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Critical Thinking Skills of Students Through Guided Discovery Learning Model Assisted by PhET Media on Stationary and Walking Wave

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Abstract: The research aims to describe students' thinking skills in the guided discovery learning model assisted by PhET media. The design used is a quasi- experimental: Posttest only control group design. The population in this study were all students of class XI SMA Negeri 2 Koto Kampar Hulu Academic Year 2021/2022 with a sample of 52 students consisting of class XI MIPA 1 as an experimental class totaling 28 students and class XI MIPA 2 as a control class. totaling 24 students. The data collection instrument was a test of critical thinking skills on stationary and running wave material consisting of 10 multiple choice questions. The data analysis technique used is descriptive analysis through the average value of students critical thinking skills and inferential analysis through the normality test, homogeneity test, and hypothesis testing with the help of the SPSS 25 program. The results showed that learning became more effective as seen from the average score - the average thinking skills of students in the experimental class were better than the control class and there were significant differences in students' critical thinking skills between the experimental class that applied the PhET media-assisted guided discovery learning model and the control class.

Keywords: Control Class; Critial Thinking Skills; Guided Discovery; PhET;

Introduction

In a sophisticated and modern era like today, information and communication technology is needed in every life. Rapid developments in ICT have changed lifestyles at this time, the development of ICT is also used as a learning medium (Azhar et al., 2021; Setyarini & Admoko, 2022). Computer simulations will visualize material that is difficult to present, especially abstract phenomena. Computer simulations can be used effectively as classroom teaching aids and can provide greater conceptual benefits because students are better able to integrate their knowledge than if students only use textbooks in the learning process (Kriek & Stols, 2010; Banda & Nzabahimana, 2023).

Physics has a big role in supporting science and technology, because the subject of Physics is a basic science in supporting the development of science and technology, thus inspiring educators to be able to design and implement education that is more focused on mastering physics concepts so that they can be applied in everyday life (Yerimadesi et al., 2023). Physics teachers in schools often discuss theory from the handbook used, then give formulas and then give examples of problems without paying attention to spatial abilities (Jalaluddin et al., 2019).

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Teachers focus more on providing material without practicum at all or using learning media. And also the dominance of teachers in the learning process causes the tendency of students to be more passive, so they wait more for the teacher's presentation than to seek and find for themselves the knowledge, skills or attitudes they need (Saktioto et al., 2021; Kurniawan et al., 2021). In addition, teacher-centered learning tends to allow students to work individually to achieve learning goals, this condition results in physics subjects still being seen as difficult subjects by students so that student learning outcomes tend to be less good (Hafizh & Fatah, 2022; Unwakoly, 2022).

This problem can occur because the implementation of learning in the classroom is still monotonous, teachers still have not implemented innovations in learning such as the use of learning models. A learning model is a plan or pattern that is used as a guideline in planning learning in class (Irawan et al., 2010; Al-Shaye, 2021). The learning model refers to the learning approach to be used, including teaching objectives, stages in learning activities, learning environment, and classroom management. For this reason, teachers need to use variations in teaching, one of which is the use of the right learning model with the learning material to be taught. Choosing the right and innovative learning model can help students focus and be active during the learning process (Farias et al., 2009; Listiqowati et al., 2022).

Learning good physics is not only mastering physics nominally but also functionally. With this, good physics learning needs to be supported by laboratory activities, and providing examples of physics events or benefits in the environment, including the workplace (Irawan et al., 2022). It can be said that learning physics without being equipped with demonstration activities, laboratories, or field experience often leads to errors in understanding physics or misconceptions of physics. Therefore, in physics learning laboratory activities are very necessary in supporting physics learning in schools (Farida Istinganah et al., 2021).

In Permendiknas No.22 of 2006, the objectives of physics subjects include basic competencies that students must have, namely developing experience and mastering physics concepts and principles. The 2013 curriculum in its development prioritizes learner-centered learning (Febliza et al., 2023). To realize learner-centered learning, educators are required to be able to create effective and fun learning activities for students. Discovery learning is one that emphasizes learner-centered learning experiences, from which they discover ideas and draw meaning upon themselves (Ristanto et al., 2022). The guided discovery learning model (Guided Discovery) has advantages in terms of involving active students in the learning process that is able to trigger critical thinking skills and train students in solving problems given by the teacher (Hermanto et al., 2023).

Learning using the help of PhET media is one of the computing media that provides physics animations that are made into blogs. PhET Simulations can display material that is abstract and can be explained easily and precisely to students (Mardiyanti & Jatmiko, 2022). In this learning with the help of PhET simulations media in deductive hypothetical thinking as well as critical thinking skills where this is very necessary, basically the abilities of students can be honed and explored so that they can help students in increasing understanding of the material learned by evaluating critically (Irawan et al., 2011; Taibu et al., 2021). So critical thinking in education is a competency that will be achieved as well as a necessary tool in constructing knowledge contained in 21st century learning that has an impact on learning outcomes because it uses higher-order thinking (Firdaus & Wilujeng, 2018; Laksono et al., 2023).

Based on the experience of researchers when carrying out School Field Introduction (PLP) activities in semester 7 of 2021 at SMA Negeri 2 Koto Kampar Hulu, students have difficulty analyzing the material taught by the teacher, tend to accept the material as it is from the textbook, and are passive when asking questions or answering questions from the problems given by the teacher, and passive in expressing ideas or ideas for problem solving. It can be concluded that a student's critical thinking ability in the learning process is included in the low class.

There are various factors that cause students' critical thinking skills not to develop, namely first, a curriculum designed with a broad target material so that teachers are more focused on completing the material (Manurung et al., 2023). This means that the completeness of the material takes precedence over the understanding of students on physics concepts. Second, that the learning process in class is carried out by the teacher only by delivering information (lecture method) which activates the teacher more, while students only listen and copy what is given by the teacher. Third, the teacher only submits sample questions, then continues to give practice questions that are routine in nature and lack critical power, then the teacher gives an assessment (Sari & Prasetyo, 2021).

The purpose of this study is to describe the critical thinking skills of students taught using the PhET media-assisted guided discovery learning model. And to find out the difference in critical thinking skills of students taught using the PhET media-assisted guided discovery learning model with those taught without using the PhET media-assisted guided discovery learning model (Hasanvand & Mohammadian, 2022).

Guided discovery learning is learning that trains and guides students to learn, acquire knowledge, and build concepts they discover for themselves. Discovery is discovering concepts through a series of data or information obtained through observation or experiment (Nurdiana et al., 2023; Jayanto et al., 2019). Discovery learning is a cognitive learning method that requires teachers to be more creative in creating situations that can make students actively learn to find their own knowledge (Haryanto, 2007). The stages of guided discovery that have been adapted can be seen in Table 1.

PhET is a simulation media created by the University of Colorado containing simulations of learning physics, chemistry, biology for the benefit of classroom learning or individual learning (Riantoni et al., 2019). PhET simulations emphasize the relationship between real-life phenomena and the underlying science, support interactive and constructive approaches, provide feedback and provide a critical workplace (Ankeli, 2020; Sundawan & Nopriana, 2019). Teachers can use experimental simulation methods using online and offline PhET which is expected to make students more active in learning and only centered on teachers and learning media. Teachers have a very important role in the learning process (Ndihokubwayo et al., 2020). This requires teachers to reorganize learning strategies using teaching aids or learning media for students. No matter how good the curriculum is developed and the facilities provided, in the end it is the teacher who carries out the learning process (Nurhayani et al., 2020). Therefore, many experts say the key factor in improving the quality of education is a teacher (Wiravanjava, 2017; Ng & Chua, 2023). Critical thinking skills will make students able to make decisions or actions on the problems faced (Firdaus & Wilujeng, 2018). Critical thinking is part of higher-order reasoning and it is very important for children to hone these skills, although critical thinking skills are still often not given more attention (Faisal et al., 2022).

Indicators of critical thinking skills according to Ennis (1985) theory consist of; Provide simple explanations, build basic skills, infer, give further explanations and set strategies and tactics. The following explanation of critical thinking skills indicators can be seen in Table 2.

Table 1. Stages of guided discovery learning

Levels – levels	Teacher activities
Explain the purpose/prepare students	Convey learning objectives, motivate learners by encouraging students to engage in activities.
Orientation of learners to problems.	Describe simple problems related to the learning material.
Formulate a hypothesis.	Guiding students to formulate hypotheses according to the problems raised.

Table 2. Critical Thinking Skills Indicators

Skill indicators critical thinking	Information
Provide simple explanations	Can analyze the problems given.
	Can write the meaning of the problem clearly and precisely.
	Can write down what is asked in questions clearly and precisely.
Build foundational skills	Can find relationships between concepts used in solving problems.
	Can determine what to do in solving the problem.
	Can solve the problem.
Retraction of conclusions	Can draw conclusions from what is asked logically.
	Can give reasons about the conclusions drawn.
Provide further explanation	Can write down the final result.
Set strategies and tactics	Can review the answers given or Written.

Methods

This type of research is quantitative research. According to Sugiyono (K. A. Sari et al., 2017) quantitative research can be interpreted as a research method used to examine certain populations or samples, data collection using research instruments, quantitative/statistical data analysis, with the aim of testing hypotheses that have been set. The type of research used is Quasi Experimental Designs research.

The design used in this study was Posttest-Only Control Design. Posttest-Only Non-equivalent Control Design is that there are two groups, the experimental class, which is the class that is given treatment, and the control class, which is the class that is not given treatment (Erwan &; Dyah, 2017; Anggraeni et al., 2023). In this design the first group was given treatment (X) and the other group was not. The treated group is called the experimental group and the untreated group is called the control group. The effect of treatment is (O_1 : O_2).

This research was conducted at SMA Negeri 2 Koto Kampar Hulu, Koto Kampar Hulu District, Kampar Regency. The implementation time is in the even semester of the 2021/2022 academic year. The

population in this study is all grade XI students of SMA Negeri 2 Koto Kampar Hulu for the 2021/2022 school year consisting of 2 classes with a total of 52 students. The sample in this study was determined through normality test and homogeneity test in the population. The data used is student test score data on the previous material. The technique used to determine the sample is simple random sampling.

The data collection method used in this study was a test of students' critical thinking skills. The data needed in this study are primary data and secondary data. The primary data obtained is from the value of students' post-test results after being given treatment. While secondary data was obtained from the Physics teacher on the results of the previous material test. Descriptive analysis in this study was used to get an idea of students' critical thinking skills and learning effectiveness.

Students' critical thinking skills in making decisions or actions on the problems they face and are assessed through indicators. Critical thinking skills have five indicators: providing simple explanations, building basic skills, drawing conclusions, providing further explanations, and organizing strategies and tactics. Students' critical thinking skills are obtained from critical thinking skills test scores in the form of multiple choice. To calculate the score of critical thinking skills acquired by students used provisions on Table 3.

Table 3. Critical Thinking Skill Level Criteria

Scale	Information
75 < Score ≤ 100	Very high
50 < Score ≤ 75	High
25 < Score ≤ 50	Low
0 < Score ≤ 25	Very low

(Karim, 2015)

Inferential analysis is an analytical technique whose data is taken from random samples that aim to draw conclusions (Erwan Agus Purwanto and Dyah Ratih Sulistyastuti, 2017; Jufrida et al., 2022). Inferential analysis was conducted to determine the differences in students' critical thinking skills after applying the PhET media-assisted guided discovery learning model to the experimental class and applying the conventional learning model to the control class through hypothesis testing. Before conducting a hypothesis test, a prerequisite test is carried out first, namely the normality test and the homogeneity test.

Result and Discussion

The presentation of the results of this study consists of 2 kinds of analysis, namely descriptive analysis and inferential analysis. Descriptive analysis consists of the average score of students' critical thinking skills while inferential analysis consists of normality test, homogeneity test, and hypothesis test. Descriptive analysis was used to determine the extent of the critical thinking skill level of SMA Negeri 2 Koto Kampar Hulu students, both for experimental and control classes. Data on the average posttest score of critical thinking skills of experimental class students per indicator are shown in Table 4.

Based on Table 4. The average percentage of students' critical thinking skills per indicator was different between the experimental class and the control class. The average posttest score for each indicator in the experimental class tended to be higher than the control class. This indicates the influence of the difference in treatment given to the experimental group and the control class.

A more detailed explanation of improving critical thinking skills for each indicator can be seen in the discussion. The average score of students' critical thinking skills in the appendix which was processed using the critical thinking skills value equation, if reviewed the average percentage of students' overall critical thinking skills can be seen in Table 5.

Table 4. Percentage of Students' Critical Thinking Skills Score per Indicator

Indicator	Experimental Class		Control Class	
	Average (%)	Category	Average (%)	Category
Provide simple explanations	94.64	Very High	77.05	High
Build foundational skills	85.71	Very High	58.35	High
Retraction of conclusions	66.06	High	41.65	Low
Provide further explanation	87.49	Very High	62.50	High
Set strategies and tactics	30.35	Low	10.38	Very low

Table 5. Critical Thinking Skills Results of Experimental and Control Class Students

Class	Average (%)	Category
Experimental classes	72.85	Tall
Control class	49.98	Low

Based on Table 5. It can be seen that the score of students' critical thinking skills in experimental classes using the guided discovery learning model is higher than control classes using conventional learning. This was shown in the experimental class the students' critical thinking skills score reached 72.85% and the control class 49.98%. The percentage of critical thinking skills scores of experimental and control class students

were in different categories, each in the high and low categories.

To better known students' critical thinking skills, an analysis of critical thinking skills indicators is carried out which includes providing simple explanations, building basic skills, drawing conclusions, providing further explanations, and organizing strategies and tactics. Analysis of indicators in the experimental class showed that of the five indicators of critical thinking skills, the indicator providing a simple explanation was the indicator with the highest gain of 94.64. While the indicator of managing strategies and tactics is the indicator with the lowest value of 30.35. In the control class itself, an analysis of indicators of critical thinking skills was also carried out which included providing simple explanations, building basic skills, drawing conclusions, providing further explanations, and organizing strategies and tactics. The indicator providing a simple explanation is also the indicator with the highest percentage in the control class, with a value of 77.05. While the indicator of managing strategies and tactics is the indicator with the lowest percentage with a value gain of 10.38. Based on the results of data analysis, critical thinking skills of each aspect in the experimental class and control class, there are differences as in Table 4.

Provide simple explanations

In this aspect, learners experience the process of analyzing arguments, focusing questions, asking and answering questions, as well as clarifying questions by investigating a reason to find out the real situation.

With critical thinking skills, students are expected to recognize problems, find ways that can be used to deal with those problems, collect and organize the necessary information, understand and use appropriate and clear language. In the experimental class obtained an average score of 94.64 while in the control class the average score was 77.05. This is in line with research conducted by Silvia Sri Astuti (2017) which states that there is an influence and increase in the average critical thinking skills of students on indicators providing simple explanations. In this indicator, learners in the experimental class were more active than learners in the control class.

Build foundational skills

The second aspect measured is building basic skills, which consist of considering the credibility of a source and observing and considering observations. Students think regularly to be able to use their thinking power so that they can think about a source by considering the criteria of a source obtained. Students explore information by understanding events related to what they are experiencing and connecting with sources obtained and anticipating information by using their way of thinking and maximizing direct observations then thinking of observations to be used as opinions. In this basic skill building indicator, students in the experimental class were more active and creative in building basic critical thinking skills than the control class. The average score on the indicator of building basic skills in the experimental class was 85.71 while in the control class the average score was 58.35. The same results were also obtained by Nefrita (2019), who stated that the application of phet media in learning can improve students' critical thinking skills in providing basic skills.

Withdrawal of Conclusion

In the third indicator of critical thinking skills, students are expected to be able to conclude by making conclusions by deducing, inducing or considering the results of induction and making decisions. To be able to make a good conclusion requires a good knowledge and experience, so in coming up with a provisional conclusion must be with a deep understanding based on the background of facts and good sources. In this third indicator, students do well even though they still need to practice continuously. In the experimental class, the average score obtained was 66.06 while in the control class it was 41.65. The results of this study are in line with research conducted by Reni Meriyana (2020) which states that there is an increase in the average value of indicators drawing conclusions after being taught with a guided discovery learning model, in this study students are still not optimal in making conclusions.

Providing Further Explanation

In this fourth inidication, students are expected to be able to develop their thinking skills in making further explanations. In this case, students are required to have a lot of practice when identifying assumptions by constructing an argument. With a good experience, students will be able to build a good opinion if accompanied by wisdom. In this indicator, students do well even though they have to practice a lot in identifying assumptions. The average score on the indicator gave further explanation in the experimental class of 87.49 while in the control class it was 62.5. The results of this study are in line with the results of Choirotul Farichah's (2015) research that there is an average increase in indicators providing further explanation after guided discovery learning is carried out. But in this indicator there are still many students who have not answered correctly because the indicator is presented in a question whose domain is higher than the previous indicator.

Set Strategies and tactics

In this fifth indicator, learners decide on an action by considering possible solutions from what they face. Students do this based on information and experience they have had from daily life interactions. So that students can produce excellent decisions and students wholeheartedly believe in a result and set it in an action. Because students have gone through daily knowledge and experience. In this phase students are doing well although there is still a lot to improve. The average score on indicators set strategies and tactics in the experimental class was 30.35 while in the control class it was 10.38. The same results were also obtained by Choirotul Farichah (2015) who stated that there was an average increase in indicators of managing strategies and tactics after guided discovery learning. This indicator is the indicator with the lowest completeness, this is because there are still many students who have not been able to answer correctly the questions with the highest domain.

Based on the discussion described, overall, it can be said that the PhET media-assisted guided discovery learning model has an influence on students' critical thinking skills, which is more effective in improving students' critical thinking skills than conventional learning. This is evidenced by hypothesis testing with the help of SPSS 25, where inferential data analysis was previously carried out prerequisite tests, namely data normality tests and data homogeneity tests to be able to conduct hypothesis tests. In this study, the data obtained were normally distributed and homogeneous because after testing, it was found that both classes had a significance value greater than 0.05. Because both classes have the same variation and are normally distributed, hypothesis testing can be done using an independent sample t-test conducted with the SPSS 25 program.

The hypothesis in this study obtained by using the independent samples t-test obtained a significance value (2-tailed) of 0.000 which means that there is a significant difference in students' critical thinking skills between classes that use the phet media-assisted guided discovery learning model with classes that apply conventional learning to stationary and walking wave material.

Conclusion

Based on the results of research and discussion that has been presented, regarding students' critical thinking skills through the PhET media-assisted guided discovery learning model on stationary wave material and running at SMAN 2 Koto Kampar Hulu, it can be concluded that there are differences in critical thinking skills of experimental class students through a guided discovery model with control class students who are taught with conventional learning models, where the aspect of critical thinking skills of the experimental class is higher than the percentage value of the control class Thus, it can be concluded that the application of the phet media-assisted guided discovery model in the physics learning process for stationary wave material and running in class XI SMAN 2 Koto Kampar Hulu is effective in improving students' critical thinking skills.

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Author Contributions

Conceptualization, A.A, and W.J.; validation, A.A. and D.I.; formal analysis, D.I. R.E.M; investigation, A.A, and W.J; resources, A.A, and W.J; data curation, A.A, and W.J: writing—original draft preparation, D.I, R.E.M, W.J.; writing—review and editing, D.I.: visualization, A.A, D.I. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

There is no conflict of interest in this research article.

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