Empowering minds: How guided inquiry enhances scientific reasoning in students with varied self-efficacy levels

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Article Info	ABSTRACT
	This study aims to determine the influence of the guided inquiry learning model on scientific reasoning abilities in students with high self-efficacy, moderate self-efficacy, and low self-efficacy categories. The method used is a quantitative approach with a quasi-experimental research type. The population was all of tenth-grade IPA (Natural Science) students. The samples taken were class XI IPA 1 and class XI IPA 2, determined with the simple random sampling technique. The research instrument consisted of description items to measure scientific reasoning ability and twenty Likert scale questionnaire items to measure student self-efficacy. The hypothesis test was conducted using the ANCOVA (Analysis of Covariance) test. Based on the hypothesis test result, the guided inquiry learning model influences students' scientific reasoning abilities with high self-efficacy, moderate self-efficacy, and low self-efficacy categories. The results of this research have several important implications for the development of educational practices, especially in science learning.

Memberdayakan pikiran: Bagaimana inkuiri terbimbing meningkatkan kemampuan penalaran ilmiah pada siswa dengan tingkat *self-efficacy* yang berbeda

Kata Kunci:	ABSTRAK
	Penelitian ini bertujuan untuk mengetahui pengaruh model pembelajaran inkuiri terbimbing terhadap kemampuan *scientific reasoning* pada peserta didik dengan kategori *self-efficacy* tinggi, sedang, dan rendah. Metode yang digunakan adalah pendekatan kuantitatif dengan jenis penelitian kuasi eksperimen. Populasi dalam penelitian ini adalah seluruh peserta didik kelas XI IPA di sekolah tersebut. Sampel yang diambil adalah kelas XI IPA 1 dan XI IPA 2, dengan teknik pengambilan sampel menggunakan *simple random sampling*. Instrumen penelitian terdiri dari sepuluh butir soal tes essay untuk mengukur kemampuan *scientific reasoning* dan dua puluh butir angket skala Likert untuk mengukur *self-efficacy* peserta didik. Pengujian hipotesis menggunakan uji ANCOVA (*Analysis of Covariance*). Berdasarkan hasil uji hipotesis, model pembelajaran inkuiri terbimbing berpengaruh terhadap kemampuan *scientific reasoning* pada peserta didik dengan kategori *self-efficacy* tinggi, sedang, dan rendah. Hasil penelitian ini memiliki beberapa implikasi penting untuk pengembangan praktik pendidikan, khususnya dalam pembelajaran sains.

1. INTRODUCTION

Scientific reasoning is a person has ability to produce conclusions based on established evidence. In many countries, scientific reasoning skills have long been an essential goal in science and mathematics education [1]. Scientific reasoning ability is included in the Programme for International Students Assessment (PISA) test conducted by the Organisation for Economic Cooperation and Development in 2012 [2]. The 2018 PISA results showed that Indonesia ranked 71 out of 79 countries in science proficiency, with an average score of 396 [3]. This result shows that the scientific reasoning of students in Indonesia needs to be improved. The average science score obtained by Indonesia is far below the international average of 489 [4]. In the Trends in Mathematics and Science Study (TIMMS), the latest results in 2015 showed that Indonesia was ranked 44th out of 49 countries with an average score of 397, below the international average score of 500 [5]. The low ranking obtained by Indonesia was caused by the low percentage of participants who answered correctly. The students are not used to thinking and reasoning scientifically. In addition, education in Indonesia only focuses on conceptual thinking skills [2].

Physics is a subject related to scientific concepts and processes. The concepts in physics are very relevant to everyday life [6]. Scientific reasoning is critical for students to understand a physics phenomenon. The need for more knowledge about scientific reasoning in learning activities causes the low scientific reasoning of Indonesian students. The student-centered learning process can be a reference so that teachers can understand the nature of learning and choose appropriate learning models and methods [7]. Reasoning ability in learning is a cognitive skill in understanding and evaluating scientific information [8]. Therefore, reviewing the supporting aspects is one of the alternatives that can be done [9] to support the improvement of reasoning ability. One of the alternatives is affective ability, and one of the affective abilities that affect students' reasoning ability is self-efficacy.

Self-efficacy is an essential factor in learning success. Self-efficacy is a person's belief about their abilities, knowledge, skills, and attitudes to achieve goals in life [10]. According to Bandura in 1977, self-efficacy describes a theory influencing how personal, environmental, and behavioral factors are interconnected. Self-efficacy influences achieving goals, the effort and perseverance required to fulfill a goal, and the ability to overcome difficulties [11]. Bandura argues that it is crucial to determine an individual's beliefs through their skills, abilities, and knowledge [12]. Linnenbrink and Pintrich 2003 state that to produce meaningful learning and increase self-efficacy, students must be involved in the learning process in both cognitive and behavioral aspects. Bandura (1997) identifies four sources that shape self-efficacy: mastery experiences (success boosts and failure diminishes confidence), vicarious experiences (comparing oneself to others), social persuasion (influenced by verbal advice that often carries stereotypes or biases), and physiological states (the physical and emotional reactions, like anxiety or stress, experienced during tasks) [13].

The results of pre-research and interviews found several problems in the learning process, including students' lack of interest in learning and self-confidence in learning physics. They tend to be passive and pay less attention to the teacher's material. Furthermore, learning has not been entirely centered on students. The students are less motivated to find concepts directly, so the scientific reasoning process is challenging.

Constructivism theory says that learning is the formation of knowledge, so students must actively learn, construct, and give meaning to what they learn. Constructivism learning has principles where students, both individually and socially build knowledge.

Knowledge is not transferred from teachers to students except with the students' activeness to reason. Students are continuously active in constructing so that changes in concepts lead to more detailed, complete, and in line with scientific concepts. Teachers act as facilitators providing facilities and situations so student construction can run [14].

The guided inquiry learning model is a model that involves all students' abilities to the maximum to find out and investigate an event or phenomenon that exists systematically, critically, and logically so that students can formulate their knowledge. The guided inquiry learning model has scientific activities where students express opinions before explaining the material. The students investigate a problem through symptoms or phenomena and find facts. They can describe and compare scientifically with theory. The students can learn actively in formulating problems, analyzing results, and drawing conclusions [15].

In addition to the results of pre-research, this research is also motivated by research gaps in previous studies. Research showed that inquiry-based learning effectively stimulates students' scientific thinking skills [16] and affects and increases students' self-efficacy [17]. In contrast, several research results showed that learning using a scientific approach with Problem-Based Learning and guided inquiry models did not affect increasing students' self-efficacy [18]. In addition, another research said there was no correlation between self-efficacy to determine students' reasoning ability [19]. From some previous research results, it is known that there are differences in research results related to the effect of guided inquiry learning models on self-efficacy and scientific reasoning.

Research related to the application of inquiry learning has been widely conducted, including the effect of guided inquiry learning model on learning outcomes [20], [21] and students' critical thinking skills [22], video-assisted guided inquiry on learning outcomes [23], guided inquiry with multiple representations on science process skills [24], guided inquiry on critical thinking skills [25], and student collaboration [26]. However, no research examines guided inquiry on students' scientific reasoning skills regarding self-efficacy.

This study aims to determine the effect of guided inquiry on scientific reasoning ability regarding self-efficacy. This research has novelty compared to previous studies. Previous studies reviewed the effect of guided inquiry on learning outcomes, science process skills, critical thinking skills, and student collaboration. Meanwhile, this research seeks to determine the effect of guided inquiry on scientific reasoning ability regarding self-efficacy. This research is expected to provide a broader picture of the application of guided inquiry in learning.

Contribution to the literature

This research contributes to:

- Providing a different understanding of how psychological factors influence learning outcomes in science education.
- The findings demonstrate the potential for this learning model to be widely applicable in diverse classroom environments, thereby promoting equity in educational outcomes.
- The research contributes to developing pedagogical practices by offering insights into effective teaching strategies that can be adopted to foster critical thinking and scientific reasoning.

2. METHOD

This research employed quantitative methods with a quasi-experimental research type. The research design used was a randomized control group-only post-test design, where the experimental class was given treatment using the guided inquiry learning model [27]. Factorial research design [28] aims to classify high, moderate, and low self-efficacy into experimental and control groups on students' scientific reasoning ability.

Both sample classes used different learning models. The experimental class was treated using a guided inquiry learning model that adopted the learning steps in the book. [29]. On the other hand, the control class used the direct instruction learning model. After the treatment, a post-test was given to both classes to compare the results of using the two learning models. Indicators of scientific reasoning ability were adopted from the journal [30], while the dimensions of self-efficacy were adopted from the journal [31].

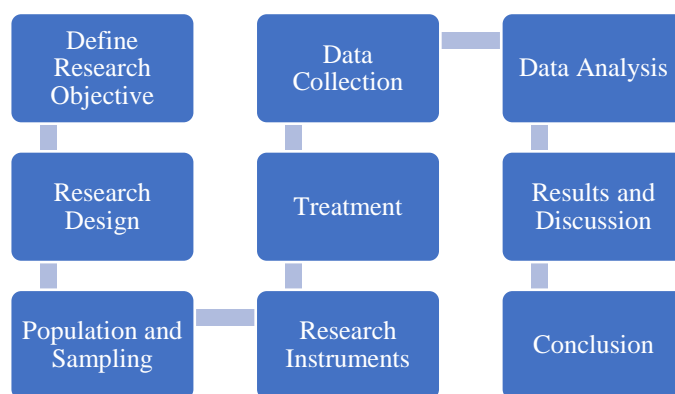The researchers illustrate the methodology through the chart below for easier understanding.

Figure 1. Chart of Research Methodology

The population was all tenth-grade IPA (Natural Science) students with two classes: class X IPA 1 as the experimental class and class X IPA 2 as the control class. The samples were determined using a simple random sampling technique. The data collection techniques were tests, questionnaires, observation, and documentation.

The research instruments used were twenty Likert scale questionnaire items to measure students' self-efficacy level and ten test questions to measure students' scientific reasoning ability. The research instruments, both questionnaires and questions, passed the validity test and obtained a significance value of more than 0.05. Then, the reliability test of the questionnaire and questions was carried out using Cronbach's alpha formula. The research instrument is reliable if the reliability coefficient (r) is more than 0.6. Discriminating index tests and difficulty tests were also conducted for the question instrument.

The questionnaire grid used WAs taken from research [32]. There were three dimensions of self-efficacy. First, the level dimension indicates self-confidence in completing tasks from easy to difficult and beyond their abilities. Second, the strength dimension with indicators of self-perseverance when working on physics problems and the influence of individual experience. Third, the generality dimension, with indicators of confidence in one's ability to deal with varied problems and confidence to be consistent in activities and tasks. Each dimension consists of positive and negative statements.

The values of the questionnaire score criteria for positive statements are strongly agree (4), agree (3), disagree (2), and strongly disagree (1). As for negative statements, the opposite score is given for each answer choice [33]. After calculating the

questionnaire score, self-efficacy is classified into three categories. The standard deviation formula is used to find these categories [34]. The category is determined according to the calculation of the score interval. If the self-efficacy value is more than 85.29, it is in the high category. If the self-efficacy value is between 55.43 and 85.29, it is in the moderate category. If the value is less than 55.43, then the self-efficacy is in the low category.

Scientific reasoning ability was measured using a description question test. The scoring rubric for each question was given a score of 0-4 with the provisions: wrong answers or no answers (0), most answers are incomplete but contain at least one correct answer (1), partially correct answers with one or more significant errors (2), the answers containing one significant error (3), and answers that are overall correct and complete (4) [35].

Ten description questions fulfill six indicators of scientific reasoning ability. Two questions represent conservation reasoning, two represent correlational thinking indicators, and two represent the variable control indicator. There is one question that represents the proportional thinking indicator, two other questions represent the probabilistic thinking indicator, and there is one question that represents the hypothesis-deductive reasoning indicator. Each indicator of scientific reasoning ability's percentage value was calculated by multiplying the number of values obtained on each question by the number of values obtained on all questions. The value of scientific reasoning ability can be categorized as follows:

Table 1. Scientific Reasoning Ability Level Category [36]

Percentage	Category
81% - 100%	Excellent
61% - 80%	High
41% - 60%	Moderate
21% - 40%	Low
0% - 20%	Poor

Quantitative data obtained in research activities were then tested using IBM SPSS-25.0. The prerequisite tests were the data normality test using the Liliefors test formula (Kolmogorov-Smirnov) to determine whether the data obtained is normally distributed and the homogeneity test to determine whether two or more groups of sample data come from populations that have the same variance. Levene's test was used to test the homogeneity of the data. The hypothesis test used was a one-way ANCOVA test. This test aimed to identify or observe the effect of treatment on response variables by controlling other variables [33].

3. RESULTS AND DISCUSSION

This research discusses in detail the research results and discussion regarding scientific reasoning ability and self-efficacy. The instruments used were description questions to test students' scientific reasoning ability. The Likert scale questionnaire was employed to measure self-efficacy. This study was conducted in four meetings. Before the treatment, and a non-test instrument in the form of a questionnaire was given to measure the self-efficacy category. The following is the frequency distribution of self-efficacy categories.

Table 2. Self-Efficacy Category Frequency Distribution

Self-Efficacy	Experiment class		Control class		Sum of Frequencies
	Percentage (%)	Frequency	Percentage (%)	Frequency	
High	88	8	87	4	12
Moderate	76	17	74	18	35
Low	50	6	48	10	16

After the treatment, the scientific reasoning ability was measured, and data based on high, moderate, and low self-efficacy were obtained, presented in Table 3.

Table 3. Results of Scientific Reasoning Ability Viewed from Self-Efficacy

Indicator	Self-Efficacy					
	High		Moderate		Low	
	Experiment Class	Control Class	Experiment Class	Control Class	Experiment Class	Control Class
Conservation	81	72	71	73	56	45
Correlation	78	66	85	78	67	55
Variable Control	72	63	63	61	44	36
Proportional	78	69	62	57	38	40
Probabilistic	78	66	71	65	56	40
Hypothesis-deductive	72	69	56	56	33	25
Average	77	68	68	65	49	40

The results of scientific reasoning ability in students with high self-efficacy in both experimental and control classes are in the moderate category. Although the average scientific reasoning ability in the experimental and control classes were both in the excellent category, the experimental class obtained a higher score than the control class. The scientific reasoning ability of students in the moderate self-efficacy category obtained a higher average score in the experimental class. In addition to the high and moderate categories, students' scientific reasoning abilities were also reviewed based on self-efficacy in the low category. The experimental class students with low self-efficacy obtained an average score of scientific reasoning ability in the moderate category, while the control class was in the moderate category.

After measuring the self-efficacy and scientific reasoning ability, the next step is to test the normality of the data. The results of the data normality test are presented in Table 4.

Table 4. Normality Test Results of Self-Efficacy and KSR Questionnaire Data

Instrument	Class	Sig.
Questionnaire Self-Efficacy	Experimental	0,063
	Control	0,080
Ability Test Scientific Reasoning	Experimental	0,200
	Control	0,200

Based on the normality test of self-efficacy data, the significance of the experimental class was 0.063, and the control class obtained a significance value of 0.080. Therefore, both classes had a significance value of more than 0.05. This means that the self-efficacy questionnaire data in both classes were normally distributed. The table above also shows the normality test results of scientific reasoning ability data. The experimental and control classes' post-test data obtained a significance value of 0.200, higher than 0.05, which indicated that the post-test data was normally distributed. The second prerequisite test was the data homogeneity test. Table 5 presents the homogeneity test of self-efficacy questionnaire data and post-test of scientific reasoning ability.

Table 5. Homogeneity Test Results of Self-Efficacy Questionnaire Data and KSR Questions

Instrument	Significance
Questionnaire on Self-Efficacy	0,413
Ability Test Scientific Reasoning	0,143

Table 5 shows the significance of the homogeneity test of the self-efficacy questionnaire data of 0.413 and the scientific reasoning ability data of 0.143. Therefore, the questionnaire data and test questions come from homogeneous variances.

After testing the normality and homogeneity of the data, hypothesis testing was performed to determine the effect of the guided inquiry learning model on students' scientific reasoning ability based on the self-efficacy category. Table 6 shows the results of hypothesis testing.

Table 6. Hypothesis Test Results

Hypothesis	Sig.	Conclusions
There is an effect of the guided inquiry learning model on the scientific reasoning ability of students who have high self-efficacy levels.	0,003	There is an influence.
There is an effect of the guided inquiry learning model on the scientific reasoning ability of students who have moderate self-efficacy levels.	0,010	There is an influence.
There is an effect of the guided inquiry learning model on the scientific reasoning ability of students who have low self-efficacy levels.	0,002	There is an influence.

As seen in Table 6, the significance value in all three hypotheses is lower than 0.05. Based on the overall data, a better level of self-efficacy will affect students' scientific reasoning ability.

Based on the data, 31 students participated in the experimental and 32 students participated in the control classes. To answer the proposed problem formulation, the researchers distributed a self-efficacy questionnaire and a post-test of scientific reasoning ability to find out whether there was an influence on the scientific reasoning ability of students after being given treatment through the guided inquiry learning model. This study was conducted for four meetings; each meeting lasted for three lesson hours, with 45 minutes per lesson hour. Before being given treatment, a non-test instrument in the form of a questionnaire was distributed to measure the level of self-efficacy. In the first meeting, the researchers executed learning activities using guided inquiry models for experimental classes and direct instruction learning models for control classes with momentum and impulse material. The learning continued at the second meeting with collision material. On the third meeting, the activity conducted in the experimental class was a simple experiment about a ball falling freely to the floor. This experiment aimed to understand the application of collisions in everyday life and to determine the coefficient of restitution of the ball to identify the type of collision. The control class conducted the lesson as usual with the same material. In the final meeting, the researchers distributed a post-test on scientific reasoning skills to each class to see the students' final results after the learning activities.

The steps of the guided inquiry learning model implemented began when the teacher started the learning activity by showing the students a phenomenon related to the learning material. This phenomenon allowed students to identify and formulate problems. To address these problems, the teacher asked students to gather in small groups. After forming groups, students formulated hypotheses based on the previously identified problems, and these hypotheses were adjusted according to the student's initial

understanding of the given phenomenon. Next, the students collected data from sources, such as books, the internet, and explanations from the teacher. After obtaining supporting data for the proposed hypotheses, the data was tested to conclude the formulated hypotheses. Then, the students concluded the results of the concept discovery and related it to the initially presented phenomenon.

The steps of the direct instruction learning model implemented in the control class were as follows. The teacher began the lesson by explaining the goals and background of the learning and prepared students to learn. The teacher presented knowledge and skills related to the learning material. The teacher-guided initial practice after delivering the material by providing practice questions. The teacher checks students' understanding of the learning material by seeing if they can perform the practice well and provides feedback. The teacher provided further practice in the form of independent assignments for students to complete using the knowledge or skills they have learned.

This research shows a difference in the scores obtained between experimental and control class students. Applying the guided inquiry learning model affects the scientific reasoning ability of students with high self-efficacy. Students in the high self-efficacy category in the experimental class obtained higher scientific reasoning scores compared to those in the control class. Research shows the guided inquiry learning model can improve students' scientific reasoning abilities [2]. In the guided inquiry learning model, the students were allowed to actively and maximally learn something systematically, critically, and logically. This process will increase students' confidence in their abilities. Other relevant research found that in guided inquiry learning with the topic of buffers, there is a significant influence and improvement in students' self-efficacy [17]. Jamali et al. stated that students with high self-efficacy feel capable of succeeding in tasks. Pintrich and De Groot noted that students with high self-efficacy tend to be more persistent in achieving their goals [36]. Kurbanoglu and Akin state that students with higher self-efficacy tend to choose to work on complex and challenging tasks [37].

In addition to the high self-efficacy category, the guided inquiry learning model enhances scientific reasoning abilities among students with moderate self-efficacy. The experimental class achieved higher scores in scientific reasoning abilities compared to the control class. Based on the steps in the guided inquiry learning model, students can actively participate in the learning process and enhance their scientific reasoning abilities. Implementing the guided inquiry learning model provides guidance and support to students at each stage of learning or investigation. It helps students gain confidence in tackling complex scientific tasks. Thus, this model has a positive influence on students' self-efficacy levels. Students with moderate self-efficacy will feel more capable of completing inquiry tasks and developing scientific reasoning abilities. The beliefs held by students will impact their learning process and influence their level of scientific reasoning abilities. Research aligned with these findings indicates that inquiry-based learning approaches effectively enhance students' scientific thinking abilities [16]. Additionally, research shows a significant positive relationship between reasoning abilities and self-efficacy [38].

The latest results indicate that the guided inquiry learning model also influences students' scientific reasoning abilities with low self-efficacy. Despite having low self-efficacy, students can engage in scientific exploration using the guided inquiry learning model. This model enhances students' abilities to formulate problems, hypothesize, gather data, analyze information, and draw conclusions based on evidence. By implementing guided inquiry learning and providing effective guidance, students can boost their confidence and improve their scientific reasoning abilities because they feel

supported and guided through each step of the scientific process. The difference in post-test scores for scientific reasoning abilities is influenced using the guided inquiry learning model. Students' self-efficacy levels reinforce it during the learning process. These research findings reveal that the guided inquiry learning model can enhance high school students' physics scientific reasoning abilities [39]. Because the guided inquiry learning model can assist students in learning independently and positively impact scientific reasoning abilities, students' scientific reasoning abilities are expected to increase if they can construct their knowledge. Self-efficacy will significantly influence students' abilities in the learning process [10].

In several studies concerning guided inquiry learning models, scientific reasoning, and self-efficacy, the researchers have not found studies that integrate all three variables. Therefore, these three variables are combined into a single study, presenting novelty in this research. The findings conclude that using the guided inquiry learning model impacts students' scientific reasoning abilities with high, moderate, and low self-efficacy categories.

4. CONCLUSION

Based on the results and data analysis of the study, the significance values for each hypothesis were less than 0.05. Therefore, this research found that the guided inquiry learning model influences students' scientific reasoning abilities by considering self-efficacy across high, moderate, and low categories. The guided inquiry learning model can enhance students' scientific reasoning abilities. Hence, this model can be applied in teaching activities if aligned with the curriculum used in the research setting. This study solely employed a quantitative methodology. Mixed methods are recommended for future research to explore the relationship between the guided inquiry learning model and self-efficacy in students' scientific reasoning abilities. These findings significantly impact educational practices, particularly in science learning. The guided inquiry learning model can increase student engagement and their critical and scientific thinking abilities.

AUTHOR CONTRIBUTION STATEMENT

RD was responsible for formulating the research ideas, collecting and analyzing data, constructing the theoretical framework, and drafting the manuscript for this research. AA contributed to developing the research methodology, validating instruments, and interpreting results. LPP contributed to reviewing the literature, collecting and analyzing data, constructing the theoretical framework, and providing guidance and revisions for the final manuscript.

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