

The Effect of Using PhET Simulation-Based Virtual Labs on Students' Analytical Thinking Ability

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Abstract: The use of media in the learning process has a very important role. When there are limitations in media use, especially in accessing real laboratories, it can cause a decrease in students' analytical thinking abilities. This research aims to identify the impact of using PhET simulation on students' analytical thinking abilities. This research is included in the type of quasi-experimental research, a quantitative approach with a pretest-posttest control group design. The research sample was taken using a purposive sampling technique, which resulted in two groups, namely 25 students from class XI-MIA 1 as the experimental group, and 25 students from class XI-MIA 2 as the control group. Data was collected using test techniques, with pretest-posttest value data. Data analysis was carried out using the independent sample t-test, and previously prerequisite tests were carried out in the form of normality and homogeneity tests. The results of hypothesis testing show that the value is $0.04 < 0.05$, which means the research hypothesis is acceptable. From this research it can be concluded that the use of PhET Simulation has a significant influence on students' analytical thinking abilities.

Keywords: Analytical thinking skills; Instructional media; PhET simulation; Virtual laboratory

Introduction

Technology integration is needed in learning at school (Agustian et al., 2021). Technology supports learning in terms of visualizing abstract ideas (Agustian et al., 2021), making it easier to understand the material being studied and making the material appear more attractive (Suharna, 2018).

PhET Simulation is a medium that utilizes digital technology. "Physics Education Technology (PhET) simulation is an interactive simulation on the internet using Java and Flash programming languages, developed by a team from the University of Colorado, United States" (Fitriani et al., 2021).

PhET Simulation has the advantage of being flexible in terms of time and location so that teachers do not need a long time to prepare lessons plus the PhET Simulation application is a Virtual Lab application (Fitriani et al., 2021). The use of Real Labs is sometimes

not supported by school facilities and infrastructure, this virtual lab can complement the limitations of real labs. So that abstract physics concepts can also be conveyed optimally to students (Salame et al., 2021). Apart from that, PhET Simulation can improve scientific literacy skills (Aina et al., 2023; Chandra, 2021), conceptual understanding (Elisa et al., 2017; Price et al., 2018; Watson et al., 2020), students' critical thinking abilities (Sutinah, 2022; Yusuf et al., 2019) as well as analytical thinking skills (Baruno, 2021).

Analytical thinking skills play an important role in solving physics problems (Fitriani et al., 2021). With the involvement of thinking, students will be active in solving a problem and can find out for themselves the concepts they are studying so that students can better understand a concept (Mustaqiem et al., 2020). A student is said to have analytical abilities if he is able to answer questions with logical reasons, make and evaluate conclusions based on practical work, draw

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conclusions from information correctly, and use relevant data to reveal why the method is correct (Yuwono et al., 2020). Analytical thinking is a competency in identifying and classifying different aspects contained in objects, stories or events, then being able to find the relationship between the components and how the aspects can be associated (Lestari et al., 2016).

Previous research only tested the effect of PhET Simulation on mechanical wave materials (Anto et al., 2022). Meanwhile, no one has researched other materials such as diffraction and interference. For this reason, researchers feel the need to prove whether the same thing applies to diffraction and interference materials.

Observation results at MAN 4 for the 2022/2023 academic year showed that student exam results were still low (<75). Apart from grades, students also find it difficult to draw conclusions and relate concepts to experimental results. This problem is supported by Mahyastuti's (2020) research, which showed that students' analytical thinking skills were still lacking, indicated by students' low success in solving problems. This problem is caused by many factors, including students' intelligence abilities (Rafid, 2021), learning motivation (Rosmaini, 2023), as well as teachers' way of teaching which does not develop learning models or media (Suendarti et al., 2021). So learning media is needed to construct students' analytical thinking abilities (Kartikasari, 2021).

With the advantages of PhET Simulation media, students' analytical thinking abilities are also organized and can be improved. This is supported by the results of Anto's (2022) research, which found that the PhET Simulation virtual laboratory learning media had a significant effect on students' analytical thinking abilities. Therefore, this research aims to see the level of students' analytical thinking abilities and the influence of PhET simulation on students' analytical thinking abilities.

Method

This research uses a quantitative approach with a quasi-experimental research type and a "Pretest-posttest control group design" research design. The sample selection in this study used a non-probability sampling technique with purposive sampling type. The samples in this research were the MIPA-1 class which consisted of 25 students and the MIPA-2 class which consisted of 25 students. MIPA-1 class is the control class and MIPA-2 class is the experimental class.

The instrument used in this research is test questions in the form of essays with level C4 (differentiating, organizing and attributing) as an indicator of analytical thinking ability. The data taken are students' pretest-posttest scores on a scale of 0-100.

Data analysis was carried out in two stages. The first stage is an analysis of the percentage of analytical thinking skills using descriptive statistics, namely the average student score and the percentage increase in student scores for each indicator of analytical thinking. In the second stage, an independent sample t-test was carried out to see the effect of PhET Simulation on students' analytical thinking abilities. Before carrying out the independent sample T-test, normality and homogeneity tests are first carried out. The normality test uses the Kolmogorof Smirnov test and the homogeneity test uses the F test. The decision making criteria for the normality test are if P value > 0.05 then the data is normally distributed. The same is true for the homogeneity test, if P value > 0.05 then the data comes from the same variant. The same. For the independent sample t-test, if Pvalue < 0.05 then the research hypothesis is accepted, with the hypothesis that there is an influence of PhET simulation on students' analytical thinking abilities. To assist data processing, SPSS software was used. The research flow can clearly be seen in Figure 1.

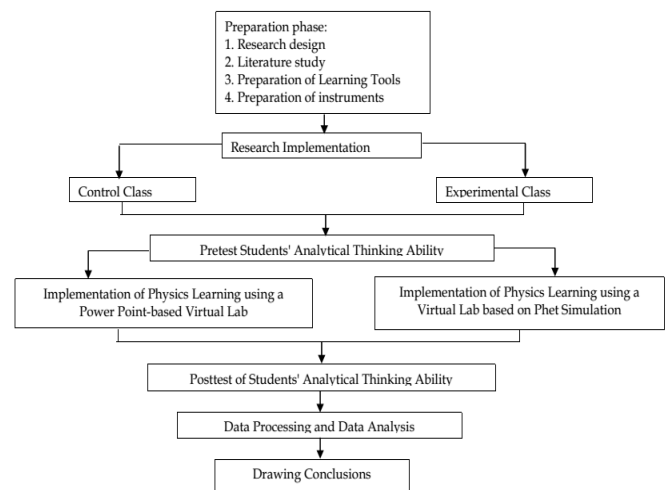


Figure 1. Research flow

Result and Discussion

In accordance with the research objectives that have been formulated in the introduction, namely the level of students' analytical thinking abilities and looking at the influence of PhET Simulation on students' analytical thinking abilities. Research data are presented in subtopics 3.1 and 3.2.

Research Results on the Level of Analytical Thinking Abilities

Pretest questions are given before treatment and posttest questions are given after treatment. From these two tests, data on students' analytical thinking abilities is presented in table 1.

Table 1. Research Results Data

Class	Ideal value	Pretest average	Posttest average	The highest score
Experimental class	100	24.4	70.24	95
Control class	100	23.2	62.32	87

Table 1 shows the increase in students' average scores before being given treatment and after being given treatment. From these results, the experimental class who studied using PhET simulation showed greater improvement than students who studied without PhET Simulation. However, the average value obtained is less than the KKM value (>75). The student's incomplete score was due to the student's ability to answer questions in domain C4 (analytical thinking) being still low so that the student was unable to achieve the KKM score (≥ 75). This is due to many factors, both in terms of students' learning interest, learning motivation, and learning independence factors. Based on research by Dores (2020), it was found that factors that influence critical thinking skills include psychological factors which include anxiety factors and intellectual factors, learning independence factors, physiological factors and interaction factors. The increase in students' analytical thinking abilities for each indicator is calculated by averaging student scores on each indicator. So the results obtained are based on Figure 2.

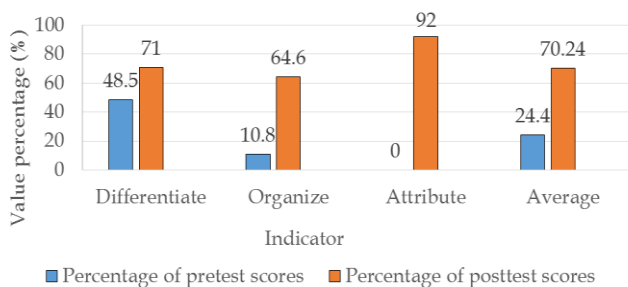


Figure 2. Graph of improvement in analytical thinking skills for each indicator

Based on Figure 2, the highest increase is in the attributing indicator. With this indicator, students are expected to be able to find implied meanings to draw conclusions. In the pretest, students did not answer questions with this indicator so that the percentage in the pretest was 0%, after being given treatment there was an increase. The smallest increase was in the differentiation indicator. In this indicator, students are expected to be able to differentiate information that is relevant and not relevant to the concept and be able to identify problems that are in accordance with the concept of interference diffraction. In the organizing indicator, students are able to analyze the effects based on experiments, and find a correspondence between the concept of interference diffraction and the results of

PhET Simulation experiments. . This is supported by the results of Baruno's research, where the largest increase was found in the attributing indicator, followed by the differentiating and organizing aspects (Baruno, 2021).

Research Results on the Influence of PhET Simulation on Analytical Thinking Skills

Analysis of the influence of PhET Simulation using independent sample t-test. Before carrying out the two-party t test, a normality test and homogeneity test are first carried out. The results of the normality test in the control and experimental classes were normally distributed. With the results in the experimental class, the test results were $0.825 > 0.05$ and in the control class the test results were $0.579 > 0.05$, so it can be concluded that the data is normally distributed.

The results of the homogeneity test calculation with the F test obtained a significance value of 0.687. In accordance with the homogeneity test criteria of $0.687 > 0.05$, it is concluded that the data comes from the same variant. The results of the independent sample t-test showed a value of $0.04 < 0.05$, so there was an influence of PhET Simulation on students' analytical thinking abilities.

The results of hypothesis testing showed that PhET simulation media had a positive influence on students' analytical abilities. In accordance with Anto's (2022) research results, a significant influence was found between PhET simulation and students' analytical thinking. This is proven by the N-gain results of 0.83 in the high category. The results of this research are also supported by Utami's (2017) research, which showed that the results of the Virtual Laboratory Science Media, Global Warming material using an inquiry approach were able to improve students' analytical skills in the high category, as indicated by the acquisition of an average Gain score of 0.73.

Based on the results of this research, PhET Simulation can be used as an alternative physics learning media, especially for conducting physics experiments. Apart from being more affordable, learning with PhET Simulation is safer for students. Students can also carry out experiments anywhere and anytime. Based on research by Tuhusula et al. (2020), PhET can be used as a facility for experimental activities with very supportive and complete tools.

Furthermore, the tools features in PhET Simulation support students to practice their analytical thinking skills. This PhET simulation has measuring tools to calculate interference and other features that students can use to see the influence between physical variables. This is based on research by Wicaksono et al. (2020) where the features in PhET Simulation can be analyzed by students, so that students can answer the questions

given as a measure of students' ability to analyze a problem.

PhET Simulation also makes learning physics more interesting (Masita et al., 2020; Nasution et al., 2023). The animation presented looks attractive and is supported by colors and a cartoon appearance (Batuyong et al., 2018). This is supported by research by Rizaldi et al. (2020), which found that the PhET simulation media was effective in explaining physics concepts that were abstract in nature and had an attractive appearance. Muzana's research (2021) supports this statement. The results obtained from the PhET simulation can help students learn without having to use a real laboratory. This PhET simulation can also be collaborated with a real laboratory (Riantoni et al., 2019). By using PhET simulations, students' learning effectiveness and understanding of the material can increase.

Conclusion

Based on the results of research regarding the effect of PhET Simulation on analytical thinking skills, the researcher can draw the conclusion that the average posttest score for both classes, it was found that the average posttest score for the experimental class was higher than the control class. This shows that PhET Simulation has a positive influence on students' analytical thinking abilities, this is based on a significance test value of $0.04 < 0.05$. Based on the established criteria, it can be concluded that learning interference diffraction material using PhET Simulation is more effective than learning without PhET Simulation. This research is limited to computer/laptop media at school, so students only see the learning process using PhET simulation through a projector screen. In future studies, it is hoped that each group of students will be able to operate the PhET simulation independently.

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Author Contributions

Conceptualization, E. M and N.U.; methodology, N. U and F. H; validation, A. H and N. U.; formal analysis, E. M and N.U; investigation, E. M and N.U; resources, E. M., A.H, and N.U; data curation, E.M: writing—original draft preparation, E.M and N.U.; writing—review and editing, F.H.: visualization, E.M and A.H. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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