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Scientific Reasoning Skills and Scientific Attitudes of Students in Learning Physics Using Guided Inquiry Model with Vee Map

Lintang Pascaeka[1*], Singgih Bektiarso[1], Alex Harijanto[1]

[1]Physics Education Department, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia.

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Corresponding Author:
Lintang Pascaeka
lpascaeka27@gmail.com

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Abstract: This study aims to examine the effect of guided inquiry learning model with vee map on scientific reasoning skills and to examine the effect of guided inquiry learning model with vee map on scientific attitude of high school students on temperature and heat material. This type of research uses true-experiment with pretest-posttest control group design. The sample determination used cluster random sampling method. The samples of this study were XI MIPA 1 class as the control class and XI MIPA 2 as the experimental class. The research instruments used were pre-test and post-test questions using Lawson Classroom Test Scientific Reasoning indicators and scientific attitude questionnaires. Data analysis techniques using SPSS 26. The results showed that there was a significant effect of guided inquiry learning model with vee map on scientific reasoning skills with a significance of 0.000 and there was a significant effect of guided inquiry learning model with vee map on the scientific attitude of students with a significance of 0.000. Therefore it can be concluded that inquiry learning model accompanied by vee map can encourage students to be active in concept discovery and improve students' scientific reasoning skills.

Keywords: Guided inquiry model; Scientific attitude; Scientific reasoning skills.

Introduction

In the age of globalization, scientific and technological advances have had a substantial impact on education systems around the world. As a result, there is competition in education. Teachers must be aware of the essential 21st-century learning paradigms in the learning process and apply them to the education system. In addition, the school environment requires learning materials. Teachers often use various teaching materials to promote learning (Trianto, 2009). However, many technologies used initially as learning tools and resources in the learning process should be used more. The education system also has an impact on students' scientific reasoning, and continuous memorization of facts and procedural knowledge during the teaching and learning process can lead to weak cognitive reasoning and low scientific reasoning (Zulkipli, 2020). This reduces students' reasoning ability and scientific attitude.

The study of science education focuses on the application of science concepts, principles, and relationships in everyday life. Scientific reasoning plays an essential role in the study of science. Scientific reasoning should be prioritized, especially in teaching for understanding. The overall goal of science education (including physics) is to help students develop a variety of skills to understand scientific concepts and appreciate the natural environment. The various skills include identifying, interpreting, and reasoning about relevant scientific data and evidence, and communicating ideas about science (Doyan et al., 2022). Students are taught to understand science content by demonstrating their ability to think and reason. These skills include collecting evidence, explaining phenomena, giving examples, applying concepts, drawing analogies, summarizing knowledge, and presenting scientific concepts of phenomena that occur in everyday life (Fry et al., 2009). Previous research has also shown that scientific reasoning is closely related to cognitive ability,

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as it involves logical thinking, reasoning, rational thinking and decision-making (Bao et al., 2009). Understanding physics concepts and being able to behave scientifically are essential to research and understanding the nature of relationships that occur in life or nature.

Indonesia is a country that has yet to maximize scientific reasoning among students compared to other countries. PISA and TIMSS research studies show this. PISA (Programme for International Student Assessment) conducted a study on the scientific reasoning skills of Indonesian students. According to the study results, students' scientific reasoning skills rank at level 2 of 6 levels. This level shows that students can explain simple situations based only on scientific knowledge, not including scientific reasoning skills (OECD, 2013). The Trends in International Mathematics and Science Study (TIMSS) ranked students in 40 out of 42 countries with the lowest level of knowledge, reasoning, and application in a research study of science achievement scores (Martin et al., 2012). The results show that the scientific reasoning of Indonesian students still needs to be improved and needs to be improved.

Physics learning emphasizes scientific reasoning in the independent curriculum. Scientific reasoning is an analytical process using logical thinking (Osterhaus & Koerber, 2021). Scientific reasoning skills help students deal with real problems, think critically, and reason well (Lai & Viering, 2012). Scientific reasoning is a competency necessary for students to receive science education (Handayani et al., 2020; Van De Sande et al., 2019). Students' skills in explaining scientific in scientific understanding can help understanding become better. It is essential to equip students with scientific reasoning skills to improve tests and support student learning, especially in physics. Most students need evidence, data, or logic to provide explanations.

Students' scientific reasoning improves when the learning model implemented can encourage students to engage in concept discovery actively. The inquiry learning model can improve scientific reasoning skills because it involves students creating new understanding and applying the knowledge gained to new situations to solve scientific thinking problems (Shofiyah et al., 2013). In addition, inquiry learning can deepen knowledge concepts in improving scientific reasoning skills (Daryanti et al., 2015). A guided inquiry learning process can facilitate the learning process so that students systematically understand the concepts of the material being taught (Wulansari et al., 2019). The formal learning in this problem is guided inquiry to improve scientific reasoning skills. This is necessary because students' scientific reasoning skills still need to be improved and must be improved.

An emphasis on assistance is strongly recommended in the inquiry model. The need to emphasize assistance to help students connect information, concepts, facts, and scientific process skills through scientific reasoning (Farber, 2003). One form of aid is the vee map, which can connect science processes, knowledge, and science products (Novak, 1990). Vee maps consist of two linkages, including knowledge or conceptual and procedural. Both encourage students to become familiar with the concepts and tests taken by students. Vee maps can be used for various laboratory tests. Scientific discovery divides scientific reasoning into three cognitive processes: hypothesis, experimentation, and evaluation of evidence (McNeill et al., 2006). Vee maps can be a valuable and practical learning tool allowing students to participate in learning actively.

Students must also have a scientific attitude in solving existing problems. This attitude must be embedded in students to overcome daily problems. Developing scientific attitudes is beneficial in developing students' personalities. Scientific attitudes are essential in finding concepts, facts, and theories. In line with the research findings of (Oktafia, 2022), it is known that the guided inquiry learning model focuses on student concept discovery and can influence learning outcomes and scientific attitudes. (Mayangsari et al., 2020), It is believed that learning physics through an inquiry-based learning model can improve scientific attitudes. Applying this learning mode to a guided inquiry will help address students' attitudes toward science in the future.

Some researchers have examined students' scientific reasoning skills to understand physics concepts about temperature and heat. Research findings (Himawan et al., 2020) explain that students' scientific reasoning still needs to improve, especially in inductive reasoning, giving reasons, and concept development due to students' lack of logical thinking when reasoning. Research findings (Rimadani et al., 2017) show that the low scientific reasoning of students is 44% correlation reasoning, 25% proportional reasoning, and 63% probabilistic reasoning. The findings (Sundari & Rimadani, 2020) explain that guided inquiry-based learning with scaffolding strategies increases students' scientific reasoning about temperature and heat. Some of these studies imply that students' scientific reasoning skills could be more optimal due to a lack of understanding of materials and concepts. Inquiry-based learning can considerably change scientific reasoning skills (Bao et al., 2009). The usher-guided inquiry learning model enhances students' scientific reasoning skills.

The results of an interview with one of the physics teachers XI MIPA at SMAN Lumajang said that students in the process of scientific reasoning skills and scientific attitudes already exist but still need to be maximized. Most students need help understanding the concept of physics well, and there are errors in explaining scientific claims and evidence. The material on temperature and heat is related to the surrounding nature and the development of science and technology, so students need to master the concepts of temperature and heat not to experience difficulties in overcoming the challenges of science and technology that develop and the competitiveness of globalization.

Based on the research studies that have been conducted, this research is needed to determine the effect of scientific reasoning skills and scientific attitudes on several students with guided inquiry learning models accompanied by vee maps. This research is expected to overcome the problem of physics learning towards scientific reasoning skills and students' scientific attitudes.

Method

This study uses a true-experiment with a research design using a pretest-posttest control group design that has an experimental group (treated) or a control group (not treated) that is not randomly selected (Sugiyono, 2015). In summary, the research design is shown in Table 1.

Table 1. Pretest-Posttest Control Group Design

Sample	Pretest	Treatment	Posttest
R	O_1	X	O_2
R	O_3		O_4

Description:
R : Random sampling
O1 : Pre-test in the experimental class
O2 : Post-test in the experimental class
O3 : Pre-test in the control class
O4 : Post-test on the control class Treatment
X : in the experimental class

The determination of the research site used the purposive sampling area method, a data collection technique using specific considerations (Masyhud, 2016). The research was conducted at senior high schools in Lumajang city on students of grade XI MIPA even semester of 2022/2023 academic year. The sampling technique used cluster random sampling method if it was declared homogeneous. The samples in this study amounted to 2 classes, namely XI MIPA 1 class as the control class and XI MIPA 2 as the experimental class. The number of students in MIPA-1 and MIPA-2 classes was 35 students. In the experimental class, physics learning was carried out by applying the guided inquiry learning model accompanied by a vee map. The control class was conducted conventional physics learning using direct learning.

The research procedure is a systematic series designed to achieve research objectives. The research procedure is divided into three stages. The initial stage is conducting interviews, school observations, identifying problems, making research hypotheses, and determining populations and samples. The implementation stage, namely collecting the first stage data from the pre-test results to determine initial understanding, conducting learning activities, and collecting the second stage data from the post-test and student scientific attitude questionnaire. The last stage, namely processing and analyzing data, compiling results, discussing, and drawing conclusions. The research procedure is stated briefly in Figure 1.

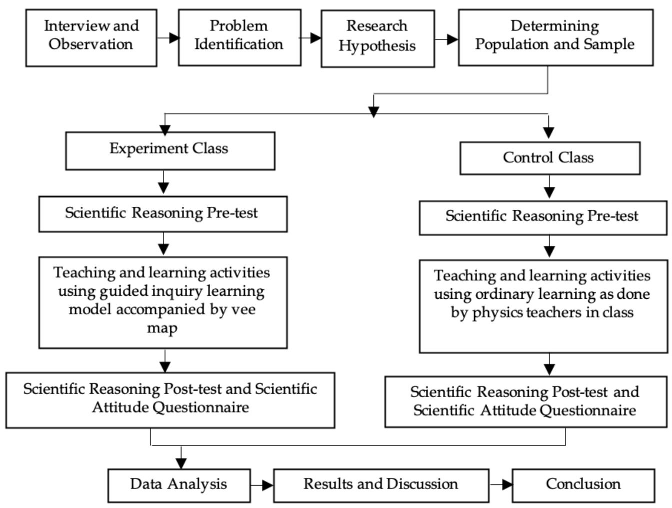

Figure 1. Schematic of the research procedure

The research instruments used were a pre-post test and a scientific attitude questionnaire. This stage aims to facilitate the development of the right questions tool. Questions are developed based on Lawson's Scientific Reasoning Test (LCTSR) indicator (Malik et al., 2021). The test is in the form of questions following the indicators of scientific reasoning skills using multilevel multiple-choice questions on temperature and heat. There are two levels of questions, namely questions that require students to choose answers, while the next question is why students choose the answer to the previous question. This study used a multiple-choice test, which aims to avoid subjective judgment. The pre-posttest consisted of 6 graded multiple-choice items, so the total items for each test were 12 questions. The scientific reasoning skills test scoring rubric is shown in Table 2 (Han, 2013).

Table 2. Scientific Reasoning Answer Score

Statement	Reason	Score	Category
True	True	2	Good
True	False	1	Enough
False	True	0	Error
False	False	0	Less

The scientific attitude data instrument was a closed questionnaire with ten positive questions. For each question, students have five choices according to the Likert scale. Likert scale with positive statements: strongly agree with a score of 5, agree with a score of 4, doubtful with a score of 3, disagree with a score of 2, and strongly disagree with a score of 1. The data obtained is in the form of scoring results, with a maximum score of 50 converted into a score. The data analysis technique uses the SPSS 26 application, which is used to process and analyze the research data. Research data analysis techniques using data normality test, independent sample t-test, and non-parametric test with Wilcoxon test.

Result and Discussion

Inquiry Learning Model Accompanied by Vee map

The vee map-assisted inquiry is student-centered. Students complete the process of investigating the problems presented in the form of worksheets in groups. The design of vee map-based worksheets helps students to discover the relationship between knowledge and scientific processes. The discovery process can be guided by several questions that require students to answer. The final section will serve to express opinions based on the results of the experiments conducted.

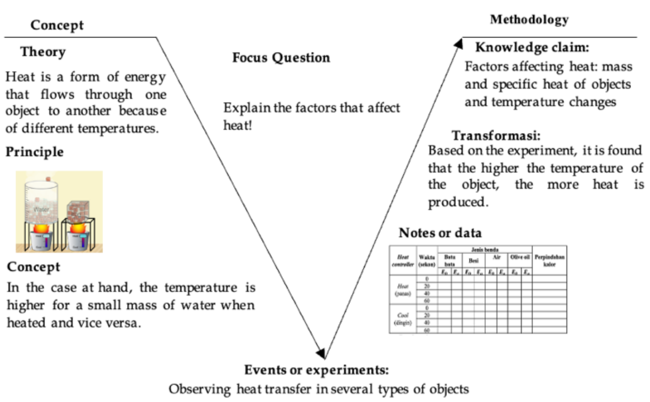

Figure 2. Tools inquiry learning model with vee map

Learning activities are carried out with students given a focus question first. The questions at this stage require analysis in maintaining a theoretical concept even under different circumstances. There is a case example, learners must answer the questions given in the conceptual and methodological columns that have been provided. After filling in several stages, then directed to fill in the vee map as in Figure 2.

The Effect of Guided Inquiry Learning Model Using Vee Map on Scientific Reasoning Skills

Scientific reasoning skill outcomes data are derived from pre-post test scores assigned to control and experimental classes. Pre-tests are done before training, and post-tests are done after training. Outcome data for scientific reasoning skills are shown in Table 3. The pre-post test data for scientific reasoning skills were first tested for normality using SPSS 26 software. The results of the data normality test using the Shapiro-Wilk test are shown in Table 4.

Table 3. Data on The Results of Student's Scientific Reasoning Skills

	Control Class		Experiment Class	
	Pre-test	Post-test	Pre-test	Post-test
The Highest Score	83	100	75	100
The Lowest Score	33	42	50	75
Median	60.71	74.22	70	87.91

Table 4. Normality Test of Scientific Reasoning Skills Data

Class		Shapiro-Wilk		
		Statistic	df	Sig.
Scientific Reasoning	Experimental class pretest	.529	35	.000
	Experimental class posttest	.868	35	.001
	Pretest of control class	.935	35	.040
	Control class posttest	.940	35	.056

a. Lilliefors Significance Correction

Table 4 shows that the pre-post test data on students' scientific reasoning skills are not generally distributed with a Sig. <0.05 is not normally distributed. Since the data is not normally distributed, we test it with the Wilcoxon test. This test is conducted to determine if there is a significant difference between students' scientific reasoning skills in the experimental and control groups. The results of the Wilcoxon test about the scientific reasoning data are shown in Table 5.

Table 5. related to the Wilcoxon test, the Asymp. Sig. (2-tailed) value of 0.000. Because the value of 0.000 <0.05 is H_0 rejected, and H_a accepted. So the scientific reasoning skills in the experimental class are better than the control class. The data states that the guided inquiry learning model accompanied by a vee map significantly

affects the scientific reasoning skills of high school students on temperature and heat material. Positive ranks or the difference (positive) between the pretest and posttest of the experimental class is 4, meaning that as many as 4 students have increased. The average increase is 8 and if summed up is 32. Positive ranks or the (positive) difference between the pretest and posttest of the control class is 35, meaning that 35 students have increased. The average increase is 18 and the total is 630. Negative ranks or the difference (negative) between the pretest and posttest of the experimental class is 24, meaning that 24 students have decreased. The average decrease is 15.58 and if summed up it is 374. Negative ranks or the (negative) difference between the pretest and posttest of the control class is 0, both in the N value, mean rank, or sum rank. A value of 0 indicates no decrease (reduction) from pretest to posttest scores.

Table 5. Wilcoxon Test Results of Scientific Reasoning Skills Data

Test Statistics[a]

	Posttest Eksperimen-Pretest Eksperimen	Posttest Control-Pretest Control
Z	-3.979[b]	-5.224[b]
Asymp. Sig. (2-tailed)	.000	.000

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.
c. Based on negative ranks.

In the experimental class, the highest pre-test percentage of scientific reasoning skills is controlling variables by 100% with an excellent category. In comparison, the lowest pre-test percentage of the experimental class was hypothesis-deductive reasoning at 20%, with an inferior category. This shows that students' initial skills in controlling variables are excellent. Students can control for dependent and independent variables that influence hypothesis testing. However, student skills in deductive reasoning by hypothesis remain weak, and students still need help testing hypotheses and drawing conclusions. The highest indicator in the experimental class during the post-test was conservation reasoning, and variable control obtained the exact percentage value of 98.57% with an excellent category. While the lowest indicator in the post-test was correlation reasoning, getting a percentage of 51.42% with a good category. This shows that students can extend their knowledge to answer questions about what will happen and control the dependent and independent variables that affect hypothesis testing. However, students still need to be sufficient in correlation reasoning, whereas students are sufficient in determining the relationship between variables.

The highest indicator in the control class during the pre-test was proportional reasoning obtained a percentage of 94.28% with an excellent category. Students can determine and compare a comparison. The lowest indicator during the pre-test was correlation reasoning obtained a percentage of 22.85% with a less category. Students still need to improve in determining the relationship between variables. While the highest indicator at the time of the post-test was, controlling variables obtained a percentage of 97.14% in the very good category. The lowest indicator is correlation reasoning obtained a percentage of 57.14% with a good category. This indicates that the students understood the test's dependent and independent variables well. In contrast, the students still had difficulty determining the relationship between the two related variables.

Based on data from each indicator, after conducting pre-test and post-test, using a guided inquiry learning model accompanied by a vee map can improve students' scientific reasoning skills. However, there are findings that students' correlation reasoning is still low and falls into the excellent category. The results of this study reinforce the previous research by (Malik et al., 2021), which concluded that students' lower scientific reasoning skills are indicators of correlation reasoning. The low scientific reasoning factor is due to students answering questions randomly. The results of this study also reinforce previous research (Aini et al., 2018). Strengthened by research (Bao, Cai, et al., 2009), it has been noted that inquiry-based guided learning can improve scientific reasoning skills. This finding also strengthens the research (Yulianti & Zhafirah, 2020) that students' reasoning power is able to increase optimally after students learn using the guided inquiry learning model.

In summary, the inquiry-based with vee map learning model significantly impacted high school students' scientific reasoning skills related to temperature and heat. The results of this study confirm the results of previous studies (Indahsari et al., 2020) that concluded that inquiry-based student worksheets by vee map could be improved high school students' scientific reasoning skills in physics. This research also strengthens previous research by (Utami et al., 2019), concluding that inquiry-based student worksheets by conceptual scaffolding can be improved students' scientific reasoning skills in physics learning. In line with research (Asmoro et al., 2021), inquiry-based learning significantly affects high school students' scientific reasoning skills. Reinforced by research (Yulianti et al., 2020), which concluded that using guided inquiry learning models could increase student test scores for each indicator of scientific reasoning, and each guided inquiry syntax increases students' scientific reasoning skills.

The Effect of Guided Inquiry Learning Model Using Vee Map on Scientific Attitudes

Data on the scientific attitudes of the experimental and control classes were obtained from the questionnaire. The data on scientific attitudes for each indicator are shown in Table 6. Table 6 indicates that in the experimental class, the lowest scientific attitude indicators are respected for data and critical thinking, with an average of 84, and the best indicators are openness and cooperation, with an average of 89.71. In the control class, the lowest average value is the scientific attitude indicator of respect for data 75.14, and the best value is the indicator of open scientific attitudes and cooperation 77.42. The overall mean results of scientific attitudes in the experimental and control classes are summarised in Table 7.

Table 6. Average Data on Scientific Attitudes For Each Indicator

Scientific Attitude Indicator	Experiment Class	Average Value Control Class
Curiosity	85.42	76.28
Respect for Data	84	75.14
Critical Thinking	84	75.71
Open and Collaborative	89.71	77.42
Perseverance	84.85	75.42

Table 7. Scientific Attitude Data

Class	Total Students	Median
Experiment	35	85.6
Control	35	75.94

Table 8. Normality Test of Students' Scientific Attitude Data

Class		Shapiro-Wilk		
		Statistic	df	Sig.
Scientific Attitude	Experimental class	0.943	35	0.072
	Control class	0.952	35	0.131

a. Lilliefors Significance Correction

The scientific attitude data were first tested for normality using the Shapiro-Wilk test technique because the sample was <50. The results of the normality test of students' scientific attitude data are shown in Table 8. The normality test results show that the data is usually distributed because it gets a Sig. Value of 0.131> 0.05 in the control class and 0.072> 0.05 in the experimental class. Analyze customarily distributed data with an independent sample t-test. The output of the t-test results is shown in Table 9.

Table 9. Independent Sample T-Test Test of Scientific Attitude Data

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Scientific Attitude	Equal variances assumed	.442	.508	7.236	68	.000
	Equal variances not assumed			7.236	67.613	.000

The results in Table 9 show a Sig. (0.508 > 0.05), which means that the data on students' scientific attitudes are homogeneous. The hypothesis was tested using the t-test for independent samples and obtained a Sig. (2-tailed) of 0.000 < 0.05 means that H_0 is rejected and H_a is accepted. These results conclude that students in the experimental class have a better scientific attitude than those in the control class. Therefore, the vee map guided inquiry learning model significantly affects students' scientific attitudes toward temperature and thermal matter.

In terms of each indicator of scientific attitudes based on Table 6. the highest and lowest average values of scientific attitudes can be obtained. The experimental class's highest indicator of scientific attitudes is openness and cooperation. This can be seen when doing practicum students actively participate in groups and respect each other's opinions in their groups. The scientific attitude indicators of respect for data and critical thinking are the lowest in the experimental class. This can be seen when doing practicum, and one group tends to ask other groups for answers, so the attitude of respect for data still needs to improve. The attitude of critical thinking is also still relatively low because some students need help to accept ideas/ideas easily and are less active in arguing when other groups present the answers.

The control class's highest indicator of scientific attitude is openness and cooperation. This can be seen when doing practicum students actively participate in groups and respect each other opinions in their groups. The lowest indicator of scientific attitude is respect for data. This can be seen when doing the practicum, and one group tends to ask the answers to other groups so that the attitude of respect for data is still low.

The results showed that the experimental class had a higher average science attitude than the control class. This was due to the influence of the learning model used in the class. The experimental class used a guided inquiry learning model with a vee map, while the control class used a problem-based learning model. Indeed, students are encouraged to obtain information by making observations or experiments and then confidently formulate their conclusions. This shows that the guided inquiry learning model accompanied by a vee map significantly affects scientific attitudes. In line with the research findings of (Istiqamah et al., 2016) concluded that the experiment-based guided inquiry learning model affects students' scientific attitudes. In line with the research findings of (Parwati et al., 2020), it was concluded that applying the guided inquiry learning model improved students' scientific attitudes and provided positive feedback. Reinforced by research (Niana & Ekawati, 2016), which concluded that applying learning with guided inquiry models in physics learning can improve students' scientific attitudes.

There are some students who get high scientific reasoning skills and low scientific attitudes. One of them in one of the experimental class students got a scientific reasoning ability score of 92 and a scientific attitude of 74. This indicates that the application of guided inquiry learning by the teacher in the experimental class is good. The teacher is able to act as a facilitator and direct during learning activities. These results are in line with research (Asmoro et al., 2021) concluded that the application of guided inquiry-based learning has a significant effect on the scientific reasoning skills of high school students. Reinforced by the research of (Parwati et al., 2020) suggested that the implementation of the guided inquiry model increased students' scientific attitudes and gave a positive response.

Conversely, there are some students who get low scientific reasoning skills and high scientific attitudes. One of them is in the control class, which gets a low scientific reasoning ability score of 58 and a high scientific attitude of 84. These results show that the problem-based learning conducted by the teacher is not good. Teachers do not provide opportunities for students to gain insight and find their own answers. The use of problem-based learning models is not able to increase students' scientific reasoning abilities but is able to improve students' scientific attitudes. In accordance with research (Astika et al., 2013) which concluded that the scientific attitudes of students who learn using problem-based learning models are better than students who learn using inquiry learning models. Strengthened by research (Ahmad et al., 2015) which concluded that there are differences in learning achievement and creativity for students who have high and low scientific attitudes in the application of problem-based models and guided inquiry.

This research aims to provide insight into how effectively using a guided inquiry learning model accompanied by a vee map is in students' scientific reasoning skills and attitudes. The inquiry learning model accompanied by a vee map can encourage students to be active in concept discovery and improve students' scientific reasoning skills. A guided inquiry learning model accompanied by a vee map influences students' scientific reasoning skills and scientific attitude. The guided inquiry learning model accompanied by a vee map can be used as an alternative for teachers in determining the appropriate learning model and media to improve the quality of learning. However, this research still has limitations. One of them is the scope that only involves class XI MIPA. Further research is expected to deepen the scope of the research and consider other factors related to applying the guided inquiry learning model with a vee map.

Conclusion

Based on the results of data analysis, the inquiry learning model accompanied by vee maps can encourage students to be active in concept discovery and improve students' scientific reasoning skills. The guided inquiry learning model accompanied by vee map affects students' scientific reasoning ability and scientific attitude. The guided inquiry learning model should be used alternately with vee maps to be applied to physics learning in the classroom. For other researchers, this research is expected to be an input to improve students' scientific reasoning skills in physics learning with different topics.

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L. P.: conceptualization, methodology, formal analysis, investigation, resources, data curation, writing-original draft preparation, writing-review and editing; supervision, S. B and A. H. All authors have read and agreed to the published version of the manuscript.

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