

THE EFFECT OF GUIDED INQUIRY LEARNING MODEL ON STUDENTS' MATHEMATICAL CRITICAL THINKING ABILITIES

Ervina Farahnaz Simatupang¹, *Nurhanurawati², Agung Putra Wijaya³

^{1,2,3} Universitas Lampung, Indonesia

nurha.nurawati@fkip.unila.ac.id

ABSTRACT Mathematics is an abstract discipline that requires higher-order thinking skills, particularly mathematical critical thinking, to be meaningfully understood. However, students' mathematical critical thinking skills in Indonesia remain relatively low. This study aimed to examine the effect of the Guided Inquiry learning model on students' mathematical critical thinking skills. The population of this study consisted of all eighth-grade students at a junior high school in Lampung Province, totaling 192 students distributed across six classes (VIII-A to VIII-F). The sample was selected using a cluster random sampling technique, resulting in 25 students from class VIII-D as the experimental group and 27 students from class VIII-B as the control group. This study employed a pretest–posttest control group design. Quantitative data were collected through essay-type pretests and posttests. Based on the results of the hypothesis testing using the Mann–Whitney U test at a significance level of $\alpha = 0.05$, the median N-gain of students' mathematical critical thinking skills in the Guided Inquiry group was higher than that of students who experienced conventional learning. These findings indicate that the application of the Guided Inquiry learning model has a positive effect on improving students' mathematical critical thinking skills.

Keywords: guided inquiry, mathematical critical thinking, mathematics learning, junior high school

ABSTRAK Matematika merupakan disiplin ilmu yang bersifat abstrak sehingga menuntut kemampuan berpikir tingkat tinggi, khususnya kemampuan berpikir kritis matematis, untuk dapat dipahami secara bermakna. Namun, kemampuan berpikir kritis matematis peserta didik di Indonesia masih tergolong rendah. Penelitian ini bertujuan untuk mengetahui pengaruh model pembelajaran Guided Inquiry terhadap kemampuan berpikir kritis matematis siswa. Populasi penelitian ini adalah seluruh siswa kelas VIII di salah satu SMP di Provinsi Lampung yang berjumlah 192 siswa dan tersebar dalam enam kelas, yaitu VIII-A sampai VIII-F. Sampel penelitian ditentukan menggunakan teknik cluster random sampling, sehingga diperoleh 25 siswa dari kelas VIII-D sebagai kelompok eksperimen dan 27 siswa dari

kelas VIII-B sebagai kelompok kontrol. Penelitian ini menggunakan desain pretest–posttest control group. Data penelitian berupa data kuantitatif yang diperoleh melalui tes esai pada pretest dan posttest. Berdasarkan hasil uji hipotesis menggunakan uji Mann–Whitney U dengan taraf signifikansi $\alpha = 0,05$, diperoleh bahwa median N-gain kemampuan berpikir kritis matematis siswa yang mengikuti pembelajaran Guided Inquiry lebih tinggi dibandingkan dengan siswa yang mengikuti pembelajaran konvensional. Dengan demikian, penerapan model pembelajaran Guided Inquiry berpengaruh terhadap peningkatan kemampuan berpikir kritis matematis siswa.

Kata-kata kunci: guided inquiry, berpikir kritis matematis, pembelajaran matematika, sekolah menengah pertama

INTRODUCTION

Mathematics is a compulsory subject for students. As stated by Nurhanurawati et al. (2021), mathematics is a crucial subject taught in education. Although mathematics is mandatory in education, many students still find it difficult to learn. This is due to the abstract nature of mathematics, which requires students to have higher-order thinking skills to understand it (Marfu'ah et al., 2022). Higher-order thinking skills can be seen from students' cognitive abilities at the levels of analysis, synthesis, and evaluation (Naen et al., 2020). The ability that leads to students' capacity to understand concepts, combine, and evaluate the information they have acquired is critical thinking.

Critical thinking involves the process of searching for, acquiring, evaluating, and analysing information as guidance in developing one's thinking, as well as the ability to use information to enhance creativity and take risks (Samosir, 2018). The ability to think critically is general and applied in various fields, while the ability applied in the context of mathematics is known as mathematical critical thinking. This ability is understood as the capability to describe, connect, analyse, evaluate, and solve mathematical problems (Haeruman et al., 2017). By possessing mathematical critical thinking skills, students will become individuals who can face the challenges and issues of mathematics by integrating their existing knowledge and organising ideas using logical reasoning.

However, currently, the critical thinking skills of Indonesian students in mathematics are still very low. This is evident from the results of the Trends in International Mathematics and Science Study (TIMSS). The questions tested in TIMSS not only require the use of formulas, but students also need critical thinking skills to solve these questions. The average percentage of correct answers for Indonesian students in the reasoning domain in 2015 was far below the average international percentage of correct answers, namely the Indonesian percentage of 20% while the international percentage was 44%. Reasoning is one of the important domains in students' critical thinking skills. Because reasoning itself is a logical thinking activity to gather facts, organize, analyze, explain, and conclude (Agustin, 2016). Thus, it can

be said that the critical thinking skills of Indonesian students in mathematics are still low.

This can also be seen from the results of the Programme for International Student Assessment (PISA). The OECD (2023) states that in the mathematics assessment, only 18% of Indonesian students reached at least level 2, while the OECD average for that level is 69%. Fauzi & Abidin (2019) mention that to solve PISA questions, students need to use their reasoning skills. Students who possess this ability should be able to apply their knowledge in unfamiliar situations, or what can be referred to as critical thinking skills (Lestari & Annizar, 2020). The PISA results indicate that the mathematical critical thinking abilities of Indonesian students are still low.

The low critical thinking skills of students are also evident from the results of a preliminary research test conducted at a junior high school in Bandar Lampung on July 24, 2024. This test consisted of two questions given to 32 eighth-grade students. After the questions were given to the 32 students, it turned out that none of them were able to answer the questions correctly, and the scores obtained were below 50. The following is an example of a student's incorrect answers in the test.

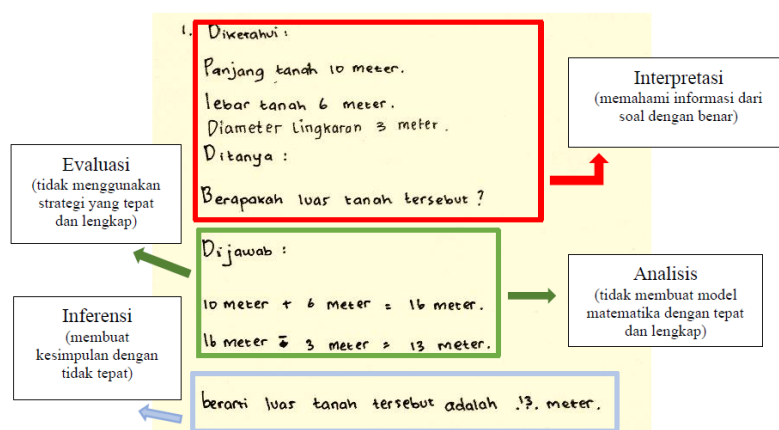


Figure 1. Examples of Student Answer Errors

During the preliminary research, interviews were also conducted with one of the mathematics teachers at SMPN 33 Bandar Lampung who teaches in the eighth grade. The teacher stated that he uses the lecture method in his teaching process. When problems are presented, most students still struggle to connect the relationship between the problems and calculation, have difficulty choosing strategies for solving the problems, and the conclusions they reach tend to be incorrect. As a result, many of them choose not to complete the assigned problems, and they will find it difficult to develop their mathematical critical thinking skills.

Based on the interview results, it can be said that one of the factors contributing to the low mathematical critical thinking skills of students is the learning model used by teachers, which is inadequate. The teacher still delivers the material through lectures and is teacher-centred, causing students to not take an active role in learning. As a result, students become passive in the learning process and their

learning outcomes will be less than optimal (Yanuar & Pius, 2023). Hutagalung et al. (2023) also stated that a teacher-centred learning model makes it difficult for students to develop higher-order thinking skills such as critical thinking.

To address this issue, an appropriate learning model is required to develop students' mathematical critical thinking skills. Noer & Gunowibowo (2018) argue that the selection of the right learning model will help students to be more active in their learning. In order for students to be active in learning, teachers need to make students the centre of the learning process, so their mathematical critical thinking skills can develop. This is in line with the opinion expressed by Rahayu & Dewi (2022), that the learning process requires a classroom learning situation that enables students to develop their mathematical critical thinking skills through several student-centred learning stages.

One student-centered learning model is Guided Inquiry. The Guided Inquiry model is a student-centered learning model that makes students active in learning. Students are trained and required to be able to think independently and can conclude the core of the material based on information provided by the teacher. The teacher's role here is as a facilitator, the teacher helps and answers questions from students who find it difficult to solve problems (Rizal et al., 2017). In line with what was stated by Khomaidah & Koeswanti (2020), Guided Inquiry learning activities actively involve students in seeking information, then investigating critically and systematically, so that students can formulate what they find through the guidance of an educator. By using the Guided Inquiry model, students can analyze, formulate problems, evaluate issues, and draw conclusions from their findings, which are indicators of students' mathematical critical thinking skills.

Based on the background that has been explained, it is necessary to conduct research on whether the Guided Inquiry learning model has an effect on students' mathematical critical thinking abilities.

METHODS

This research employs a quantitative approach. This approach involves the use of numbers throughout the process, from data collection, interpretation of the data, to the presentation of the results (Jayusman & Shavab, 2020). This study is a quasi-experimental research, which aims to determine the effect of one variable on another, similar to a real experiment. The variables in this study consist of one independent variable and one dependent variable. The independent variable is the learning model, while the dependent variable is the mathematical critical thinking.

The research design used in this study is a pretest-posttest control group design. The researchers administered a pretest to determine the students' initial mathematical critical thinking ability and a posttest to assess their mathematical critical thinking skills after treatment. In this design, there are two sample groups involved. This aligns with what was stated by Abdullah et al. (2022) as presented in Table 1.

Table 1. Pretest-Posttest Control Group Design

Class	Pretest	Treatment	Posttest
Experiment	O1	X1	O2
Control	O1	X2	O2

Description:

O1 : pretest of mathematical critical thinking skills

O2 : posttest of mathematical critical thinking skills

X1 : Learning using the Guided Inquiry learning model

X2 : Conventional learning

The population of this study was 192 eighth-grade junior high school students in Bandar Lampung in the 2024/2025 academic year, consisting of six classes, namely VIII-A to VIII-F. Of the six classes, two classes were selected as research samples using cluster random sampling techniques, namely random sampling from a population that has similar abilities (Sugiyono, 2013). The selected classes were VIII-D with 25 students as the experimental class and VIII-B with 27 students as the control class. In the experimental class, the learning model used was the Guided Inquiry model, while the control class used conventional learning.

This research has a procedure that consists of three stages: the preparation stage, the implementation stage, and the final stage. In the preparation stage, an initial observation is conducted to determine the number of students, the curriculum, the teaching methods used in the class, and the mathematical critical thinking skills of the students at the school. In this stage, the researcher also determines the research population and sample, the materials to be used, the proposal writing, the research test instruments, the validation and trial of the test instruments, as well as analysing the data from the trial tests. In the implementation stage, a pretest is conducted to measure the mathematical critical thinking skills of students in the experimental and control classes, followed by the delivery of the learning material and conducting a posttest. In the final stage, statistical processing and analysis of the data is carried out along with the preparation of the report.

The testing instrument in this study consists of essay questions used to measure students' mathematical critical thinking skills. The questions consist of three essays focused on circles. The test was administered to students in both the experimental and control classes individually before and after the treatment. The pretest and posttest used the same test instrument. The test instrument grid was developed based on indicators of mathematical critical thinking skills. Question items and answer keys were created based on the grid, with each question containing indicators of students' mathematical critical thinking skills. To obtain accurate data, this research meets the criteria for a good test, which includes validity, reliability, discriminatory power, and difficulty level.

The data in this study were obtained from pretest and posttest scores used to measure the improvement (N-Gain) in students' mathematical critical thinking abilities in the experimental and control classes. The data were analyzed using statistical tests on the N-Gain scores of mathematical critical thinking abilities. Before the test was carried out, a prerequisite test was conducted, namely the normality test. The results of the normality test in this study showed that the N-Gain data of students' mathematical critical thinking abilities came from a population that was not normally distributed, so a hypothesis test was conducted using nonparametric statistics, specifically the Mann Whitney U test.

FINDING AND DISCUSSION

Baseline Data on Students' Mathematical Critical Thinking Skills

The first analysis conducted was on the baseline data of the mathematical critical thinking abilities of students in the experimental and control classes, obtained from the students' pre-test scores. Based on the collected data, the initial data on students' mathematical critical thinking abilities is presented in Table 2.

Table 2. Baseline Data on Students' Mathematical Critical Thinking Skills

Class	Number of Students	Lowest Score	Highest Score	Average	Standard Deviation
Experiment	25	1	14	5,96	5,47
Control	27	1	35	15,52	11,36

Maximum Score: 48

Based on Table 2, there are differences in the average and standard deviation of the initial data of students' mathematical critical thinking abilities in the experimental class compared to the control class. It can be seen that the initial data of the students' mathematical critical thinking abilities in the control class is more varied than in the experimental class.

Final Data on Students' Mathematical Critical Thinking Skills

The second analysis conducted was on the final data of the mathematical critical thinking abilities of students in the experimental and control classes, obtained from the students' post-test scores. Based on the data that has been collected, the final data on students' mathematical critical thinking abilities is presented in Table 3.

Table 3. Final Data on Students' Mathematical Critical Thinking Skills

Class	Number of Students	Lowest Score	Highest Score	Average	Standard Deviation
Experiment	25	12	45	35,60	8,12
Control	27	6	39	20,67	13,26

Maximum Score: 48

Based on Table 3, there are differences in the average and standard deviation of the final data on students' mathematical critical thinking skills in the experimental class compared to the control class. It can be seen that the final data on the mathematical critical thinking skills of students in the control class is more varied compared to the experimental class.

N-Gain Data on Students' Mathematical Critical Thinking Skills

After analysing the initial and final data on students' mathematical critical thinking skills, a subsequent analysis of students' N-Gain data obtained from the pretest and posttest results was conducted. This data was used to determine the improvement in the mathematical critical thinking skills of students in the experimental class and the control class. The students' N-Gain data is presented in Table 4.

Table 4. N-Gain Data on Students' Mathematical Critical Thinking Skills

Class	Number of Students	Lowest N-Gain	Highest N-Gain	Average	Standard Deviation
Experiment	25	0,2	0,9	0,70	0,19
Control	27	-0,1	0,6	0,20	0,21

Based on Table 4, there are differences in the average and standard deviation of the N-Gain data of students in the experimental class compared to the control class. It can be seen that the N-Gain data of the mathematical critical thinking ability of students in the control class is more varied compared to the experimental class.

Analysis of the Results of Hypothesis Testing on Students' Mathematical Critical Thinking Skills

Based on prerequisite tests, namely normality tests and homogeneity tests, it was obtained that the N-Gain data on students' mathematical critical thinking abilities from the experimental and control classes originated from a population that is not normally distributed. Therefore, the hypothesis test conducted is the Mann Whitney U test. The results of the Mann Whitney U test calculations for the students' N-Gain data are presented in Table 5.

Table 5. Mann-Whitney U Test N-Gain

Class	Number of Students	$ z_{count} $	z_{table}	Conclusion
Experiment	25	5,64	1,96	H_0 rejected
Control	27			

Based on Table 5, it is evident that $|z_{count}| > z_{table}$ thus H_0 is rejected. herefore, a follow-up test is conducted to ascertain the highest increase from the two data sets by examining the average rank of the highest data. The experimental class rank is obtained as $38.76 >$ the control class rank of 16.36 , leading to the conclusion that

the median of the N-Gain of students' mathematical critical thinking skills who participated in the Guided Inquiry model is higher than the median of the N-Gain of students' mathematical critical thinking skills who participated in conventional learning. This indicates that the improvement in mathematical critical thinking skills among students in the class using the Guided Inquiry model is greater than that of students in the conventional learning environment.

The results of the hypothesis testing are also supported by the achievement results of the students' mathematical critical thinking ability indicators. This is conducted to determine the extent of the students' achievement in mathematical critical thinking ability for each indicator. Analysis was performed on the pretest and posttest data. The calculation results are presented in Table 6.

Table 6. Analysis of Achievement of Mathematical Critical Thinking Indicators

Indicator	Experimental		Increase	Control		Increase
	Initial	Final		Initial	Final	
Interpretation	24,7%	93,7%	69%	54,3%	65,1%	10,8%
Analysis	6%	78,3%	72,3%	34%	43,8%	9,8%
Evaluation	11%	71,3%	60,3%	36,1%	42,9%	6,8%
Inference	8%	53%	45%	6,2%	20,4%	14,2%

Based on Table 6, each indicator of mathematical critical thinking ability in both the experimental and control classes showed improvement. The improvement of each indicator of mathematical critical thinking ability in the experimental class was higher compared to the control class.

The results of the hypothesis testing indicate that the improvement in students' mathematical critical thinking skills using the Guided Inquiry model is higher compared to students using the conventional model. This aligns with the research conducted by Danisa et al. (2017) and Waleulu et al. (2023), which found that the improvement in students' mathematical critical thinking skills using the Guided Inquiry model is greater than that of students using the conventional model. This occurs because in the learning process with the Guided Inquiry model, students are engaged in discovering several concepts and principles used to draw conclusions.

The highest increase in the indicator of students' mathematical critical thinking skills using the Guided Inquiry model is observed in the analysis section, at 72.3%. This happens because students are able to create mathematical models using information from the problem. Students who are able to create mathematical models do so because during the learning process with the Guided Inquiry model, they effectively follow the stages of formulating problems and hypotheses. In line with Widiyowati (2015), students who master the analysis indicator can formulate problems by identifying the relationships between statements and concepts in

solving issues, which involves transforming word problems into mathematical models.

The lowest increase in the indicator of students' mathematical critical thinking ability using the Guided Inquiry model was observed in the inference section, with an increase of 45%. This occurred because many students made incorrect conclusions due to errors in calculation. In line with what was stated by Rani et al. (2018), students who completed problems but with incorrect calculations will affect subsequent solutions, particularly in the summarising section. Another cause of the low increase in students' inference indicators is that students are unable to make conclusions when they are at the conclusion-formulating stage in the Guided Inquiry model. According to Tanzimah & Sutrianti (2023), the low increase in the inference indicator is due to students lacking the skills to formulate conclusions because they are not yet accustomed to summarising what they have obtained.

The Guided Inquiry learning model involves students significantly in the learning process with the guidance of teachers. In this learning process, the stages of the Guided Inquiry model encourage students to engage their brain's activity in problem-solving. The first stage is orientation. Students' responses indicate that they are beginning to understand and digest the initial information present in the student worksheets. This suggests that the interpretative indicators of students' mathematical critical thinking skills are improving. By going through this stage, the learning process proceeds well because after understanding the information in the worksheets, students' curiosity increases and they become more focused on learning. Consistent with what Latiifani et al. (2016) stated, the stages of Guided Inquiry learning can foster students' curiosity.

The next stage is the second phase, which is formulating the problem. The answers provided by the students show that their ability to analyse the components of the issues faced in order to formulate problems is beginning to develop. This stage encourages students to think scientifically so that they focus on the process rather than just the end result (Maisitoh et al., 2017). This means that the analysis indicators of students' mathematical critical thinking skills are experiencing improvement.

The third stage involves formulating hypotheses. Students' responses indicate that their ability to draw initial conclusions based on available information is beginning to develop. This means that the indicators of inference and analysis in students' critical thinking skills are starting to improve. In line with what Maisitoh et al. (2017) stated, this stage trains students' inferential and analytical aspects because during the process, students analyse the opinions of each group member, and then they establish initial assumptions based on the information that has been analysed.

The fourth stage involves gathering information or data. At this stage, students play an active role in learning. According to Setiowati et al. (2015), the Guided Inquiry model provides opportunities for students to be actively engaged in learning, making classroom experiences more meaningful. Based on observations, students

collaboratively completed worksheets to find information and then solved problems given to prove the validity of their initial hypotheses. Students' answers indicate that their ability to organize and analyse information is beginning to improve. This suggests that the indicators of interpretation and analysis in students' mathematical critical thinking skills are experiencing enhancement.

The fifth stage is testing the hypothesis. At this stage, students test whether the hypothesis they formulated aligns with the data that has been collected. Based on observations, students in groups evaluate the suitability of the initial hypothesis they formulated. The teacher monitors students during the hypothesis testing and provides reinforcement to the students. Students' responses indicate that their evaluation skills have improved, as they can assess the validity of the hypothesis based on the data they have analysed. This means that the indicators of student evaluation have shown improvement. As Munandar (2009) states, activities involving evaluation, exchanging opinions, and sharing knowledge can enhance students' mathematical critical thinking skills.

The final stage is to formulate conclusions. Students' answers indicate that their ability to evaluate and draw conclusions has improved. This means that the indicators for students' evaluation and inference have shown progress. As Maisitoh (2017) stated, this stage trains students' critical thinking ability in inference, as in the process, students actively work in groups using their knowledge to evaluate their work results to draw conclusions. Bahri et al. (2016) also stated that the inquiry model can make students active in formulating problems, analysing the results they encounter, and drawing conclusions from what they have worked on.

In the implementation of learning with the Guided Inquiry model, there are several obstacles encountered, namely in the first meeting during the orientation stage, only a few students were active in the learning process. Then, in the stage of formulating hypotheses, only two groups provided initial guesses, while the others merely copied. At the data collection stage, only one group actively asked the teacher about things they did not understand, while the other groups simply waited for answers from the questioning group. Then, at the hypothesis testing stage, all groups whose initial guesses were incorrect replaced those guesses with the correct answers. This indicates that students are only focused on getting the answer right. Aristianti et al. (2018) stated that students who use the guided inquiry model are able to write their findings or problem-solving results systematically and completely. Based on this opinion, the reason for the obstacles encountered is that students are not yet accustomed to using the Guided Inquiry model in learning.

To address this issue, the teacher explained to the students that the most important aspect of learning is understanding the material being studied, and that group assessment is viewed based on how the students approach problems to reach the conclusions they have obtained, rather than from the correctness or incorrectness of their initial assumptions. As stated by Kartika & Rakhmawati (2022), in inquiry-

based learning, the processes to be considered include formulating problems and hypotheses, acquiring information, identifying assumptions, seeking solutions, evaluating, and concluding what has been discovered. After understanding the system of the Guided Inquiry learning model, the students participated well in the lessons from the second meeting until the end without cheating. The students, in groups, were able to follow the stages of learning well and orderly, actively ask questions, and confidently present their group work results without fear of receiving low grades. Even the students compete to finish the worksheets to earn extra marks from the teacher for solving the problems quickly and accurately.

Unlike students who are treated with conventional teaching. In the first stage (orientation), some students listened and answered the teacher's questions, while others just stayed silent and listened to their classmates. In the second stage (demonstration), no students actively asked questions and only received explanations from the teacher without wanting to delve deeper into the material. In the third stage (guided practice), only a few students were interested in working on the exercises while the others simply waited for the final results from those who completed the tasks. During the stage of checking students' understanding and providing feedback, no students were eager to present their work. The teacher chose one student representative to present their work and provided feedback by explaining the issues that still hindered their completion of the exercises. In the final stage, which is independent practice, the teacher assigns independent tasks to students as a reinforcement of material understanding. Based on observations, students' work results are still below average.

During the five conventional learning sessions, students tended to only listen to the teacher and did not actively ask questions during the lesson. This led to most students not fully understanding the information provided. Students also struggled to tackle problems of different types compared to the examples given and to draw conclusions. As a result, the improvement in the students' mathematical critical thinking skills in that class was not very high.

Based on the discussion above, the achievement of the Guided Inquiry learning model can enhance students' mathematical critical thinking skills. According to the analysis of the percentage achievement of indicators of students' mathematical critical thinking skills, it shows that students who follow the Guided Inquiry learning model have a higher improvement compared to those who follow the conventional model. The reason is that the learning stages allow students to discover concepts independently with the guidance of the teacher and to understand information well, so that the material is retained for a long time and they are able to solve various problems because they have mastered the material. Charolina et al. (2022) in their research also state that the implementation of the Guided Inquiry learning model has a positive impact on improving students' mathematical critical thinking skills in schools.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of research and discussions, the Guided Inquiry learning model has an impact on the critical mathematical thinking ability of eighth-grade students at SMPN 33 Bandar Lampung in the second semester of the 2024/2025 academic year. This is evident from the greater improvement in the critical mathematical thinking ability of students participating in the Guided Inquiry learning model compared to those using the conventional model.

Recommendations that can be given are for teachers who want to understand the effects of the Guided Inquiry learning model to measure students' critical mathematical thinking abilities, as the stages in this model can enhance students' critical thinking skills. For other researchers who wish to conduct studies using the Guided Inquiry model, it is recommended to use LKPD as it greatly aids students' thinking processes through its stages.

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