
Cognitive Methods: How the Use of the Free Inquiry Learning Model Increases Students' Cognitive Empathy in Science Learning

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Abstract. Education research continues to develop, one of which is related to the application of appropriate learning models to improve the quality of learning. The free inquiry learning model in science learning can train students to understand scientific concepts, as well as improve students' cognitive empathy. This study aims to analyze the effect of the application of the free inquiry learning model with a cognitive method approach on improving students' cognitive empathy in science learning. This study uses a quantitative method with a quasi-experimental design, where the pretest and posttest were conducted in the experimental class and the control class. The sample used in the experimental class was 18 students, while the control class was 18 students. Data processing using normality tests, homogeneity, paired t-tests, and Anova tests. The results of this study indicate that the free inquiry learning model with a cognitive method approach has an effect on students' cognitive empathy in science learning with a t-test result of 0.000. This study will support the development of learning strategies to improve students' cognitive empathy.

Keywords: Cognitive empathy, cognitive methods, free inquiry, science learning, students

Introduction

Now, research continues to develop, and one of them is in education. Research that is often conducted in the realm of education is research in teaching and learning activities. Instruction and educational activities by implementing the right learning model will have a significant influence on success in learning. A variety of strategies must be provided in learning to improve the quality of learning activities, especially within the classroom. In learning, there are often students who are not yet independent without direct guidance from the teacher (Jundu et al., 2020). The view in this research takes the focal point of something whose impact can be known and seen or measured by the level of difference. Learning with various types of models applied will create different results according to the expected goals.

Students must have an understanding related to cognitive empathy, especially in science learning. This ability is associated with the process of real thinking about logical concepts. Problems in the classroom are often encountered as there are still many teachers who only measure students' cognitive abilities as a reference for success during the process

of learning. Therefore, it is essential to determine the right model for science learning to ensure its optimal implementation in alignment with the role of education. With the free inquiry model, learning will be student-centered, and students will be trained to think critically (Apsari & Sastiawati, 2021; Warmadewi, 2022). Learning using a free inquiry model will provide a new colour to teaching and learning activities. Learners will have a greater capacity to grasp the content delivered by the teacher.

The needs of the 21st century require the development of some competition among students so they can tackle future challenges effectively. Student needs competencies include critical thinking skills, collaboration skills, effective communication abilities in both spoken and written communications, and resilience in facing changes and difficulties that occur within themselves. Using this learning model has the potential to assist in overcoming the problem of not understanding the material because it will be easier for students to help each other and explain concepts to their classmates to create an active and more interactive learning environment (Hasja et al., 2023).

In learning activities, teachers must be able to think about determining the right strategy in learning to create learning outcomes in the classroom that are based on the goals and targets of learning. According to 21st-century principles, the learning process must be effective in enhancing learning outcomes. During the learning process, teachers must provide facilities for students to engage in thinking and taking action during education and instruction activities. Educators need to be capable of showing phenomena, especially natural science phenomena, that occur so that students can analyze them according to the learning model applied by the teacher during learning activities (Munajah et al., 2020).

Science learning is essentially a scientific inquiry, which involves learning through direct experiences and the cultivation of process skills and scientific attitudes. Science learning will be meaningful if it starts from curiosity, the ability to think, the ability to always learn, having a caring attitude, being able to apply something, and being responsible for nature and the surrounding environment (Eka et al., 2021). Students' scientific thinking skills can be influenced by various factors, including student motivation and environment, so teachers are important in developing learning (Afifah & Faizah, 2023). Innovative learning models are needed to support the achievement of the expected science learning objectives. In the context of the free inquiry learning model, various levels of thinking are involved, which are included in Bloom's taxonomy, starting from the basic level, which consists of the knowledge, to higher levels, such as evaluation and creation (Apriany et al., 2020). Cognitive empathy assessment is where the teacher uses an assessment instrument in the form of a cognitive test device to determine the level of students' thinking abilities.

The potential of students' cognitive empathy can be maximized through free inquiry learning, and it is important to overcome the challenges that arise during the science learning process. In knowledge, students must be able to collect basic information relevant to scientific concepts. With the free inquiry learning model, students must have an initial understanding before they can formulate questions to be studied. In the understanding stage, students are expected to understand the information obtained, beginning with the connection of scientific ideas to natural phenomena and formulating hypotheses or scientific questions based on their understanding. Then, students apply their knowledge by conducting experiments or direct investigations into the problems being studied. Learn to apply theory to real situations and use scientific tools and methods to solve problems. In the free inquiry learning model, students analyze data obtained during experiments or observations. They try to identify patterns, relationships, and variables that influence outcomes and reason critically about the information available.

In Baddeley's view, working memory becomes a "bridge" between scientific understanding and the student's ability to empathize cognitively, which means that by using working memory, students can connect the scientific facts they learn to their social

impact, helping them see how science impacts real life. Thus, working memory not only enhances students' cognitive abilities in science but also supports the development of deeper empathy for others. The cognitive components impact learning: 1) Working memory is a temporary storage place for information used to perform cognitive tasks such as understanding concepts, solving problems, and making decisions; 2) Long-term memory allows information to be stored for a long time and accessed again when needed; 3) Attention as the basis of learning, because students need to focus attention on the material to process information well. Without adequate attention, the information received is difficult to understand or remember.

Empathy is the ability to put an individual in another person's shoes, see the situation from their perspective, and understand and express the feelings they experience appropriately. This ability is very important in building good relationships and mutual understanding between individuals. In accordance with its development, empathy plays a crucial role in educational activities and the teaching process. Students must instill cognitive empathy that can facilitate learning activities and improve individual development. Cognitive empathy focuses on the intellectual process of understanding another person's perspective or point of view (Lestari & Agung, 2016). So that students will be able to build interactions between fellow students to achieve learning goals.

Learning is not only an individual process but also involves social interactions and the social environment that influence students' cognitive development. This approach combines cognitive theory, which focuses on how students understand and process information, with a sociocultural perspective, which sees learning as a social activity. In the context of science learning, the sociocognitive position involves collaboration between students, group discussions, and interactions with teachers and the environment to develop scientific understanding. Education that encourages a more profound comprehension as students engage in discussions with their peers. Teachers can connect what students learn during lessons to skills or knowledge they can develop over the long term (Uno & Mohamad, 2022).

Inquiry is grounded in Jean Piaget's cognitive constructivist theory and Vygotsky's social constructivist theory. Jean Piaget emphasizes that learning is a process of self-exploration, where individuals actively engage with, interact with, and observe their environment to acquire knowledge. In contrast, Vygotsky believed that cognitive development arises from interactions with the environment and social context (Ellis & Sampe, 2022).

Inquiry learning emphasizes the process of seeking knowledge over simply acquiring it. Among the various types of inquiry learning models, one notable example is the free inquiry learning model, where students are active in identifying problems independently. This model has three components, namely knowledge, values and attitudes, and processes.

And the free inquiry learning model is based on cognitive learning flow. The stages carried out in learning activities are: 1) The stage of facing problems, where the teacher provides the context of the problem situation to motivate students, then students pay attention, listen, and formulate problems; 2) The stage of collecting data that is tested, the teacher directs students to collect information according to the problems faced; 3) The stage of collecting data obtained during experimental activities, students conduct experiments in groups and ask questions about problems when conducting experiments; 4) The formulation stage of the explanation, by using experimental data, students answer questions from the teacher and ask questions about terms that are not yet understood; 5) Analysis at the inquiry stage, questions that have been asked at the stage of dealing with problems in groups are reanalyzed and connected to theory (Fadly, 2022).

An alternative learning strategy in classroom teaching and learning activities is undoubtedly intertwined with various approaches, methods, and other strategies used by the teacher. If the learning approaches, methods, and strategies used do not help convey

information, the student's ability to think will be less trained, and reasoning abilities will be reduced (Nuayi, 2020). During learning, students are not accustomed to thinking logically. By considering the explanation that has been presented above, this study aims to increase cognitive empathy in students through the application of a free inquiry learning model with a cognitive method approach to science learning.

Methods

This research employs a quantitative research approach. Quantitative research refers to a structured and methodical approach, which is planned and structured research where the observations made include everything that has a relationship with the object of research, phenomena, and correlations (Iwan, 2019). The research design used is quasi-experimental research. Experimental research focuses on efforts to understand how changes in one variable can cause changes in other variables with other treatments under controlled conditions (Gusti, 2023). The researcher employed a control group design with a pretest-posttest approach, incorporating both a control class and an experimental class in the study. The research design can be seen in Figure 1 quasi-experimental research design.

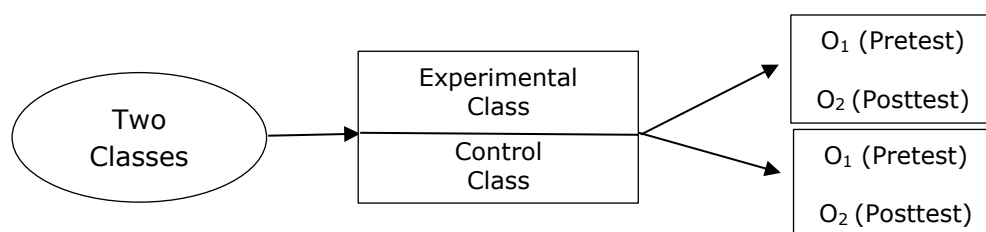


Figure 1. Quasi-Experimental Research Design

This research contains three types of variables, namely independent variables, intermediate variables, and dependent variables. The independent variable is the application of the free inquiry learning model. The free inquiry learning model has five stages, namely: 1) Stages of facing problems; 2) Stages of collecting tested data; 3) Stages of collecting data obtained during experimental activities; 4) Stages of formulation in explanation; and 5) Analysis at the inquiry stage. The intermediate variable is the cognitive method approach. The cognitive method is an approach that emphasizes behaviour, which is an individual's active mental process of capturing, assessing, comparing, and responding to stimuli before reacting. The cognitive approach focuses on the mental processes occurring within an individual, including how they think, remember, comprehend language, solve problems, interpret experiences, develop moral standards, and form beliefs (Destiannisa, 2012). The dependent variable is cognitive empathy. Cognitive empathy has two indicators (Lestari & Agung, 2016), according to Table 1.

Table 1. Cognitive Empathy Indicators

Indicator	Descriptor
Perspective taking	Feeling what others feel Putting yourself in the shoes of others
Fantasy	Understanding other people's feelings imaginatively Understanding other people's actions imaginatively

The subjects in this study were students of class VIII MTs Ma'arif Al-Mukarrom Kauman in the 2024/2025 academic year. The sample selected as the experimental class in this study had 18 students, and the control class had 18 students. From the results of this sampling, those who participated in the learning in this study. The data gathering

method employed in this study used a written test. The assessment employed was a multiple-choice test given before (pretest) and after (posttest) the learning process in the experimental class and control class. This study will use the validity instrument of the learning device obtained with the validation instrument sheet. This instrument is a sheet designed and used by researchers and then given to the validator to validate the learning device. The data analysis method in this study involves multiple tests, namely the data normality test, data homogeneity test, hypothesis test with t-test, and Anova analysis.

Results and Discussion

The data for this study were collected from an experimental class made up of 18 students and a control class also comprising 18 students. Before being given treatment, the class first underwent a pretest to assess the student's initial abilities. After receiving the treatment, the class was administered a posttest. The results of the data can be seen in Table 2.

Table 2. Pretest-Posttest Results

No	Class	Average Pretest Score	Average Posttest Score
1	Experiment	55.00	73.05
2	Control	52.22	61.66

According to Table 2, it is evident that the average pretest score in the experimental class is 55.00, while the average posttest value is 73.05. Then, the average pretest value in the control class is 52.22, while the average posttest value is 61.66. In this case, it can be seen that the results obtained in the experimental class are classes that are given treatment with a free inquiry learning model with cognitive methods that can provide a better impact compared to the control class that only uses conventional learning models.

Before testing homogeneity, the data must be tested for normality. The results of the data normality test can be seen in Table 3.

Table 3. Data Normality Test Results

	Statistic	Shapiro-Wilk	
		df	Sig.
Empathy Cognitive	.962	18	.632

Based on Table 3, the results of the data normality test can be seen where the sig value is > 0.05 . The results of the normality test using Shapiro-Wilk show a significant value of 0.632. This value is more than 0.05, so it can be concluded that the data can be stated as normally distributed. Furthermore, the homogeneity test can be seen in Table 4.

Table 4. Results of Data Homogeneity Test

	Levene Statistic	df1	df2	Sig.
Based on Mean	.231	1	34	.634
Based on Median	.291	1	34	.593
Based on Median and with adjusted df	.291	1	33.486	.593
Based on trimmed mean	.270	1	34	.606

Based on Table 4, the results of the data homogeneity test can be seen where the sig value is > 0.05 . The results of the homogeneity test show a significance value of 0.634. This value is more than 0.05, so it can be concluded that the data can be stated as homogeneous.

Hypothesis testing in this study uses parametric statistical tests with t-test statistics. The results of the hypothesis test can be seen in Table 5.

Table 5. Paired Samples Test Result

Paired Differences								
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	df	Sig. (2-tailed)
				Lower	Upper			
Pair 1 Pretest - Posttest	-17.944	12.027	2.835	-23.925	-11.964	-6.330	17	.000

According to the t-test results, the significance value is 0.000, where sig > 0.000, indicating a difference between the pretest and posttest scores of students. This result suggests that the implementation of the free inquiry learning model can enhance students' cognitive empathy abilities. In addition, the data was tested using one-way Anova parametric statistics. The results of the Anova test can be seen in Table 6.

Table 6. Anova results

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1156.000	1	1156.000	12.264	.001
Within Groups	3204.889	34	94.261		
Total	4360.889	35			

Based on the Anova results table, the significance value is 0.001, which is less than 0.05. Therefore, it can be concluded that there is a significant difference between the application of the free inquiry learning model and the conventional learning model in enhancing students' cognitive empathy abilities.

The results of the study showed the influence of the application of the free inquiry learning model with a cognitive method approach on students' cognitive empathy. This result occurs because the relationship exists between the characteristics of science learning and the free inquiry learning model. Science learning does not only focus on material related to the environment and nature but also on learning about individual understanding and sensitivity to the surrounding environment. State that science learning in education is not just learning about things that smell nature (Nafiah & Aristiawan, 2024). Learning science by integrating the free inquiry learning model with cognitive approaches introduces new variations to classroom instruction and enhances students' cognitive empathy skills. Learning science by integrating the free inquiry learning model with cognitive approaches introduces new variations to classroom instruction and enhances students' cognitive empathy skills.

According to Bruner's information processing theory, cognitive methods can improve students' cognitive empathy. Bruner explains the importance of strategy and process in learning. When students are given tasks that involve case analysis or problem-solving, they are trained to process information deeply, recognize behavioral patterns, and understand the consequences of actions on others (Malle, 2022). This kind of activity will help build a better understanding of other people's emotions and motivations, which is the core of cognitive empathy (Swargiary, 2024).

Learning with cognitive methods will improve students' cognitive empathy because, in the process, it has led to and linked competencies about cognitive empathy. Through cognitive methods with cognitive empathy, there is a close and influential relationship. Especially in this cognitive method by the indicators of cognitive empathy, namely

perspective taking, which includes things about students being able to feel what others feel and being able to put themselves in what others are feeling. In addition, the indicators of cognitive empathy, namely fantasy, include students' ability to understand empathetically other's emotions and imaginatively comprehend their actions.

Not only about the application of methods, but science learning is also needed ability that is very closely related to empathy, including cognitive empathy. Cognitive empathy encompasses various elements, including the ability to recognize, comprehend, and mentally process the emotions of others (Abramson et al., 2020; El Ray et al., 2022). Teaching and learning activities that can improve students' abilities must be combined with an appropriate model. Learning that incorporates an appropriate instructional model, such as the free inquiry learning model, can enhance the attainment of predetermined learning objectives. The free inquiry learning model has five stages, namely: 1) The stage of facing problems; 2) The stage of collecting data that is tested; 3) The stage of collecting data obtained during experimental activities; 4) The formulation stage in the explanation; and 5) Analysis at the inquiry stage (Fadly, 2022).

In science learning activities, the stages of facing this problem are in accordance with the cognitive empathy indicator, which can help students feel what others feel. The teacher provides a context of the problem situation so that students can be motivated. Students who pay attention, listen and then formulate learning materials from the teacher, these students will be able to motivate themselves to achieve the goals they want to achieve and will have the capacity to be able to understand and feel what others feel (Kusumaningpuri, 2024; Ronnie & Philip, 2021).

The learning stages in collecting test data are where the teacher directs students to collect information obtained according to the problems faced. The stage is related to students' cognitive empathy in placing themselves in what others feel. Students who empathize will be able to feel what is happening around them (Alzayed et al., 2021). In collecting data, students will exchange information with each other, thus giving rise to the ability to understand and appreciate the perspectives of their friends (Cahyani, 2019).

In collecting data during experimental activities, students conduct experiments in groups and ask questions about problems when conducting experiments. Students, while searching for data in groups, will have the ability to understand the actions of other students through learning experiments. In addition, students will be able to think imaginatively during group discussion activities. In collecting explanations, students will be able to organize data clearly according to the results of discussions in group experiments (Bohari, 2020; Pratiwi & Setyaningtyas, 2020). In this way, students will have the ability to feel the actions of others imaginatively.

Students formulate explanations by asking questions related to terms that are not yet understood and then answering teacher questions. Teaching methods that incorporate imagination can enhance and foster the growth of students' physical, social, emotional, and cognitive abilities (Mavrellos et al., 2023). Students who receive an education based on imagination are likely to have a higher perception of their skills so they can understand other people's feelings (Haryanto et al., 2021).

In the analysis stage at this inquiry learning stage, students will group to reanalyze and connect with theories related to questions that have been raised during the problem-solving stage. At this stage, students' curiosity arises, reflecting a feeling of wanting to know (Peterson, 2020; Tang et al., 2022). Students will exchange arguments with each other to get answers from the analysis carried out so that this stage can foster a sense of students understanding the feelings felt by others.

In the second and fifth stages of the free inquiry model learning stage, in each stage, students are formed into groups. In group learning, students will be active, interact with each other, exchange opinions and suggestions, and convey opinions (Crisianita & Mandasari, 2022; Rapp et al., 2021). The process of cognitive methods integrated with the

free inquiry learning model, more precisely in the second stage, namely, the stage of collecting submitted data, and the fifth stage, namely group data analysis, will be able to bring out students' sensitivity to other people's feelings (Falla et al., 2021).

The ability to associate emotional or mental states with others requires various processes, one of which is implementing a cognitive method approach to learning, with a cognitive method approach through the cognitive control process, which facilitates the coordination of self and other necessary representations. In the cognitive control process, emotional regulation is involved (Pruessner et al., 2020; Schweizer et al., 2020). Students will base their ability to exert control or response. The ability to consider when carrying out activities related to students' capacity to regulate their emotions, including awareness or understanding of emotions or feelings of others (Thompson et al., 2022).

This study demonstrates an improvement in students' cognitive empathy through the implementation of a free inquiry learning model in science education, consistent with research conducted by Levti (Bely et al., 2019). Levti's research emphasizes that the use of appropriate learning models will provide a more active learning process capable of resolving issues in learning. Therefore, this study emphasizes the significance of incorporating real contexts in education, especially science learning, to improve students' cognitive empathy. The findings of this study affirm that students not only comprehend the material but also contribute to the development of learning strategies aimed at enhancing their cognitive empathy.

This study provides significant strength in the cognitive method approach to science learning by integrating the free inquiry learning model, which can increase students' cognitive empathy in learning. This integration not only increases student engagement through the approach but also supports the progress of students' thinking and competencies, which are very much needed in 21st-century education. In addition, this study faces limitations, including the potential sample size used. However, the impact of the variables used is the execution of the free inquiry learning model with the cognitive method approach, which can increase students' cognitive empathy.

Emphasizing the importance of context in learning from a literature perspective shows that the integration of appropriate learning models can provide changes based on learning objectives. Innovative learning models can improve students' cognitive empathy in learning contexts. Thus, this study not only offers fresh perspectives on science learning but can additionally play a role in the development of new learning strategies in the realm of education to achieve goals that are by the curriculum that has been implemented.

Conclusion

Based on the results, it can be concluded that students' cognitive empathy can be increased in science learning materials through a free inquiry learning model with a cognitive method approach, with the results of the t-test showing a value of 0.000. In addition, there was an increase in the average score of students after being given treatment, which is free inquiry learning, there was the average pretest score being 55.00 and the average posttest score being 73.05. The result shows that there was an increase before and after being given treatment, so the application of the free inquiry learning model with a cognitive method approach can increase students' empathy in science learning.

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