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Application of Guided Inquiry Model to Improve the Ability and Critical Thinking Disposition of Senior High School Students in Physics Learning

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ABSTRACT

This study aims to examine the effectiveness of the Guided Inquiry model in improving students' critical thinking ability and disposition on alternative energy materials. The research design used a pseudo-experiment with a quantitative approach. The research subjects consisted of 70 X grade students who were divided into two groups, namely the experimental group (Guided Inquiry) and the control group (Problem-Based Learning). The results showed that the increase in CTA and CTD of the experimental class was significantly greater than the control. Critical thinking ability increased from 37.26 to 74.03, and critical thinking disposition from 45,11 to 70,34. T-test and effect size analysis showed significant differences and a large impact. There was a positive correlation between critical thinking skills and disposition ($r = 0.483$; $p < 0.001$). The Guided Inquiry model proved effective in developing students' overall critical thinking skills.

1. INTRODUCTION

Thinking is a personal human activity that produces goal-directed discoveries. The thinking process is a mental activity that plays a role in building and acquiring knowledge. Critical thinking is classified as one of the higher order thinking skills in the cognitive taxonomy. In general, critical thinking consists of two main components, namely Critical Thinking Ability (CTA) and Critical Thinking Disposition (CTD). Critical thinking ability includes the activities of analyzing arguments, claims, or evidence; drawing conclusions through inductive or deductive reasoning; evaluating; and making decisions or solving problems (Lai, 2011). In critical thinking, there is another aspect that is also very important, namely critical thinking disposition. (Ennis, 2011) stated that critical thinking disposition shows the ability to think critically. These components should be one of the expected outcomes of the education system (Daly, 1998). Critical thinking ability is the ability to remember, analyze, understand,

apply, conclude, evaluate and synthesize. Students with critical thinking dispositions are expected to have attitudes and intentions that support the improvement of their thinking abilities in certain ways, so as to improve understanding of the subject matter(Afriansyah et al., 2021).

Critical thinking ability and disposition are very important, the importance of using critical thinking ability and disposition is a priority in everyday life to solve problems (Alghadari, 2013). This is supported by Halpern (Yunarti, 2011) who said that an ideal critical thinker must have critical thinking ability and disposition. Along with the times and curriculum demands, it turns out that Indonesian students' performance in critical thinking is still far from satisfactory. The results of the Program for International Student Assessment (PISA) in 2022 showed a decline in international learning outcomes due to the pandemic. Even so, Indonesia's ranking in PISA 2022 rose 5-6 positions compared to PISA in 2018. However, PISA questions require not only problem-solving ability, but also logical and systematic reasoning skills (Fauzi & Abidin, 2019). A student is considered capable of reasoning if they can apply their knowledge to new situations that they have never encountered before. This ability is known as critical thinking ability. Likewise with disposition, often what is more considered is the final score of students without considering their attitude in seeking the truth, curiosity about new things, and their thought process when solving problems. This connection between PISA performance and critical thinking emphasizes the relevance of developing both CTA and CTD in Indonesian educational contexts, particularly as students need to adapt to post-pandemic learning environments that demand higher-order thinking skills.

Physics is still classified as a subject that is perceived as difficult by students and requires more intensive thinking to be understood and learned (Ady & Warliani, 2022). It turns out that the results of a study in one of the high schools in Garut district based on the results of an interview with a physics teacher on Thursday, July 20, 2020 stated that the high school was categorized as having low critical thinking ability and disposition because it was influenced by several factors, one of which was that students were not used to thinking critically at previous levels and could not analyze the phenomenon of a problem. Many factors cause the low critical thinking skills of students. The results of research (Mappan et al., 2020) related to critical thinking ability by obtaining data analysis showed 43.5%, this shows that students' critical thinking ability is low. The results of research (Syamsuddin et al., 2024) related to critical thinking disposition showed a figure of 77.8% with a low category of 22.2%.

The results of the study (Rizky & Sritresna, 2021) concluded that the increase in critical thinking ability of students who received the Guided Inquiry learning model had a high increase, as well as students' critical thinking disposition but further research is needed. In this model, students act like a scientist. Asking questions, making hypotheses, conducting experiments, identifying relationships between concepts, and explaining the findings according to their understanding (Wenning, 2011). The guided inquiry learning model is an approach that emphasizes the active involvement of students in the process of discovering concepts and establishing relationships between concepts. In its application, students are given the freedom to design experimental procedures independently, while educators act as facilitators who guide the learning process to stay on the right scientific path. The inquiry model is a strong model using constructivism, which explains that knowledge is constructed by students themselves through a process of investigation so that they find their own knowledge (Verawati, 2013).

2. METHODS

To determine the effectiveness of a learning method, an experimental design can be used, either an experiment in the form of an actual experiment or a quasi-experiment (Ruhbani Amarulloh & Asep Irvan Irvani, 2025). In this study, a quantitative approach with a quasi-experimental design was used to test the effectiveness of the Guided Inquiry learning model in improving students' critical thinking ability and disposition in physics lessons with alternative energy material. Experimental research methods allow us to identify cause-and-effect relationships because they allow us to observe, under controlled conditions, the effects of changing one or more variables systematically (Johnson & Christensen, 2024).

The quasi-experiment design was specifically chosen over a true experiment due to practical limitations in an educational setting, including the inability to randomly assign students to groups (which would disrupt existing classroom structures) and the need to work within existing school schedules and classroom settings. Experimental and quasi-experimental research designs are research designs that aim to examine whether there is a causal relationship between independent variables and dependent variables (Rogers & Revesz, 2019). The research was conducted at one of the public madrasah aliyah in Garut, with two X classes that have different characteristics as research subjects. The research sample consisted of 70 grade X students, which were divided into two groups, namely the experimental class and the control class, each consisting of 35 students. The sampling technique used is purposive sampling, which is a sampling technique carried out by considering certain characteristics of the population that are relevant to the research objectives, in this case the differences in the characteristics of academic classes (classes that focus on mastering theoretical knowledge according to the traditional curriculum) and skills (classes that emphasize the development of practical and vocational skills with a more practical learning approach) are considered to provide deeper information regarding the effectiveness of the learning model being tested. The experimental class is the skills class, while the control class is the academic class. Both classes were chosen to study the effect of treatment on classes with different characteristics.

Before the treatment was carried out, a pre-test was conducted to identify the initial ability and critical thinking disposition of students in both class groups. The pre-test results showed that the experimental class had lower average critical thinking ability and critical thinking disposition than the control class. In addition, researchers introduced different learning methods to the two classes. The experimental class learned using the guided inquiry model, while the control class used the problem-based learning (PBL) model. The learning process was conducted for three meetings for both classes with the same material, namely alternative energy. In the context of the complexity of alternative energy issues in Indonesia, critical thinking ability is very relevant to be applied (Maulidia et al., 2019).

After the learning process was completed, a post-test was conducted on both class groups using the same instrument as the pre-test, to measure students' ability and disposition in critical thinking. A written test was used as an instrument to measure aspects of critical thinking ability, as suggested (Hasan et al., 2020), who stated that critical thinking assessment instruments for high school students must meet high st andards of validity and reliability to ensure measurement accuracy. Meanwhile, critical thinking disposition is measured through a validated questionnaire. This confirms the importance of non-test instruments in describing and analyzing educational reality from various perspectives (Fraenkel & Meierhenrich, 2018).

Data collection is a very important step in quantitative research because the data is the basis for conducting analysis and drawing conclusions (Sutton & Austin, 2015). To analyze the data, researchers used various statistical analysis methods. The first step was to test for normality and homogeneity to determine the appropriate type of statistical test. If the data was normally distributed and homogeneous, a parametric test in the form of an independent t-test was then applied to compare the mean difference between the two groups. Conversely, if the assumptions of normality and homogeneity are not met, a non-parametric test in the form of an unpaired t-test is used. In addition, to measure the improvement of critical thinking ability and student disposition, N-gain analysis was conducted to determine the difference between pre-test and post-test scores. N-gain calculation: To measure improvement in CTA and CTD, an N-gain analysis was conducted using Hake's formula: N-gain = (post-test score - pre-test score)/(maximum score - pre-test score) (Hake, 2002). The N-gain interpretation categories followed Hake's criteria: high improvement ($g > 0.7$), moderate improvement ($0.3 \leq g \leq 0.7$), and low improvement ($g < 0.3$) (Hake, 1999). This study also analyzed the correlation between CTA and CTD to determine the relationship between these variables, which is important for developing comprehensive learning strategies to improve students' overall critical thinking skills. This study also analyzed the correlation between critical thinking ability and student disposition to determine the relationship

between the two variables. This relationship is important as a basis for developing comprehensive learning strategies to improve students' critical thinking skills in general.

3. RESULT AND DISCUSSION

This study explores in depth the potential of the Guided Inquiry model in improving the critical thinking ability and disposition of high school students in physics learning. This study explores the potential of the Guided Inquiry model in improving CTA and CTD of high school students in physics learning. Statistical analysis results show that the Guided Inquiry model has significant impact on improving students' critical thinking ability. Before conducting main analyses, normality tests using Shapiro-Wilk showed that pre-test data for both CTA ($p = 0.058$) and CTD ($p = 0.071$) were normally distributed ($p > 0.05$). Levene's test for homogeneity of variances indicated homogeneous variances for CTA ($p = 0.234$) and CTD ($p = 0.198$), supporting the use of parametric tests. The results of statistical analysis show that the Guided Inquiry model has a significant impact on improving students' critical thinking ability. Based on the independent samples t-test, there is a very real difference between the experimental and control groups at various stages of measurement. The following table shows the improvement of CTA and CTD ability in the experimental class. The table shows a comparison of the average pre-test and post-test scores, as well as the improvement value obtained after treatment in the experimental class.

Tabel 1. Variable improvement experiment class

variable	pre-test	post-test	Improved
Critical Thinking Ability	37,26	74,03	36,77
Critical Thinking Disposition	45,11	70,34	13,89

The following table shows the improvement of CTA and CTD ability in the control class. The table shows a comparison of the average pre-test and post-test scores, as well as the improvement value obtained after treatment in the control class. From the data, it can be observed the difference in students' achievements between before and after the learning is implemented.

Tabel 2. Variable improvement control class

variable	pre-test	post-test	Improved
Critical Thinking Ability	54,00	67,89	13,89
Critical Thinking Disposition	52,03	64,49	12,46

On the Knowledge Based Criteria (KBK) pretest, the experimental group had an average score of 37.26 with a standard deviation of 13.230, while the control group reached 54.00 with a standard deviation of 8.738. After the intervention, on the KBK posttest, the experimental group increased to 74.03 with a standard deviation of 10.028, while the control group reached 67.89 with a standard deviation of 10.105.

The following Table 3 presents data on the implementation of learning by teachers based on the indicators of the guided inquiry model. The data shows the implementation score for each learning stage,

starting from orientation to designing experiments, with an assessment range of 1-4. From the table, it can be observed the level of teacher success in implementing each indicator of guided inquiry-based learning.

Tabel 3. Teacher implementation

no	Indikaror Guide inquiry	Skor (1-4)
1	Orientation	4
2	Formulate the problem	4
3	Problem solving	4
4	Formulate a hypothesis	4
5	Testing the hypothesis	4
6	Designing an experiment	4
Total Scores		24
Maximum score (6x4)		24
Presentase		$\frac{24}{24} \times 100 = 100\%$
Category		Very good

The following Table 4 displays data on the implementation of learning from the students' perspective using the guided inquiry model. This table summarizes student achievement on each learning indicator with a rating scale of 1-4. The results show the level of student participation and involvement reached a percentage of 91.67% with a total score of 22 out of a maximum score of 24, which is included in the excellent category. This data provides an overview of the effectiveness of the application of the guided inquiry learning model from the point of view of student learning activities.

Tabel 4. Student engagement

no	Indikaror Guide inquiry	Skor (1-4)
1	Orientation	4
2	Formulate the problem	4
3	Problem solving	3
4	Formulate a hypothesis	4
5	Testing the hypothesis	4
6	Designing an experiment	3
Total Scores		22
Maximum score (6x4)		24
Presentase		$\frac{22}{24} \times 100 = 91{,}67\%$
Category		Very good

The learning implementation assessment was conducted to ensure that the guided inquiry model was applied consistently and in accordance with the learning syntax. The results of teacher implementation showed a total score of 24 out of a maximum score of 24, with a percentage of implementation of 100%. All guided inquiry indicators, namely orientation, formulating problems, problem solving, formulating hypotheses, testing hypotheses, and designing experiments, were thoroughly implemented. Based on the criteria adapted from (Arikunto, 2021) this is categorized as very good. Meanwhile, student implementation in participating in learning obtained a total score of 22 out of a maximum score of 24, with a percentage of 91.67%, also in the very good category. This indicates that some students still need further guidance in developing analytical and investigative thinking skills at certain stages in the inquiry process. This research is in line with the findings conducted by (Hasan et al., 2020; Penulis, n.d.), who stated that the application of the Guided Inquiry model in physics learning can improve students' science process skills, with well-implemented learning. The results of this study indicate that this model can be applied effectively in the classroom and plays an important role in developing students' skills in critical and analytical thinking, in accordance with learning objectives. In addition, in a study by (Arfianawati et al., 2016), the implementation of the ethnoscience-based Guided Inquiry model also showed positive results, with the implementation reaching the maximum value. This research confirms that the Guided Inquiry model is not only effective for developing concept understanding, but also for improving students' ability to identify and solve problems with a scientific approach.

In general, these results show that guided inquiry learning has been implemented very well, both in terms of teacher implementation and student involvement. Guided Inquiry learning emphasizes the critical thinking process to seek and find answers to a questionable problem and build students' knowledge concepts (Rizky & Sritresna, 2021). This high implementation is a strong basis that the learning process runs according to design, and contributes to improving students' critical thinking ability and disposition. Effect size analysis using Cohen's d shows that the Guided Inquiry treatment has a substantial impact. On the pretest, Cohen's d was -1.493, indicating a significant difference between the two groups. After the intervention, the Cohen's d value increased to 0.610, signaling a positive effect of the learning model. In addition, research by (Irwanto et al., 2024) showed that the application of Guided Inquiry combined with problem solving techniques significantly improved the critical thinking ability of grade XI students. (Antonio & Prudente, 2023)showed that the inquiry-based approach had a significant positive impact on students' higher order thinking skills, with a combined effect size of g = 0.893, which is categorized as a large effect. Here are the results of the CTA answers with the highest scores.

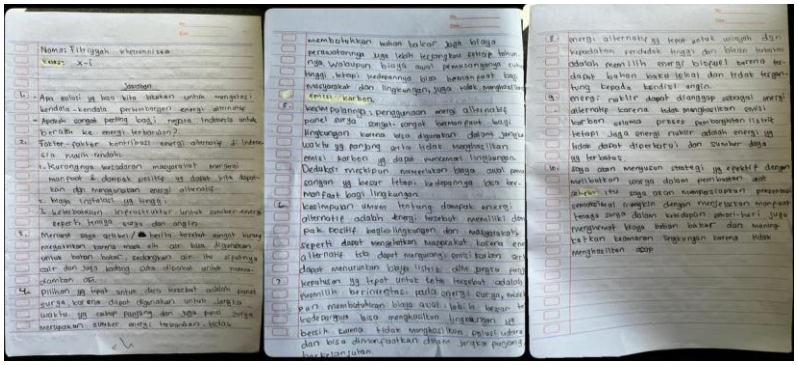

Figure 1. Highest student CTA answer

The CTA answer from one of the lowest scoring students. This image shows the students' handwritten form on the original answer sheet collected during the assessment. This document was used as part of the research data to analyze the variation of critical thinking ability among students.

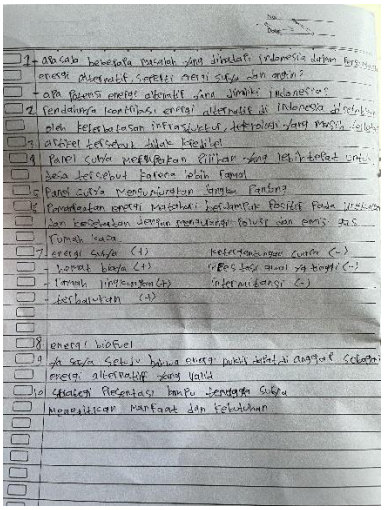

Figure 2. Lowest student CTA answer

The student with the highest score showed excellent critical thinking ability. In the elementary clarification indicator, he was able to identify problems and provide logical explanations related to the barriers to alternative energy development in Indonesia. In the basic support indicator, the student was able to provide an opinion accompanied by relevant and logical reasons for the content of the article. The ability to provide arguments with relevant and logical reasons is a characteristic of good critical thinkers (Abrami et al., 2015). While on the inference indicator, he can draw the right conclusions and consider various aspects of the impact of alternative energy. His ability is seen in the advanced clarification indicator, where he shows a deep understanding of the concept of nuclear energy as an alternative. Finally, in the strategies and tactics indicator, he was able to develop concrete strategies to overcome the problem through active community involvement. Overall, he obtained a perfect score of 20 out of the total maximum score, which is categorized as "very good".

On the other hand, the student with the lowest score showed low critical thinking performance. The answers given tended to be descriptive, less analytical, and did not show the ability to develop ideas or organize solutions systematically. In some indicators such as advanced clarification and inference, students did not provide adequate answers, and in other indicators there were still logical errors or answers that were too general. This student obtained a total score of 9 out of 20, which is in the "sufficient" category.

This comparison shows that although there are students who have been able to apply critical thinking thoroughly, there is still a need to strengthen critical thinking skills, especially for students in the lower middle category. Critical literacy-based learning strategies and open discussions can be one solution in improving this ability in the future.

This research also focuses on the critical thinking disposition aspect, which not only measures cognitive abilities, but also students' tendency to think critically. On Critical Thinking Disposition (CTD), the experimental group showed a significant increase. The experimental group's CTD pretest score was 45.11 with a standard deviation of 4.670, which increased to 70.34 on the posttest with a standard deviation of 10.392. In addition, research (Palavan, 2020) emphasized the importance of developing critical thinking dispositions through learning approaches that encourage curiosity and the desire to learn more. Compared to the control group who only experienced minimal changes, this shows the effectiveness of the Guided Inquiry model in developing critical thinking disposition. This finding is in line with previous research which shows that the Guided Inquiry model can improve students' critical thinking skills. For example, research(Maknun, 2020) showed that the application of the Guided Inquiry model significantly improved concept understanding and critical thinking skills of vocational high school students in Bandung, Indonesia.

Pearson correlation analysis revealed a strong and significant relationship between critical thinking ability and disposition. The correlation coefficient of 0.483 with a significance of $p < 0.001$ indicates that the increase in critical thinking ability is directly proportional to the increase in critical thinking disposition. Students who have a critical thinking disposition will be more sensitive to critical thinking activities, feel motivated to think critically, and have basic abilities in critical thinking even though the concept of ability is included in the disposition element. So a good critical thinker should not only show his cognitive skills but also will always try to equip himself with the attitude of critical thinking disposition. Research conducted by (Ennis, 2011) also confirms that critical thinking is a rational and reflective process, which focuses on making decisions about what should be believed or done, which is supported by a series of dispositions and critical thinking ability. These dispositions include openness to new evidence, intellectual curiosity, and commitment to logical reasoning.

Contemporary research in Bangladesh involving 109 students and 20 teachers showed that inquiry-based learning projects foster development of communication and collaboration skills, with notable gains in critical thinking and creativity skills (Rahman & McLaughlin, 2025). Our CTD improvement of 25.23 points aligns with recent findings from Peru showing that critical thinking disposition development programs significantly improve adolescents' analytical capabilities (Martínez-Huamán et al., 2025). Studies emphasize that group experiments foster community among students, improving learning environment and supporting critical thinking, communication, and teamwork abilities development (Dunbar-Morris, 2023).

This research also focuses on CTD aspects, measuring not only cognitive abilities but also students' tendency to think critically. On CTD, the experimental group showed significant increase from 45.11 (SD = 4.670) to 70.34 (SD = 10.392) on posttest. Research emphasizes the importance of developing critical thinking dispositions through learning approaches that encourage curiosity and desire to learn more (Martínez-Huamán et al., 2025). Compared to the control group experiencing minimal changes, this demonstrates the Guided Inquiry model's effectiveness in developing CTD.

Pearson correlation analysis revealed strong and significant relationship between CTA and CTD. The correlation coefficient of 0.483 with significance $p < 0.001$ indicates that increases in CTA are directly proportional to increases in CTD. Students with CTD are more sensitive to critical thinking activities, feel motivated to think critically, and possess basic critical thinking abilities. Research confirms that critical thinking is a rational and reflective process focusing on making decisions about what should be believed or done, supported by a series of dispositions and critical thinking abilities including openness to new evidence, intellectual curiosity, and commitment to logical reasoning (Spector, 2019).

4. CONCLUSION

The results showed that the Guided Inquiry learning model was effective in improving the ability and disposition of critical thinking of high school students in physics learning. This is shown through an increase in the average score in the experimental group, where the KBK score increased from 37.26 to 74.03 (98.7% increase) and the DBK score increased from 45.11 to 70.34 (55.9% increase). Statistical analysis through independent samples t-test showed significant differences between the experimental and control groups both before and after treatment. In addition, the effect size (Cohen's d) showed a substantial impact of the Guided Inquiry model on students' critical thinking ability.

A strong relationship was found between critical thinking ability and critical thinking disposition with a correlation coefficient of 0.483 ($p < 0.001$). This finding confirms that students who have a critical thinking disposition tend to show an increase in cognitive critical thinking ability. Thus, the application of the Guided Inquiry model not only improves students' critical thinking ability, but also fosters critical thinking attitudes and dispositions as a whole. Therefore, this model is worth considering as an effective learning approach in developing students' critical thinking in secondary education.

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AGM played an active role in all stages of the research, from proposal preparation, research implementation, data analysis, to article writing. RW and AII acted as supervisors who provided direction, input, and academic supervision during the research process and article writing.

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