into physics learning. In a previous study, the making process of traditional textile called "Batik" was brought to physics class to show the application of the thermal physics concept (Shabrina & Kuswanto, 2018). Traditional toys and games also have been used to engage Indonesian students in analytical and critical thinking during the discussion about mechanics (Maghfiroh & Kuswanto, 2022; Permata Sari et al., 2020).

In Kulon Progo, Yogyakarta, Indonesia, the influence of Javanese culture is dominant. The Javanese culture can be found in traditional games called 'Nglarak Blarak,'

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This game is played by dragging coconut leaves carried out by several people, with one other person standing at the end of the coconut leaf and being carried along with the coconut leaves. Traditional games can engage students in learning work and energy concepts. The application of work and energy concepts can be seen directly in traditional games like Nglarak Blarak.

The tremendous development of technology has influenced all aspects of life, including education. Students are more engaged in learning when recent technology is involved (Cheng et al., 2019; Zhan et al., 2022). The function of technology has evolved a lot. Technology can help students to understand situations and problems in the real world by visualizing the materials (Kiryakova et al., 2018). Augmented Reality (AR) (Chang et al., 2018) is a technology that combines real and virtual environments. AR technology in physics learning can improve learning achievements and positively impact students (Rahmat et al., 2023). AR allows students to explore concepts that are not visible to the naked eye and make them visible and displays real objects which have never been seen before (Sahin et al., 2020). AR is suitable for teaching abstract physics concepts, one of which is the concept of work and energy (Ismalina et al., 2018).

In the era of the industrial revolution, with significant growth of advanced technology, students need to be prepared with critical thinking skills (Patricia Coberly-Holt and Kemi Elufiede, 2016; Terblanche & De Clercq, 2021). Critical thinking involves essential abilities such as reasoning, hypothesis testing, argument analysis, likelihood and uncertainty analysis, problem-solving, and decision-making (Tiruneh et al., 2017). Nowadays, school curricula, including physics classes, should accommodate critical thinking skills cultivation. In addition, using and selecting the appropriate representation format in physics learning can improve learning achievements and provide access to more detailed knowledge (Mulhayatiah et al., 2019), making it easier for students to understand physics concepts. Physics concepts can be explained visually, such as using diagrams or graphs. Graphical representation has an important role in learning physics. Critical thinking and graphical representation skills can increase when the stimulation provided is concrete and has been experienced by students directly, such as in local culture (Kurniawan & Kuswanto, 2021). Integrating technology and local-culture context can be combined in the physics classroom to engage students in learning physics and developing their critical thinking and graphical representation skills.

This study identifies the effect of implementing AR technology integrated traditional games Nglarak Blarak into a physics learning activity. Students learned they used a smartphone to analyze the concept and explain 'Nglarak Blarak' while learning the concepts of work and energy. This study investigates the effect of AR-integrated traditional games Nglarak Blarak on students' critical thinking and graphical representation skills. In parallel with this study, the following research questions will be answered.

Is there a significant difference between students' critical thinking using AR-integrated traditional games Nglarak Blarak and those using PowerPoint and textbooks?

Is there a significant difference between graphical representations of students using AR-integrated traditional games Nglarak Blarak and those using PowerPoint and textbooks?

Is there a correlation between students' critical thinking and graphical representation skills when using AR-integrated traditional games Nglarak Blarak?

METHOD

Research Design

This study was based on a quasi-experimental design, a quantitative research method. The pre-and post-test design was used in the study. Pre- and post-tests were administered before and after students were exposed to the physics learning activity. This design has two groups, class A and class B. Both groups took courses on "work and energy", a unit in the physics curriculum in senior high school. While Class A learned AR technology, class B learned to use PowerPoint and textbooks. The critical thinking and graphical representation tests were used to evaluate classes A and B. The research model is shown in Figure 1.

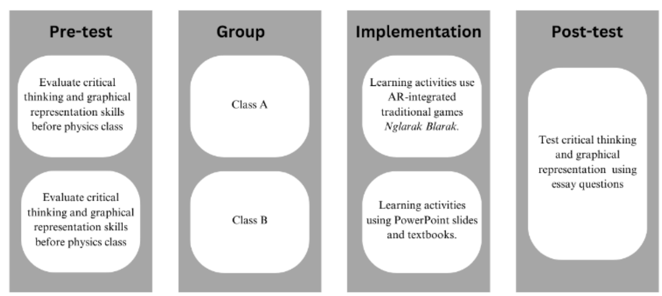


Figure 1. Research Model of the Study

Research Participants

The research was conducted in a state senior high school in Kulon Progo, Yogyakarta, Indonesia. The participant of this study was 62 10th-grade senior high school on physics subjects in the 2021-2022 academic year. The research participant was selected by random cluster sampling. The demographic characteristics of student distribution regarding gender are given in Table 1.

Table 1. Demographic characteristics of research participant

Group	Girl	Boy	Total
Class A	14	18	32
Class B	13	17	30

Design of AR Integrated Traditional Games Nglarak Blarak

Firstly, the "work and energy" topic was chosen because of its potential to attract students' attention and draw their interest. Additionally, this topic involves many abstract concepts, and there is no other way to objectify these concepts in schools. The traditional game Nglarak Blarak was chosen because it can visualize work and energy through 3D simulation using AR. The design of AR technology is shown in Figure 2.

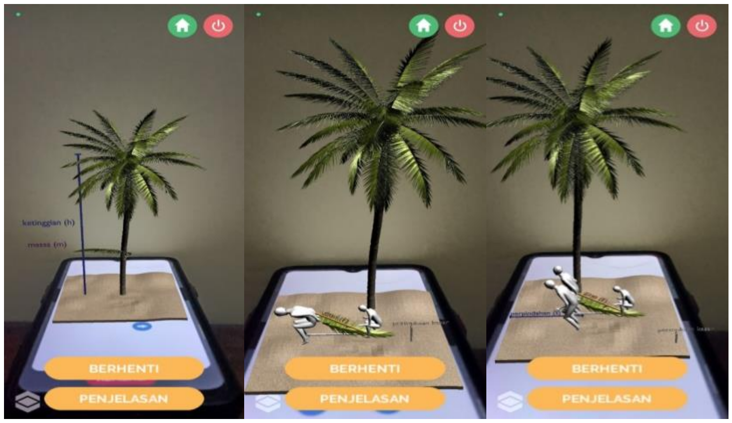


Figure 2. Design of AR-integrated traditional games Nglarak Blarak

Instruments

The instruments used in this research are pre-test and post-test to investigate AR integrated traditional games Nglarak Blarak affects students' critical thinking and graphical representation skills. The instrument consists of four essay questions related to aspects of critical thinking and four essays related to graphical representation. Each essay question has a maximum score of 4. Two lectures and two practitioners as an expert has validated the instrument. Question indicators in this study are shown in Table 2.

Table 2. Detail instrument research

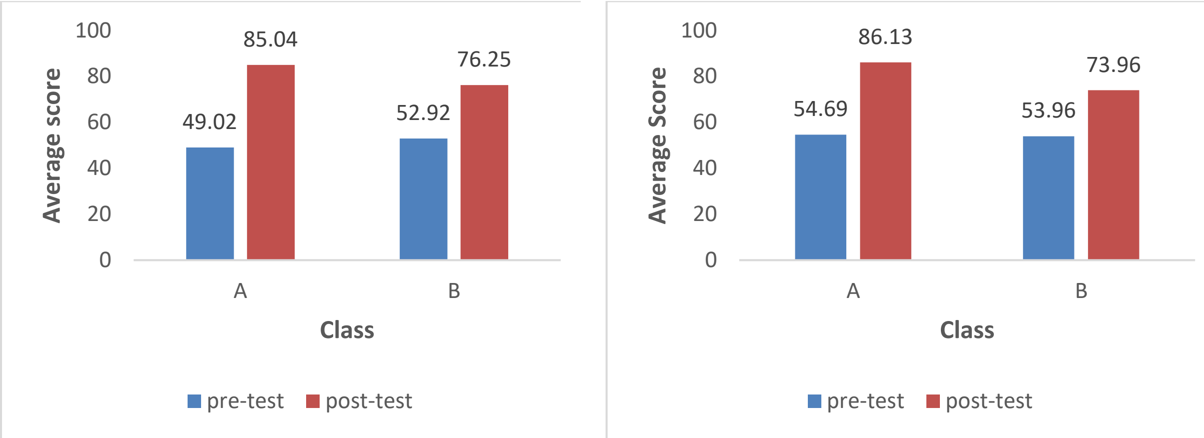
Skill	Aspect	Question Indicator
Critical thinking	Interpretation of problem	Students are asked to interpret problems related to work and energy in traditional games Nglarak Blarak.
	Analysis of fact	Students are asked to analyze the facts when someone pulls a coconut tree in traditional games Nglarak Blarak.
	Evaluation	Students evaluate to determine the strategy of traditional games Nglarak Blarak.
	Create a conclusion	Students make conclusions on cases related to traditional games Nglarak Blarak.
Graphical representation	Representing a graph in another representation	Students represent graphs based on the problems related to traditional games Nglarak Blarak.
	Analysis of graphics according to the physics concept	Students interpret graphs based on physics concepts on Nglarak Blarak

Data Analysis

Research data were obtained from the post-test results of students after learning activities. The data analysis technique used to determine the differences in the results of increased critical thinking and graphical representation skills is the Multivariate Analysis of Variance (MANOVA) test with a significance level of 0.05. The assumption test is carried out before analyzing the MANOVA test, namely the normality and homogeneity tests. The software used for data analysis is the Statistical Program for Social Science (SPSS).

FINDINGS

Within the aim of the study, the critical thinking and graphical representation skills of the students were determined. Detailed information on students' critical thinking and graphical representation skills of those in classes A and B can be found in Figure 3.



(a) (b)

Figure 3. Result of the study (a) critical thinking (b) graphical representation

Is there a significant difference between the critical thinking skills of students using AR-integrated traditional games Nglarak Blarak and those using PowerPoint and textbooks?

A pairwise comparison analysis was conducted to determine any significant difference between the students in classes A and B regarding their critical thinking skills. The result can be found in Table 3.

Table 3. Difference between critical thinking skills of students

Group	(I) Test	(J) Test	Mean Difference (I-J)	Std. Error	Sig.
Class A	Pretest	Posttest	-36,02	2,53	.000
Class B	Pretest	Posttest	-23,33	2,61	.000

The mean difference is obtained from the mean value of the pre-test minus the average value of the post-test. The negative sign indicates that the average post-test score is higher than the pre-test. The mean difference in class A is -36,02, and class B is -23,33. Based on the pre-test and post-test scores, the result interpreted a significant increase in critical thinking skills in classes A and B. This is clarified by the significance value in the classes A and B are 0.000, which mean that the significance value is < = 0.05. the result can be interpreted that class A who uses AR-integrated traditional games Nglarak Blarak has significantly different critical thinking skills than those using PowerPoint and textbooks.

Is there a significant difference between the graphical representation skills of students using AR-integrated traditional games Nglarak Blarak and those using PowerPoint and textbooks?

A pairwise comparison analysis was carried out to determine any significant difference between the students in classes A and B in terms of their graphical representation skills. The result can be found in Table 4.

Table 4. Difference between graphical representation skills of students

Group	(I) Test	(J) Test	Mean Difference (I-J)	Std. Error	Sig.
Class A	Pretest	Posttest	-31,44	2,07	.000
Class B	Pretest	Posttest	-19,97	2,13	.000

The mean difference in class A is -31.44, and class B is -19,97. The negative sign indicates that the average post-test score is higher than the pre-test score. Based on the pre-test and post-test scores, the result interpreted a significant increase in critical thinking skills in classes A and B. This is clarified by the significance value in the classes A and B is 0.000, it mean that the significance value is < = 0.05. the result can be interpreted that class A who uses AR-integrated traditional games Nglarak Blarak has significantly different graphical representation skills than those using PowerPoint and textbooks.

Is there a correlation between students' critical thinking and graphical representation skills when using AR-integrated traditional games Nglarak Blarak?

The correlation test was conducted to determine the relationship between critical thinking and graphical representation skills when students use AR-integrated traditional games Nglarak Blarak. These results can be seen in Table 5.

Table 5. Correlations between critical thinking and graphical representation used AR-integrated traditional games Nglarak Blarak

Test	F	Sig.	Partial Eta Squared
Pillai's Trace	2,000	0,000	0,417
Wilks' Lambda	2,000	0,000	0,417
Hotelling's Trace	2,000	0,000	0,417
Roy's Largest Root	2,000	0,000	0,417

The four types of tests are 0.000, which means it is smaller than 0.05. The results can be interpreted that there are differences in critical thinking skills and graphical representation between classes A and B simultaneously. A partial eta squared value indicates that the effect of AR-integrated traditional games Nglarak Blarak is 0.417. It can be interpreted that AR-integrated traditional games Nglarak Blarak have simultaneously impacted 41.7% of students' critical thinking skills and graphic representation. Furthermore, the Test of Between-Subjects is carried out to examine the effect of AR-integrated traditional games Nglarak Blarak on each skill, namely critical thinking and graphical representation. The results can be found in Table 6.

Table 6. Results of Test of Between-Subjects

Skills	F	Sig.	Partial Eta Squared
Critical Thinking	12,41	0,001	0,171
Graphical Representation	28,38	0,000	0,321

The significance value of critical thinking is 0.001, it is smaller than 0.05. Also, partial eta squared value of critical thinking is 0.171. These results indicating that there is a difference before and after using AR-integrated traditional games Nglarak Blarak, which is 17.1%. While the significance value of the graphical representation is 0.000, and the partial eta squared value of 0.321. It can be interpreted that there is a difference after using AR-integrated traditional games Nglarak Blarak of 32.1%.

Discussion

The current study aimed to identify the effect of AR- integrated traditional games Nglarak Blarak on senior high school students critical thinking and graphical representation skills in physics learning. In addition, another aim of the current work was to investigate the relationships between these students' critical thinking and graphical representation. It was observed that the students in class A scored higher on critical thinking and graphical representation skills than those in class B. This difference can be interpreted as evidence of the positive effects of using AR-integrated traditional games Nglarak Blarak. Implementing the AR-integrated traditional game Nglarak Blarak is a topic discussed in physics learning. This topic was developed and implemented in class A and is an exciting topic according to students. However, because most of them contain abstract concepts, students generally have difficulty learning relevant concepts and difficulty achieving meaningful learning (Sahin et al., 2020; Yilmaz, 2021).

Integrating indigenous knowledge into the science curriculum positively impacts student learning achievement (Handayani et al., 2018). Integrating traditional games, believed to be the experiences of students embodied in real life, can create meaningful learning (Baran et al., 2018; Pavkov-Hrvojević & Bogdanović, 2019). Learning activities related to students' daily life, like traditional games in their area of residence can help construct local knowledge into scientific knowledge (Rahmi & Rosdiana, 2018). It supports the integration of the traditional games Nglarak Blarak in Kulon Progo of this study. The integration of technology and traditional games brought into physics learning has a positive impact on student learning outcomes (Sari et al., 2019).

However, integrating AR technology into physics learning can help students understand physics concepts more easily (Rahmat et al., 2023), see these abstract concepts through 3D virtual objects (Cai et al., 2012; Kassim & A Bakar, 2021), and achieve more meaningful learning (Rahmat et al., 2022). AR technology is a new technology in the world of education, so it is new for students to use it. According to the literature, when new technology is used in education, it will potentially attract interest and motivation toward learning (Huwer et al., 2018). This will make students active during learning (Kiryakova et al., 2018). The transformation of objects in AR applications is extraordinary for students and can attract their attention.

The significant difference between classes A and B in critical thinking and graphical representation skills in physics learning shows that using AR scores higher on using PowerPoint. These results are relevant to research that AR positively impacts learning achievement compared to traditional methods such as textbooks (Erbas & Demirer, 2019; Karagozlu, 2018). AR technology in physics learning can improve critical thinking skills, whereas AR has a 3D simulation feature that can stimulate students' critical thinking skills (Syawaludin & Rintayati, 2019). Students can easily interpret problems with the help of 3D simulations on AR and help students make conclusions (Setiawan et al., 2022). In addition, the use of AR technology also affects students' graphical representation skills. AR technology can help represent physics concepts so that students easily understand them. If the concept of physics can be adequately represented, then the skill of multiple representations will increase (Bakri et al., 2019).

The correlation between students' critical thinking and graphical representation skills on the implementation of the AR-integrated traditional game Nglarak Blarak was examined in this study. There is a significant correlation between critical thinking skills and students' graphical representation skills toward physics learning activities. This study found a correlation between increased critical thinking and graphical representation. Critical thinking and graphical representation increase after using AR-integrated traditional game Nglarak Blarak. Thus, students who study physics using the AR-integrated traditional game Nglarak Blarak have better critical thinking skills and graphical representations.

Conclusion

Integrating traditional games with AR technology into learning physics creates meaningful learning. AR-integrated traditional games Nglarak Blarak from Kulon Progo were developed and implemented into physics learning. It was found that there was a significant difference in students' critical thinking and graphical representation skills using AR-integrated traditional games Nglarak Blarak than learning using PowerPoint and textbooks. In addition, a correlation was found between the increase in students' critical thinking and graphical representation skills when using AR-integrated traditional games Nglarak Blarak into learning physics.

Suggestion

Integrating current trending technology with local knowledge that is almost extinct is one of the ideas for preserving culture to exist today with significant technological improvements. Future research can integrate other local knowledge that is adapted to the area or concept of physics to be taught.

Limitation

The limitation of this study is the use of traditional games which students only know from the area, so if they are to be widely implemented, it is necessary to describe how to play the games first.

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