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Application of Multimedia Interactive Learning Based on Problem-Based Learning to Improve Students' Cognitive Learning Outcomes and Critical Thinking Skills

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Abstract: The purpose of the study is to determine how applying multimedia interactive learning based on problem-based learning affects students in the XI IPA grade at Senior High School's cognitive learning outcomes and critical thinking skills. Purposive sampling and a nonrandomized control group pretest-posttest design are employed in this quasi-experimental study design. Students from class XI IPA 5 (the experimental class) and class XI IPA 6 (the control class) were the samples used; each was assigned a pretest and a posttest. The study's instruments comprise non-tests such as observation sheets for syntax execution, double-choice tests for cognitive learning outcomes, and essays for critical thinking skills. The treatment instruments include learning gadgets and measurement instruments. The findings of the cognitive learning exam yielded an F_{count} of 18,375 with a p-value of $0.000 < \alpha$ ($\alpha = 0.05$) when analyzed, whereas the results of the critical thinking skills test yielded an F_{count} of 18,648 with a p-value of $0.000 < \alpha$ ($\alpha = 0.05$). The test results of the hypothesis showed that H_0 was rejected and the research hypotheses were accepted. In order to draw the conclusion that the application of multimedia interactive learning based on problem-based learning improved the cognitive learning outcomes and critical thinking skills of eleventh grade students at Senior High School.

Keywords: Cognitive Learning Outcomes, Critical Thinking Skills, Problem-Based Learning, Interactive Multimedia

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INTRODUCTION

Learning in primary and secondary education should be arranged on an activity-based basis with interactive, inspiring, enjoyable, and challenging characteristics that encourage students to actively participate in the realization of meaningful learning, according to government regulation number 103 of 2014 Chapter 2, Paragraphs 1 and 2 (Sanaky, 2011). Furthermore, learning and innovation skills which include critical thinking in problem-solving, communication and collaboration, as well as creativity and innovation are among the high-level thinking abilities that students must possess to meet the challenges of the twenty first century educational landscape (Murti, 2013). The use of engaging, inventive, and creative learning media, which serves as a tool to transfer the learning message from instructor to student, is one element that can achieve learning in accordance with government regulation No. 103 (2014) and address the difficulties of the 21st century (Sanaky, 2011).

Learning media can help teachers prepare lessons faster, distribute lesson materials more easily, foster student engagement in learning, and lessen the likelihood that students will misunderstand what teachers are trying to say (Arsyad, 2011). Learning media have developed in the twenty-first century alongside technological development. Information and communication technology (ICT) is used in numerous learning media because it contributes to high-quality learning (Gora & Sunarto, 2013). Interactive learning multimedia is one of the ICT-based teaching tools that has gained significant ground in the field of education.

According to (Munadi, 2013), multimedia interactive learning is learning that allows for student interaction through the use of images, sounds, texts, videos, and displays. The use of multimedia in learning is encouraged in the 2013 curriculum, according to government regulations in Indonesia number. 59 (2014) on the 2013 curriculum of higher secondary schools, since the 2013 course is established through the perfection of the attitude of boosting multimedia-based learning. In addition to enhancing high-level thinking skills, such as critical thinking skills, and can improve student cognitive learning outcomes (Amelia et al., 2023; Ayuningrum et al., 2015), the application of multimedia interactive learning to learning can increase the attraction and attention of students so that ongoing learning is more attractive and motivates students to learn (Daryanto, 2012; Hariati et al., 2020).

Enhancing students' cognitive learning outcomes and critical thinking skills with the use of interactive learning multimedia based on problem-based learning (Yokhebed, 2012). Expert study supports the idea that applying interactive learning multimedia can enhance critical thinking skills. According to research by (Frear & Hirschbuhl, 1999), students' passing grades in the treatment group were significantly higher than those in the control group, indicating that

interactive multimedia increased critical thinking skills in solving environmental science problems.

To achieve effective and meaningful learning, interactive multimedia learning development is combined with a student-centered model; the problem-based learning model is one of the ideal models (Lestari et al., 2015; Mercury et al., 2015). The problem - based learning model is a problem-based learning approach that relies heavily on authentic research, that is, research that calls for genuine answers to real-world issues (Ratumanan, 2015; Trianto, 2010). According to research findings from (Indrawati Romadhoni et al., 2017), using interactive multimedia in conjunction with a problem-based learning model has been demonstrated to help students comprehend challenging course materials, thereby enhancing their cognitive abilities. It has been demonstrated that knowing motion benefits high school pupils (Setyorini et al., 2011; Supiadi & Julung, 2016). According to several studies on interactive multimedia, students' critical thinking skills and learning outcomes can both be enhanced (Husein et al., 2017; Isnaneny et al., 2018; Monica & Pramudiani, 2022; Noviar & Hastuti, 2015; Oktavia, 2020; Putri & Ardi, 2021).

The results of observations that have been carried out on the learning process of classes XI IPA 5 and XI IPA 6 State High School 1 Turen, revealed that at the time of the teacher asking a question of a problem, only about 20% of students are actively answering questions from the teacher with some answers given out of context and not in accordance with the principles and concepts of the material discussed. The fact suggests that students are still not able to analyze problems properly, which is one of Fascione's critical thinking indicators. (2015). In addition, the student biology UAS score is relatively low with the rate in grade XI IPA 5 of 62.00 with the percentage of proficiency of 42.5% and the rate of grade XI IPA 5 of 60.00 with the presentation of provision of 35%. In an effort to enhance critical thinking skills and cognitive learning outcomes of these students, it is necessary to apply multimedia interactive problem-based learning to learning.

The results of interviews conducted with students revealed that biology learning that had been carried out often used learning media in the form of power points containing text and images, but teachers still rarely used interactive learning multimedia (Anggraini et al., 2019). This is in line with a biology teacher's statement that teachers more often use lecture and discussion methods, teachers admit that they have never implemented a problem-based learning model. Teachers reveal that less than 50% of students interact with learning media such as textbooks and power points, other data show students tend to be passive during learning, especially during discussion and evaluation, so teachers say they need to apply multimedia

interactive learning. In Turen's 1st State High School, there are enough LCDs available in every classroom that can be used to broadcast interactive multimedia.

Some of the above descriptions are the guidelines for conducting research entitled "Application of multimedia interactive learning based on problem-based learning to improve students' cognitive learning outcomes and critical thinking skills". The purpose of the study is to determine how applying multimedia interactive learning based on problem-based learning affects students in the XI IPA grade at Senior High School's cognitive learning outcomes and critical thinking skills.

METHOD

This research is quasi-experimental, the experimental groups and control groups are included in the research design. In contrast to the control group, which received standard educational treatment, the experimental group received treatment using multimedia interactive learning based on problem-based learning. The two groups are given the pretest and posttest, and the outcomes are then compared between them. Nonrandomized control group pretest-posttest design with a preliminary design is used in a quasi-experimental study, as shown in **Table 1**.

Table 1. Research design nonrandomized experimental control group pretest-posttest design

Group	Pretest	Treatment	Posttest
Experiment	O1	X1	O2
Control	O3	X2	O4

Source: (Leedy & Ormrod, 2005)

Description: X1 = treatment (multimedia interactive learning based on problem-based learning);
X2 = conventional;
O1 = pretest score of the treatment class;
O2 = posttest score of a treatment grade;
O3 = pretext score of control class;
O4 = posttest score of a treatment grade;

The study was conducted at 1st State High School in Turen, JL.Mayjen Panjaitan 65 Turen in February until March. The population in this study is the entire students of XI grade IPA State High School 1 Turen with a total of 7 classes from XI class IPA 1 up to the XI degree IPA 7 in the full semester. The samples in this study are classes XI IPA 5 and XI IPA 6. Class XI IPA 5 as experimental class or class given treatment while class XI IPA 6 as control class or without treatment. The number of students in each class was 40 students. Sampling in this study was done purposive sampling.

A research instrument is a tool used to measure observed natural and social phenomena. Instruments in this research consist of free variable instruments or treatment instruments and bound variable instrument or measurement instruments. Treatment tools include learning devices and measuring instruments include cognitive learning outcomes and student critical thinking skills tests that are validated by experts. The validity criteria table of the learning device as in **Table 2**.

Table 2. Validity criteria for learning devices

No	Criteria	Validity Level
1	01,00% - 50,00%	Invalid (recommended not to be used because it needs major revision)
2	50,01% - 70,00%	Invalid (recommended not to be used because it needs major revision)
3	70,01% - 85,00%	Fairly valid (usable but needs minor revision)
4	85,01% - 100,00%	Very valid (can be used without revision)

Source: (Akbar, 2013)

The treatment instruments developed include syllabus, learning implementation plan, student Worksheets, multimedia interactive learning based on problem-based learning, and syntax implementation observation sheet. The syntax implementation score will be calculated using **Equation 1**.

$$syntax\ executable = \frac{\Sigma\ syntax\ implemented}{\Sigma\ entire\ syntax} \text{.....(1)}$$

With the criteria in **Table 3** below.

Table 3. Percentage of Learning Syntax Implementation

Level of Implementation of Learning Syntax	Scale of Effectiveness
85-100 %	Very Good
80-84 %	Good
75-79 %	Enough
70-74 %	Less
0-69 %	Failed

Instruments critical thinking skills test in this study was given to students along with a cognitive learning outcomes test before treatment (pretest) and after treatment (posttest) with the same questions totaling 5 essay questions. Critical thinking skills tests are also created by compiling a grid first. The critical thinking skills test is equipped with an assessment rubric. Critical thinking skills calculations can be done using the following **Equation 2**.

$$critical\ thinking\ ability\ score = \frac{\Sigma score\ obtained}{\Sigma question} \text{.....(2)}$$

The critical thinking skills test instrument was validated by material experts and item analysis was carried out to determine the validity, reliability, level of difficulty and differentiability of the questions. Next, the average increase in critical thinking score is calculated using the average gain formula with the following **Equation 3**.

$$< g > = \frac{\%<Sf>-\%<Si>}{100-\%<Si>} \text{.....(3)}$$

Information:

<g> = Average gain

<Si> = Pretest average

<Sf> = Posttest average

Table 4. Criteria for improving critical thinking skills

Average gain <g>	Improvement Criteria
<g> > 0,7	High
0,3 < <g> ≤ 0,7	Medium
<g> ≤ 0,3	Low

Source: (Hake, 1998)

Criteria for improving critical thinking skills can be seen in the **Tabel 4**. This research produces data in the form of cognitive learning outcomes and critical thinking skills results. Data were analyzed using anacova or analysis of covariance. The previous data was first tested for normality with Kormogolov-Smirnov and homogeneity with Levene's Test of Equality of Errors Variences.

FINDING AND DISCUSSION

Validation of learning tools is carried out by validators, learning tool experts, material experts and field experts validated learning tools include learning curricula, learning implementation plan, student worksheets and critical thinking skills pretes-postest on respiratory material as well as excretion systems. A summary of validation results of the curriculum, learning implementation plan and student worksheets and the pretest postest are presented in **Table 5.**

Table 5. Learning device validation results data by expert validator

No	Learning Device	Score	Categories
1.	Syllabus	88,4%	Very Valid
2.	Learning Implementation Plan Experimental Class	89,1%	Very Valid
3.	Learning Implementation Plan Control Class	91%	Very Valid
4.	Student Worksheets Experimental Class	96,6%	Very Valid
5.	Student Worksheets Control Class	97,3%	Very Valid
6.	About the Pre-Postest of the Respiratory System	96.7%	Very Valid
7.	About the Pre-Postest of the System Respiration	93,3%	Very Valid

The validation data above produces a total score from expert validators of 93.2%. These results show that the syllabus, lesson plans, worksheets and critical thinking pretest-posttest questions are categorized as very valid.

Results of detail analysis

On the pretest-postest think critically with a total of 5 essays in the trial test to 40 students of State High School 1 Turen class XII IPA 1. After a detailed analysis of the questions, the result was that the 5 questions of the essay were declared valid. The value of the reliability of the issue is 0.552 which falls into the category sufficient. Next, for the difficulty level questions get the numbers 1, 2, 3, and 4 with the middle level and the number 5 with the difficult level. Differential power calculations on issues 1, 2, 3, and 4 have a good difference of power, whereas the number 5 has a very good difference.

Syntax Execution Test Results

Measurement of learning syntax performance using observations from field experts (teachers) as well as peers analysed descriptively. The rate of successive syntax execution by teachers and students can be seen in **Table 6** and **Table 7**.

Table 6. Presentation of Learning Syntax Implementation for teacher

Meeting To	Syntax Implementation (%)	Categories
1	84,2%	Very Good
2	89,5%	Very Good
3	89,5%	Very Good
4	94,5%	Very Good
Average	**89,4%**	

Table 7. Percentage of implementation of learning syntax among students

Meeting To	Syntax Implementation (%)	Categories
1	89,5%	Very Good
2	94,5%	Very Good
3	89,5%	Very Good
4	94,5%	Very Good
Average	**92%**	

The descriptive analysis data above produces an average implementation of interactive multimedia learning syntax based on problem-based learning for teachers of 89.4%, while implementation for student learning is 92%. Based on this percentage, it can be concluded that the level of implementation of interactive multimedia learning syntax based on problem-based learning for teachers and students in class XI Science is very good and effective.

Data from critical thinking skills tests were analyzed using Quade's rank analysis of covarian with the SPSS, data that had been obtained were pre-tested and included normality

tests with Kolmogorov smirnov tests and homogeneity tests with Levene's Test of Equality of Errors Variences. The results of the critical thinking skills pretest and posttest data normality test respectively have a p-value of 0.022 and 0.000. The first and second data have a p-value < α (α = 0.05). Thus, it can be concluded that the pretest data and posttest data are not normally distributed.

Table 8. Summary of critical thinking skills homogeneity test

Variable	F	df1	df2	Sig.
Pretest thinking critically	1,955	1	78	,166
Postest thinking critically	,169	1	78	,682

The results of the homogeneity test of pretest and posttest critical thinking skills data according to **Table 8** respectively have a p-value of 0.166 and 0.682. Pretest data and posttest data have a p-value > α (α = 0.05). Thus, it can be concluded that the critical thinking skills pretest and posttest data are homogeneous.

Based on the results of the above prerequisite test, it can be found that the critical thinking skills post-test data on this study is not normally distributed so it does not meet the requirements for continuation to the parametric differential test. Then it was decided to switch to non-parametric statistics Quade's rank analysis of covariance to find out if there were any differences in cognitive learning outcomes between the experimental class and the control class in this study. The following **Table 9** presents a summary of the test results of the hypothesis.

Table 9. Quade's rank analysis of covariance

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	7931,841	1	7931,841	18,648	,000
Within Groups	33176,698	78	425,342		
Total	41108,539	79			

From **Table 11**, it can be seen that the F count is 18.648 with p-value = 0,000 < α (α = 0.05). Thus, the H_0 that sounds no difference in critical thinking skills between students in the experimental and control classes is rejected. Because the rate in the experiment class is higher than the control class based on **Table 10**, and the hypothesis test results conclude that "there are differences", it can be concluded that the critical thinking achievement of the students in the experiments class is significantly higher than that of the control classes.

Table 10. Corrected critical thinking skills classes of experiment and control

Class	Pretest	Postest	Differential	Enhancment	Corrected Recangle
Control	44,7	74,6	29,9	66,89%	**74,554**
eksperimen	36,8	80,55	43,75	118,89%	**80,596**

Increased critical thinking skills in the experimental class with the application of multimedia interactive learning based on problem-based learning has a calculation score of gain rate of 0.69 that falls within the medium criteria.

The results of data analysis on this study showed that H_0 research was rejected and HP accepted, which suggested that there was an influence of the interactive problem-based learning multimedia teaching on the improvement of students' critical thinking skills. Critical thinking skills indicators that are measured include interpretation, analysis, evaluation, inference, and explanation using tests such as pretest and posttest quetions. Measuring the student's initial skills before using multimedia interactive problem-based learning is done with pretest, while posing is done to find out the influence of the interactive multimedia subject matter based on problem-driven learning on the students' critical thinking skills.

The critical thinking skills of students are improved with moderate criteria shown with a gain rate score of 0.69, because through the use of interactive multimedia teaching, students will be assisted in the process of solving problems and further problem solving skills will be improved. In this study showed from the student's activity at the time of evaluation, actively asking questions and answering questions given by his friend as well as questions given to the teacher with the correct answers and concepts of the material. It is consistent with (Frear & Hirschbuhl, 1999) research the result that interactive multimedia improves students' high-level thinking skills i.e. reasoning and problem solving in environmental geology lessons demonstrated by student passing grades that are significantly higher in the student group treatment compared to students in the control group.

Application of interactive multimedia to learning it was proven to improve critical thinking skills of high school students on temperature and calorie material because multimedia interactive teaching can help students understand the material and solve misunderstandings on a given subject (Husein et al., 2015). The role of interactive multimedia learning in enhancing critical thought of students was also supported by research from (Wiyono et al., 2009) on high school relativity students with the result that critical think skills of students using interactive multimedia is significantly higher.

The success of the application of interactive multimedia to enhance student critical thinking skills is also supported by a suitable learning model, one of which is the problem-based learning model (Noviar & Hastuti, 2015). The problem-based learning model is effectively used for learning high level thinking processes as well as the development of basic and complex knowledge of students, as expressed by (Ratumanan, 2015). In addition, problem-based

learning also prepares students for critical and analytical thinking to find and use appropriate learning resources (Amir, 2010).

The study carried out by (Kono et al., 2016) also has the results of Model influence problem-based learning on improved critical thinking skills of students on the material of ecosystems and the environment in the X class of State High School 1 Sigi, as well as the research of Ayuningrum (Ayuningrum et al., 2015) with the result of the influence of problem-based learning model on the improvement of critical thought skills of the students of X class MIA Senior High School 1 Rembang. The success of improving critical thinking skills students through the application of interactive multimedia to this study is demonstrated by the ratio of post results of students who in their studies applied multimedia interactive learning based on problem-based learning with a higher ratio that is 80,59 than conventional class with a rate of 74,55.The combination of interactive multimedia together with the learning model in the form of multimedia interactive learning based on problem-based learning is able to improve critical thinking skills of students, because between interactive multimedia learning and the problem-based learning model has a mutually supportive influence based on the results of research from the experts that have been shown.

CONCLUSION

The study's findings support the hypothesis that the use of interactive multimedia-based problem-based learning improves students' critical thinking skills in eleventh grade high school. Students in the experimental class achieved significantly higher cognitive learning outcomes than those in the control class, with an increase of 0.69 that meets the medium criteria.

Future researchers should consider implementing multimedia interactive learning based on problem-based learning by teachers and other researchers in the classroom with different materials and concepts as a recommendation from this study, since it has been demonstrated to enhance students' critical thinking skills and cognitive learning outcomes.

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