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IMPLEMENTATION OF THE GUIDED INQUIRY LEARNING MODEL TO IMPROVE SCIENTIFIC REASONING ON VIRUS MATERIAL FOR GRADE X STUDENTS AT SMA NEGERI 7 PEKANBARU

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ABSTRACT

Twenty-first-century learning requires students to possess higher-order thinking skills, one of which is scientific reasoning. The low level of students' scientific reasoning is caused by learning processes that are still teacher-centered, resulting in students being less active in developing scientific thinking skills. This study aimed to determine the improvement of students' scientific reasoning abilities through the implementation of the guided inquiry learning model. This study employed a quasi-experimental method with a pretest–posttest control group design. The research samples were classes X.7 and X.8, selected using purposive sampling techniques. The guided inquiry learning model supported by PowerPoint instructional media was applied in the experimental class during the learning process, while the control class used the discovery learning model. The research instruments consisted of a scientific reasoning test and observation sheets. The results showed that the average posttest score of the experimental class reached 88.75%, categorized as scientific reasoning, while the control class reached 69.19%, categorized as moderate scientific reasoning. The N-gain test results indicated that the level of scientific reasoning in the experimental class was in the effective category (0.74), higher than that of the control class (0.60). The data were analyzed using an independent samples t-test, yielding a significance value (2-tailed) of 0.000 < 0.05. Thus, the implementation of the guided inquiry learning model was proven to have a significant effect on improving students' scientific reasoning on virus material.

Keywords: Guided Inquiry; Scientific Reasoning; Biology; Viruses.

INTRODUCTION

The learning process in science education is a series of activities that guide students in the learning process to gain experiences and achieve learning objectives optimally. Education plays a role in improving the quality of a nation's human resources by teaching various fields of knowledge to learners. In the current era of globalization, education is required to develop students' skills that are relevant to the 21st century, one of which is critical thinking skills. Included in critical thinking skills are scientific reasoning, systematic thinking, computational thinking, decision-making, and problem-solving. Mastery of 21st-century skills, which refer to both knowledge and skills, is essential for students to adapt and live in the era of globalization. One of the important skills that must be mastered in learning is scientific reasoning ability.

Scientific reasoning is an individual's ability to draw conclusions based on the evidence obtained. Scientific reasoning is one of the important factors in science learning, and its development has become a fundamental goal of science education at all levels of education. However, in reality, the results of the Trends in International Mathematics and Science Study (TIMSS) survey in 2015 showed that Indonesia ranked 44th out of 49 countries in the science domain, with an average score of 397 compared to the international average score of 500. Based on TIMSS criteria, achievement levels are divided into four categories: low (400), intermediate (475), high (550), and advanced (625). Based on these results, Indonesia is categorized at the low level. Scientific reasoning is one of the 21st-century skills expected to be applied in science classrooms as an effort to prepare students to face the challenges of globalization. On the other hand, scientific reasoning contributes to students' cognitive skills; however, research identifying scientific reasoning abilities, particularly in science subjects, is still limited (Aini et al., 2018).

Similar problems were also found at SMA Negeri 7 Pekanbaru. Based on teacher interviews and preliminary tests of students' scientific reasoning abilities, students still experienced difficulties in various indicators of scientific reasoning. Initial scores indicated that the indicators of control of variables reasoning and correlational reasoning were categorized as low scientific reasoning, while proportional reasoning, hypothetical-deductive reasoning, and probabilistic reasoning were categorized as moderate scientific reasoning. The overall average of scientific reasoning was classified as moderate, indicating that students' scientific reasoning abilities in biology learning still need to be improved. One of the Grade X biology topics that requires scientific reasoning skills is viruses. This topic involves several aspects of scientific reasoning, including the ability to argue, problem-solving skills, logical thinking skills, and reasoning related to conceptual understanding. Therefore, a learning model that is capable of improving and is closely related to students' scientific reasoning abilities is needed.

Efforts to improve students' scientific reasoning abilities require the implementation of a learning model that actively involves students in the learning process. One relevant learning model is the guided inquiry learning model. This model emphasizes the process of scientific investigation through problem identification, question formulation, data collection and analysis, and drawing conclusions with teacher guidance. According to Putra et al. (2022), guided inquiry provides systematic direction for students in conducting investigations, thereby helping them develop scientific thinking skills. In line with this, Shofiyah et al. (2019) stated that guided inquiry learning is effective in improving scientific reasoning because it encourages students to construct new understanding through the application of knowledge in different contexts. Therefore, this study was conducted under the title "Implementation of the Guided Inquiry Learning Model to Improve Scientific Reasoning on Virus Material for Grade X Students at SMA Negeri 7 Pekanbaru".

RESEARCH METHODS

This study is a quantitative study employing a quasi-experimental method with a pretest–posttest control group design to determine the effect of the guided inquiry learning model on students' scientific reasoning abilities. The population of the study consisted of all Grade X students at SMA Negeri 7 Pekanbaru. The research sample was selected using a purposive sampling technique based on considerations of homogeneous academic ability, stable learning conditions, and suitable learning schedules. The sample comprised two classes, namely class X.7 as the experimental group and class X.8 as the control group. The experimental group implemented the guided inquiry learning model assisted by PowerPoint media provided by the teacher, while the control group used the discovery learning model.

The independent variable in this study was the guided inquiry learning model, while the dependent variable was students' scientific reasoning ability. Data collection instruments consisted of a scientific reasoning ability test and observation sheets using a rating scale. The scientific reasoning test instrument had undergone validity and reliability testing. The validity test results indicated that all test items were valid at a 5% significance level. The reliability test showed a reliability coefficient of 0.818, indicating that the instrument was reliable and appropriate for use as a data collection tool. In addition, the item difficulty analysis revealed that 19 items were categorized as moderate and 6 items as difficult, while the item discrimination index was in the high category, indicating that the instrument was able to measure scientific reasoning ability optimally.

The research was conducted through three main stages: the preparation stage, the implementation stage, and the reporting stage. The preparation stage involved the development of guided inquiry-based learning materials and the validation of research instruments. The implementation stage included administering the pretest, conducting learning activities using PowerPoint media in the experimental group and the discovery learning model in the control group, observing scientific reasoning abilities during the learning process, and administering the posttest. The reporting stage involved data processing, analysis of research results, and drawing conclusions.

Data were analyzed using quantitative analysis techniques with SPSS version 26. Scientific reasoning ability was analyzed by calculating the percentage of achievement for each scientific reasoning indicator and computing the normalized gain (N-gain) to determine the improvement in students' scientific reasoning abilities. Prior to hypothesis testing, prerequisite tests were conducted using the Shapiro–Wilk normality test and the homogeneity of variance test. Subsequently, hypothesis testing was performed using the Independent Samples t-test at a 5% significance level to determine differences in scientific reasoning abilities between the experimental and control groups.

RESULTS AND DISCUSSION

Results

Results of Instrument Feasibility Testing

The research instrument used was a scientific reasoning ability test consisting of 25 items. Prior to its use, the instrument was tested for feasibility, which included validity, reliability, item difficulty level, and item discrimination. The results of the instrument feasibility testing are presented in Table 1.

Table 1. Results of the Feasibility Test of the Scientific Reasoning Test Instrument

Instrument Testing Aspect	Test Result
Item validity	All items are valid
Instrument reliability	Reliable (α = 0,818)
Difficulty level	19 moderate items; 6 difficult items
Item discrimination	High category

Based on the results of the instrument feasibility test shown in Table 1, all items of the scientific reasoning test were declared valid and therefore suitable for measuring students' scientific reasoning ability. The reliability test results showed a coefficient value of 0.818, which falls into the high reliability category. In addition, the item discrimination index was in the high category, indicating that the instrument is able to optimally distinguish between students with high and low levels of scientific reasoning ability.

Scientific Reasoning Ability Based on Pretest–Posttest

Pretest and posttest data were analyzed to examine students' scientific reasoning ability in each class. The results of the analysis of students' scientific reasoning ability in the experimental and control classes are presented in Table 2.

Table 2. Pretest and Posttest Results of Students' Scientific Reasoning Ability

Class	Mean Pretest (%)	Category	Mean Posttest (%)	Category
Control	31,87	Very low scientific reasoning	69,19	Scientific reasoning
Experimental	39,12	Very low scientific reasoning	88,75	Scientific reasoning

Based on the data in Table 2, the average initial scientific reasoning ability of students in both the control and experimental classes was in the very low scientific reasoning category, with pretest scores of 31.87% and 39.12%, respectively. This indicates that the initial abilities of both classes were relatively low and at comparable levels before the treatment was implemented. After the learning process, the average posttest scores in both classes increased. The control class obtained an average posttest score of 69.19%, which falls into the scientific reasoning category, while the experimental class achieved an average posttest score of 88.75%, also in the scientific reasoning category. The greater improvement in the experimental class indicates that the implementation of the guided inquiry learning model is more effective in improving students' scientific reasoning ability compared to the learning conducted in the control class.

Scientific Reasoning Ability Based on Observation Results

Observation data were obtained from two observers, namely a biology teacher and a university student. The observation results in each class are presented in Table 3.

Table 3. Observation of Students' Scientific Reasoning Ability

Class	Mean	Category
Control	60,68	Moderate scientific reasoning
Experiment	78,16	Scientific reasoning

Based on Table 3, the observation results of students' scientific reasoning ability show differences between the control and experimental classes. The control class obtained an average observation score of 60.68, which falls into the moderate scientific reasoning category. Meanwhile, the experimental class obtained an average observation score of 78.16, which falls into the scientific reasoning category. These results indicate that students' scientific reasoning ability in the experimental class is better than that in the control class, suggesting that the implementation of the guided inquiry learning model is able to encourage students' engagement and scientific thinking activities more optimally during the learning process.

N-gain Test

The analysis of the improvement in students' scientific reasoning ability was conducted by calculating the normalized gain (N-gain) values based on the average pretest and posttest scores in the experimental and control classes. The results of this analysis are presented in Table 4.

Table 4. N-gain Test Results

Class	Mean Pretest	Mean Posttest	N-gain	Category
Control	31,87	69,19	0,55	Moderately effective
Experiment	39,12	84,75	0,74	Effective

Based on Table 4, the results of the normalized gain (N-gain) test indicate that the improvement in students' scientific reasoning ability in the experimental class is higher than that in the control class. The experimental class obtained an N-gain value of 0.74, which falls into the effective category, while the control class obtained an N-gain value of 0.55, categorized as moderately effective. The difference in N-gain values indicates that the implementation of the guided inquiry learning model is more effective in improving students' scientific reasoning ability compared to the learning conducted in the control class.

Hypothesis Testing

Based on the results of the prerequisite tests conducted on the pretest and posttest data of each class, the data were found to be normally distributed and to have homogeneous variances. Therefore, the hypothesis testing was carried out using the Independent Samples T-Test with a significance level of < 0.05. If the significance level is < 0.05, the hypothesis is accepted. The results of the hypothesis testing are presented in the following table.

Table 5. Results of Hypothesis Testing (Independent Samples T-Test)

Independent Sample Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Different
Posttest	Equal variances assumed	8.540	62	0.000	21.000
	Equal variansces not assumed	8.540	58.443	0.000	21.000

Based on the results of hypothesis testing using the independent samples t-test in Table 5, a significance value (2-tailed) of 0.000 < 0.05 was obtained, with a calculated t-value greater than the t-table value (8.540 > 1.999). This indicates that there is a significant difference between the mean posttest scores of students' scientific reasoning ability in the experimental class and the control class. Therefore, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted, confirming that the implementation of the guided inquiry learning model has a significant effect on improving the scientific reasoning ability of Grade X students at SMA Negeri 7 Pekanbaru.

Discussion

Instrument Feasibility Testing

The results of the instrument feasibility testing indicate that the 25 test items met the criteria for validity, reliability, difficulty level, and item discrimination. The validity test of the scientific reasoning items showed that all items were valid, indicating that each item was appropriate for measuring the construct of students' scientific reasoning. A valid instrument ensures that the measured scientific reasoning ability truly represents students' scientific thinking abilities both conceptually and empirically (Azwar, 2020). The reliability test results showed a coefficient value of 0.818, which falls into the high reliability category, indicating that the instrument has good internal consistency and is capable of producing stable and trustworthy data in measuring improvements in students' scientific reasoning ability (Fraenkel et al., 2019).

The analysis of item difficulty revealed that most items were categorized as moderate and difficult, allowing the instrument to measure scientific reasoning ability across various levels of student ability. Items with moderate and high difficulty levels encourage students to engage in higher-order thinking processes, such as analyzing, interpreting data, and drawing evidence-based conclusions, which are central to scientific reasoning (OECD, 2019). In addition, the high category of item discrimination indicates that the instrument is able to effectively distinguish between students with high and low scientific reasoning abilities. An instrument with good discrimination power is essential in educational research because it can clearly demonstrate improvements in students' scientific reasoning ability after the learning process (Retnawati, 2021). Therefore, the test instrument used is considered feasible and effective as a measurement tool to assess and support the improvement of students' scientific reasoning ability in biology learning.

Indicators of Scientific Reasoning

Students' scientific reasoning was measured through five indicators: proportional reasoning, control of variables reasoning, hypothetical-deductive reasoning, correlational reasoning, and probabilistic reasoning. The results showed that the average posttest and observation scores in the experimental class using the guided inquiry learning model increased compared to those in the control class. This finding is in line with Diani et al. (2020), who stated that guided inquiry learning encourages students to build deep conceptual understanding through structured investigative processes. These processes directly train scientific reasoning skills, particularly in controlling variables and constructing logical reasoning based on observational results.

For the proportional reasoning indicator, the improvement in students' abilities was evident in their capacity to understand proportional relationships between variables, such as the relationship between the number of virus particles and the level of spread. Through guided inquiry activities, students were trained to analyze data, compare quantities, and interpret information quantitatively.

This aligns with Zimmerman (2020), who stated that proportional reasoning skills develop optimally when students are directly involved in data analysis and context-based scientific problem solving.

The control of variables indicator also showed improvement because students were guided to identify independent, dependent, and control variables during the investigation process. In guided inquiry learning, teachers provide gradual guidance, enabling students to understand the role of each variable in a scientific phenomenon. This finding is consistent with the study by Sampson et al. (2019), which stated that inquiry-based learning can improve students' ability to control variables through systematic investigative activities. For the hypothetical-deductive reasoning indicator, students demonstrated improvement in formulating hypotheses and drawing conclusions based on observational data. The guided inquiry model encourages students to develop tentative explanations and test them logically, particularly in virus-related topics that require evidence-based reasoning. This is consistent with the findings of Minner et al. (2020), who emphasized that inquiry learning plays an important role in training deductive thinking and hypothesis testing skills in science learning.

Improvements in the correlational reasoning indicator indicate that students were able to understand relationships between variables without directly inferring causal relationships. Data analysis activities and group discussions in guided inquiry learning provided opportunities for students to interpret intervariable relationships more deeply. This is supported by Furtak et al. (2021), who stated that inquiry approaches encourage students to develop skills in analyzing relationships between variables through data exploration.

Meanwhile, for the probabilistic reasoning indicator, the improvement in students' abilities was reflected in their capacity to predict the likelihood of an event occurring based on available data, such as the probability of virus transmission under certain conditions. Guided inquiry learning trains students to consider uncertainty and make decisions based on probability, which is an important characteristic of 21st-century scientific reasoning. This is in line with the National Research Council (2018), which emphasized the importance of probabilistic reasoning in science learning to address real-world problems.

Overall, the findings of this study reinforce previous research showing that the guided inquiry learning model is effective in improving all five indicators of students' scientific reasoning. Students' active involvement in the processes of investigation, data analysis, and drawing conclusions makes biology learning, particularly on virus topics, more meaningful and capable of optimally developing scientific thinking skills. In addition, the effectiveness of the guided inquiry learning model in improving scientific reasoning is consistent with the findings of Lubis & Hakim (2022) and Suyatna (2022), which showed that guided inquiry approaches significantly improve students' scientific reasoning compared to conventional learning.

The Relationship Between Scientific Reasoning Ability and the Guided Inquiry Learning Model

The results of the study indicate that the implementation of the guided inquiry learning model has a positive effect on improving students' scientific reasoning ability in virus-related material. This improvement is evident in the posttest results, N-gain scores, and observation data, which show that the experimental class achieved higher outcomes than the control class. These findings indicate that guided inquiry learning is more effective in developing students' scientific thinking skills.

The guided inquiry learning model emphasizes active student involvement in the learning process through structured scientific investigation stages, including observing phenomena, formulating problems, developing hypotheses, collecting and analyzing data, and drawing conclusions. This process aligns with the characteristics of scientific reasoning, which require logical, analytical, and evidence-based thinking. In virus-related material, which is abstract and complex, the guided inquiry approach helps students gradually build conceptual understanding through meaningful learning experiences.

Improvements in scientific reasoning on the proportional reasoning and control of variables indicators show that students are able to understand relationships between variables and identify factors influencing biological phenomena, such as the relationship between the number of viruses and their rate of spread. This is consistent with Kruit et al. (2019), who stated that inquiry-based learning is effective in training students' ability to control variables and understand quantitative relationships in science contexts. Furthermore, improvements in the hypothetical-deductive and correlational reasoning indicators indicate that students are able to formulate tentative explanations and analyze intervariable relationships based on empirical data. In guided inquiry learning, students are guided to test hypotheses and systematically evaluate investigation results. This finding aligns with the research of Opitz et al. (2020), which stated that inquiry learning contributes significantly to the development of students' deductive and analytical reasoning abilities.

For the probabilistic reasoning indicator, improvements in students' abilities are demonstrated through their capacity to predict the likelihood of events, such as virus transmission under certain conditions. Guided inquiry learning provides opportunities for students to consider uncertainty and make data-based decisions, as emphasized by Kind & Osborne (2021), who stated that probabilistic reasoning is an essential component of inquiry-based science learning. The results of this study are also consistent with the findings of Fischer et al. (2018) and Pedaste et al. (2020), who concluded that inquiry learning, particularly guided inquiry, is able to enhance scientific reasoning by providing adequate scaffolding for students during the investigation process. Thus, the implementation of the guided inquiry learning model has a strong relationship with and a significant effect on improving students' scientific reasoning ability, especially in virus-related material.

CONCLUSION

Based on the results of the study on the level of scientific reasoning ability of students at SMA Negeri 7 Pekanbaru, there was a significant improvement in scientific reasoning ability in the experimental class compared to the control class. This is evidenced by the average posttest scores of the experimental class, which fall into the "scientific reasoning" category, while the control class falls into the "moderate scientific reasoning" category. Similarly, observation results indicate that the scientific reasoning ability of the experimental class is in the scientific reasoning category, whereas the control class is in the moderate scientific reasoning category. Therefore, based on the posttest and observation results of both classes, it can be concluded that the guided inquiry learning model has a significant effect on improving the scientific reasoning ability of students at SMA Negeri 7 Pekanbaru.

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